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Assessment of Groundwater Levels in Narnaul Block, Mahendergarh District (1991-21)

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Abstract
Groundwater is a crucial resource for sustaining agriculture and domestic water supply in semi-arid regions of India. The present study assesses the temporal variation in groundwater levels in Narnaul Block of Mahendergarh District, Haryana, over a period of three decades (1991–2021). The analysis is based on secondary data collected from ten selected observation wells, focusing on depth to groundwater level (meters below ground level). The study employs a time-series and decadal approach to examine trends, fluctuations, and spatial variations in groundwater levels.
The results reveal a significant decline in groundwater levels during the study period. The average depth increased from 21.78 m bgl in 1991 to 61.41 m bgl in 2011, indicating severe depletion, followed by a partial recovery to 54.48 m bgl in 2021. Decadal analysis shows that the most critical phase of decline occurred between 2001 and 2011. Spatial variations among villages highlight localized differences in groundwater conditions, with some areas experiencing extreme depletion. The major factors contributing to this decline include excessive groundwater extraction for irrigation, erratic rainfall, unfavorable geological conditions, and inadequate water management practices.
The study concludes that groundwater resources in Narnaul Block are under significant stress despite recent signs of recovery. It emphasizes the urgent need for sustainable groundwater management strategies, including efficient irrigation practices, artificial recharge measures, and regulatory interventions. The findings provide valuable insights for policymakers and planners to develop effective groundwater conservation and management strategies in the region.
Key words: *Groundwater depletion, Depth to water table, Decadal fluctuation, Narnaul Block, Mahendergarh District.*

1. Introduction

Groundwater is a fundamental resource for sustaining agriculture, domestic consumption, and economic activities, particularly in countries like India where dependence on monsoon rainfall creates uncertainty in surface water availability. A substantial proportion of irrigation and rural drinking water supply in India is met through groundwater sources, making it crucial for food security and livelihoods (Central Ground Water Board [CGWB], 2020). However, increasing demand due to population growth, agricultural expansion, and industrial development has led to excessive extraction of groundwater. In many regions, this extraction exceeds the natural recharge capacity, resulting in a continuous decline in groundwater levels.

The problem of groundwater depletion is especially severe in the northwestern parts of India, including Haryana, where agricultural intensification since the Green Revolution has significantly increased water demand. The widespread use of tube wells, supported by subsidized electricity, has encouraged over-exploitation of aquifers (Shah, 2009). Mahendergarh District, located in the semi-arid zone of southern Haryana, experiences low and erratic rainfall along with hard rock geological formations that limit groundwater recharge. Narnaul Block, lacking reliable surface water sources, depends heavily on groundwater for irrigation and domestic needs, which has intensified pressure on the resource over time.

