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A Case Study of Groundwater Potential for Agricultural Sustainability in Ambala District, Haryana by using Geospatial Approach

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Abstract*: *This study focuses on analyzing the behaviour of groundwater in the Ambala District using a Geographic Information Systems (GIS) approach. The Ambala District, located in* 30.2862° N, 76.9643° E *faces challenges related to groundwater availability and sustainability due to increasing water demand and potential environmental impacts. The research integrates various datasets, including hydrogeological parameters, groundwater level measurements, land use/land cover data, and geological information specific to the Ambala District. These datasets are processed and analyzed using GIS tools, enabling the identification of spatial patterns, trends, and relationships associated with groundwater behaviour.The analysis encompasses key aspects such as groundwater recharge areas, flow direction, aquifer characteristics, and vulnerability to contamination. By overlaying different thematic layers and conducting spatial analysis, the study identifies areas with high potential for groundwater recharge, areas of groundwater flow convergence or divergence, and regions prone to contamination risks from anthropogenic activities.

Keywords*: *Groundwater behavior, groundwater draft, water behavior, GIS, Remote Sensing

I. INTRODUCTION

Water is the most significant natural resource supporting human health, economic development, and ecological diversity. Groundwater is part of the water cycle, and which is stored in the saturated zones underneath the land surface and moves slowly through geologic formations called aquifers. Water could remain in an aquifer for hundreds or thousands of years. The existence and flow of groundwater is controlled by factors such as geological formations, soil type, lineament density, slope, drainage density, rainfall form, morphology, land-use/land-cover characteristics, and the interrelation between them. Baqui, A. (2009[3][5][6][7]). Most groundwater originates from precipitation that percolates through the rock strata. Groundwater replenished, or recharged, by rain and snow melt that seep down in to the cracks and crevices beneath the land's surface.

In different areas of the world, people face solemn water scarcities because groundwater discharge