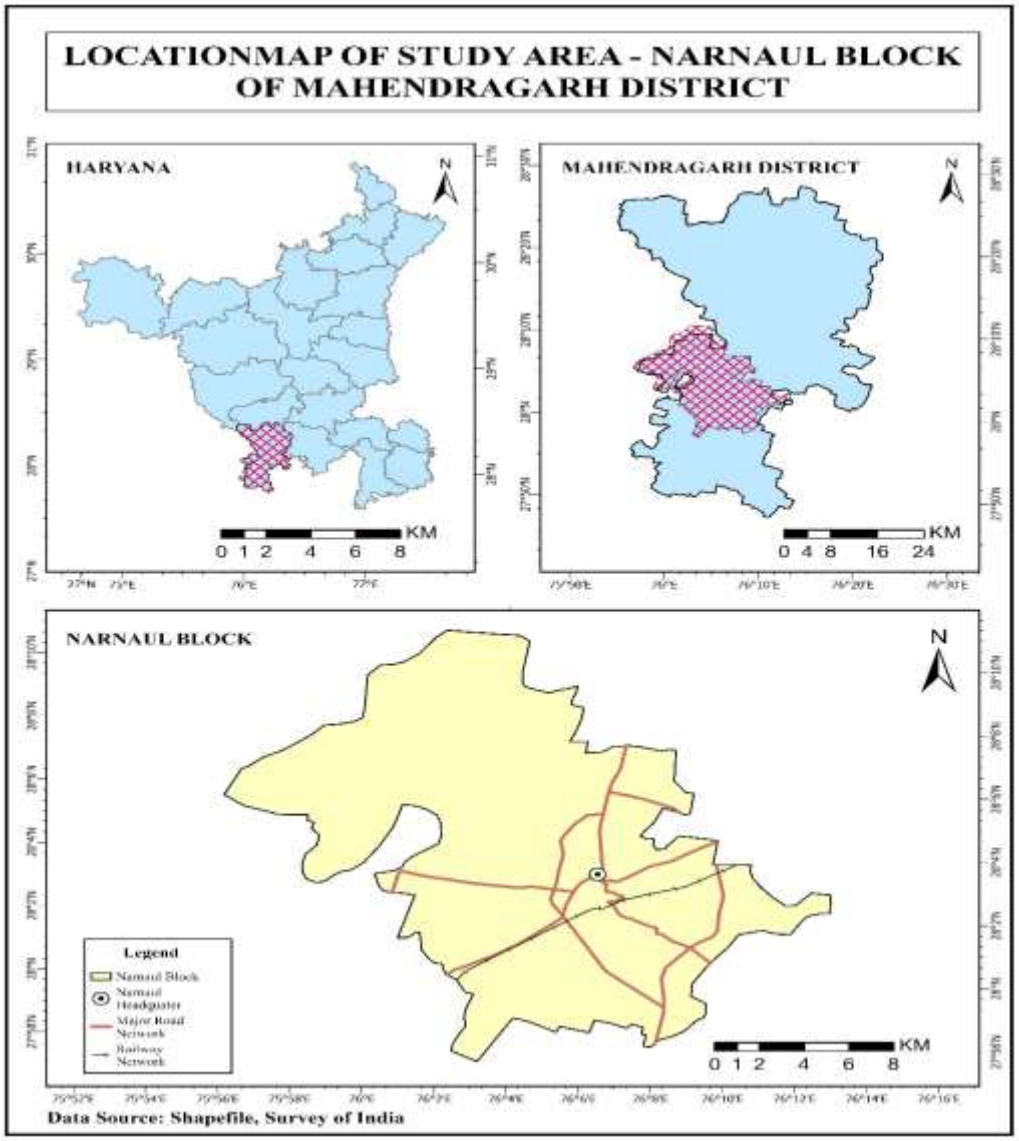
Scientific studies have consistently highlighted declining groundwater trends across northern India using both field observations and advanced technologies such as the GRACE satellite mission, which revealed significant groundwater loss in the region (Rodell et al., 2009). In addition to climatic variability, factors such as inefficient irrigation practices, urbanization, and inadequate water management policies contribute to the depletion problem (Kumar & Shah, 2006). In this context, a long-term assessment of groundwater levels in Narnaul Block from 1991 to 2021 is essential to understand the extent of decline and to support the development of sustainable water management strategies.

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2. Study Area

Narnaul Block is situated in Mahendergarh District of Haryana, within the semi-arid region of northwestern India. It lies between approximately 27°58' N to 28°10' N latitudes and 75°56' E to 76°16' E longitude. The area is largely rural, with agriculture as the main occupation, leading to a high dependence on groundwater for irrigation and domestic purposes.

Map: 1



The climate of the region is semi-arid, characterized by hot summers, cool winters, and low, erratic rainfall ranging from 400 to 500 mm annually. Most rainfall occurs during the monsoon season, but its variability often results in inadequate groundwater recharge. High evapotranspiration further reduces water availability.

Geologically, the area is dominated by hard rock formations such as quartzite and schist, which limit groundwater storage. The absence of perennial surface water sources increases reliance on groundwater, contributing to its continuous decline in the region.

3. Methodology

The present study is based on secondary data collected from the Irrigation & Water Resource Department, Haryana. Groundwater level data were obtained for ten selected observation wells/villages in Narnaul Block, namely Dohar Kalan, Goad, Khorma, Koriawas, Kultazpur, Mehrampur, Narnaul,

Nuniaval, Raghunathpur, and Thana. The dataset covers four benchmark years—1991, 2001, 2011, and 2021—and represents depth to groundwater level measured in meters below ground level (m bgl).
The selection of these ten wells was based on data availability and their spatial distribution across the study area to ensure representative coverage of groundwater conditions. However, some data gaps (NA values) exist for certain villages in earlier years, which is a common limitation in long-term groundwater monitoring datasets. Despite these gaps, sufficient data points are available to analyze temporal trends and overall groundwater behavior in the block.
For analysis, the groundwater data were compiled and averaged to determine mean groundwater levels for each reference year. A comparative and time-series approach were adopted to examine changes over the three decades (1991–2021). The increase in depth to groundwater level was interpreted as depletion, while a decrease indicated recharge or recovery. This approach enabled the assessment of spatial variation among villages as well as overall trends in groundwater depletion across Narnaul Block.

4. Data Analysis and Results

4.1 Depth to Groundwater Level (1991-2021)

The depth to groundwater level in Narnaul Block was analyzed using data from ten selected villages for the years 1991, 2001, 2011, and 2021. The values are expressed in meters below ground level (m bgl), where an increase in depth indicates groundwater depletion and a decrease indicates improvement or recharge. The data were obtained from the Irrigation & Water Resource Department, Haryana.

Table 1: Depth to Ground Water Level (m bgl) in Narnaul Block (1991-2021)

Monitored Well/ Village	1991	2001	2011	2021
Dohar Kalan	NA	NA	84.1	48.25
Goad	NA	54.20	90	78.25
Khorma	NA	NA	96.7	97.25
Koriawas	NA	NA	76.87	63.03
Kultazpur	NA	NA	94.6	98.75
Mehrampur	29.35	31.45	34.85	43.95
Narnaul	22.60	18.55	17.6	19.63
Nuniaval	12.30	17.57	16.65	11.18
Raghunathpur	22.85	25.05	45.8	32.60
Thana	NA	55.30	56.9	51.90
Average	**21.78**	**33.69**	**61.41**	**54.48**

Source: Village Level Ground Water Data, Irrigation & Water Resource Department, Haryana

The analysis reveals a clear declining trend in groundwater levels over the study period. The average depth to groundwater increased from 21.78 m bgl in 1991 to 33.69 m bgl in 2001, indicating moderate depletion during the first decade. This declining trend intensified significantly by 2011, when the average depth reached 61.41 m bgl, reflecting severe groundwater depletion across most villages.
At the village level, considerable spatial variation is observed. Villages such as Khorma, Kultazpur, and Goad recorded extremely deep groundwater levels in 2011 and 2021, indicating critical depletion conditions. In contrast, villages like Nuniaval and Narnaul show relatively shallow groundwater levels, suggesting comparatively better groundwater conditions or localized recharge. However, even in these areas, fluctuations indicate stress on groundwater resources.
Between 2011 and 2021, there is a noticeable improvement, with the average groundwater depth decreasing to 54.48 m bgl. This suggests partial recovery or recharge in certain areas, possibly due to improved rainfall or water management practices. Nevertheless, the overall trend from 1991 to 2021 indicates substantial groundwater depletion in Narnaul Block, highlighting increasing pressure on groundwater resources and the need for sustainable management strategies.

4.2 Decadal Fluctuation in Depth to Ground Water Level (1991-2021)

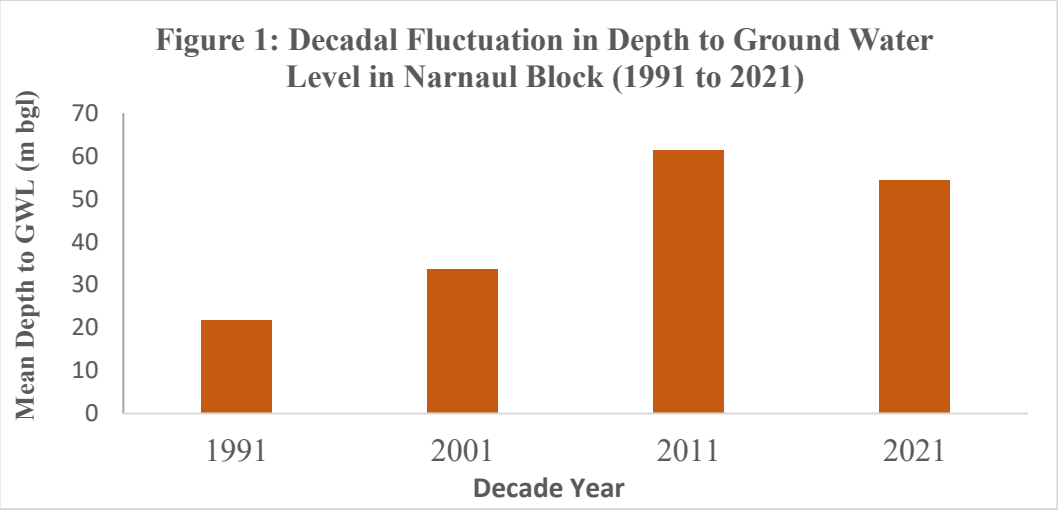
The decadal fluctuation in groundwater levels provides insight into long-term changes in aquifer conditions in Narnaul Block. The analysis is based on the mean groundwater depth (m bgl) derived from

ten selected wells. An increase in depth indicates groundwater depletion, while a decrease reflects recharge or recovery.

Table 2: Decadal Fluctuation in Depth to Ground Water Level in Narnaul Block (1991 to 2021)

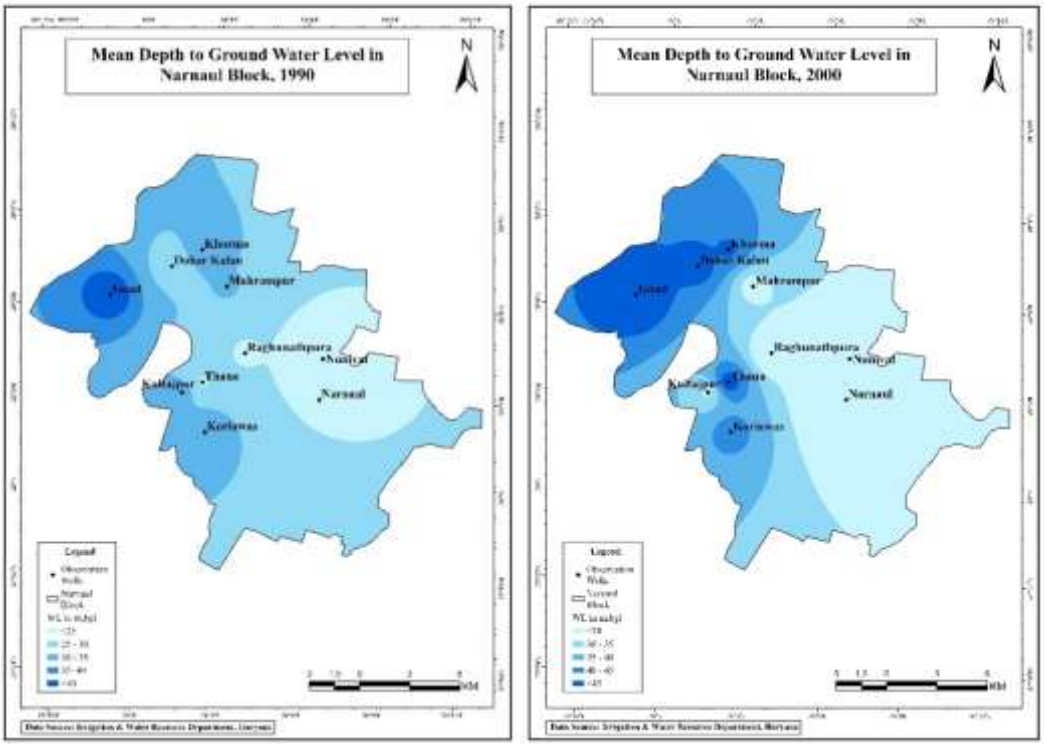
S. N.	Decade Year	Mean Depth to GWL (mbgl)	Decadal Change (mbgl)	Decadal Change (%)	Interpretation
1.	1991	21.78	+11.11	+104.12	Depletion
2.	2001	33.69	+11.91	+54.68	Depletion
3.	2011	61.41	+27.72	+82.28	Depletion
4.	2021	54.48	−6.93	−11.28	Recharge
Change from 1991 to 2021			+32.70	+150.14	Depletion

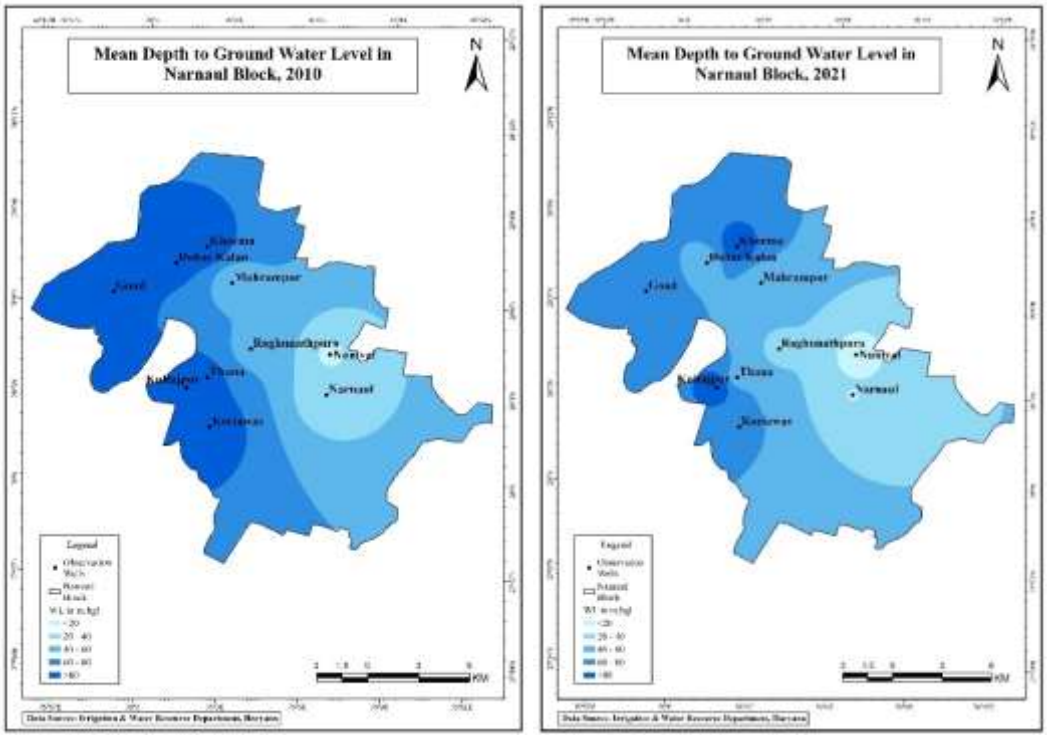
Source: Mean Data of 10 selected Wells, Irrigation & Water Resource Department, Haryana



Source: Mean Data of 10 selected Wells, Irrigation & Water Resource Department, Haryana

Maps 2: Decadal Fluctuation in Depth to Ground Water Level in Narnaul Block (1990 to 2021)





The results indicate a continuous decline in groundwater levels from 1991 to 2011. During the first decade (1991–2001), the mean groundwater depth increased by 11.91 m (54.68%), reflecting significant depletion. This trend continued during the next decade (2001–2011), where the groundwater depth increased sharply by 27.72 m (82.28%), representing the most critical phase of depletion during the study period.

However, a reversal of this trend is observed between 2011 and 2021, where the mean groundwater depth decreased by 6.93 m (−11.28%), indicating partial recovery or recharge of groundwater levels. This improvement may be attributed to better rainfall conditions, reduced extraction, or increased awareness and implementation of water conservation measures.

Overall, the long-term change from 1991 to 2021 shows a net decline of 32.70 m (150.14%) in groundwater levels. Despite recent recovery, the cumulative trend clearly indicates significant groundwater depletion in Narnaul Block, emphasizing the need for effective groundwater management and sustainable utilization practices.

4.3 Causes of Groundwater Depletion

The decline in groundwater levels in Narnaul Block is attributed to a combination of natural and human-induced factors. The major causes are as follows:

- Intensive use of tube wells and bore wells for irrigation has led to over-exploitation of groundwater resources.
- Increased cultivation of crops requiring high water input and multiple cropping cycles has raised groundwater demand.
- The semi-arid climate with irregular monsoon reduces natural recharge of groundwater.
- Elevated temperatures result in higher water loss, limiting effective recharge.
- Presence of quartzite and schist formations restricts groundwater storage and movement.
- Rising domestic and commercial water demand has increased pressure on groundwater resources.
- Absence of perennial rivers or canals makes groundwater the primary water source.
- Limited use of efficient irrigation methods such as drip and sprinkler systems.
- Insufficient rainwater harvesting and artificial recharge structures.

These factors collectively contribute to the continuous decline of groundwater levels in the study area.

5. Conclusion

The analysis of groundwater levels in Narnaul Block over the period 1991–2021 reveals a clear and consistent pattern of decline, indicating growing stress on groundwater resources. The average depth to groundwater increased significantly from 21.78 m bgl in 1991 to 61.41 m bgl in 2011, reflecting severe depletion across the study area. Although a partial recovery is observed in 2021, with the average depth improving to 54.48 m bgl, the overall long-term trend still indicates substantial groundwater decline.

The decadal analysis further highlights that the most critical phase of depletion occurred between 2001 and 2011, when groundwater levels declined sharply due to intensified extraction and inadequate recharge. Spatial analysis of selected villages also shows considerable variation, with some areas experiencing extremely deep groundwater levels, indicating localized over-exploitation. The limited improvement observed in recent years suggests that groundwater conditions may respond positively to favorable rainfall and improved management practices, but such recovery remains insufficient to offset long-term depletion.

The study concludes that groundwater depletion in Narnaul Block is primarily driven by excessive extraction for agriculture, erratic rainfall, unfavorable geological conditions, and lack of effective water management strategies. If current trends continue, the region may face serious water scarcity in the future. Therefore, there is an urgent need for sustainable groundwater management, efficient water use practices, and strengthened policy interventions to ensure long-term water security in the area.

6. Suggestions

Considering the observed decline in groundwater levels, the following measures are recommended to ensure sustainable management of groundwater resources in Narnaul Block:

- Promote the use of water-saving irrigation systems such as drip and sprinkler methods to minimize unnecessary water loss.
- Encourage cultivation of crops that require less water, thereby reducing dependence on groundwater for irrigation.
- Construct check dams, recharge pits, and percolation tanks to enhance groundwater replenishment.
- Implement rooftop rainwater harvesting systems in residential, institutional, and agricultural areas to improve recharge.
- Introduce regulations to monitor and limit excessive withdrawal of groundwater, especially through deep bore wells.
- Educate local communities and farmers about the importance of water conservation and sustainable groundwater use.
- Adopt better irrigation scheduling and modern techniques to optimize water use efficiency.
- Apply tools such as GIS and remote sensing for regular monitoring and planning of groundwater resources.
- Increase vegetation cover to improve soil moisture retention and facilitate groundwater recharge.
- Enhance coordination among government agencies and local stakeholders for effective implementation of water management policies.

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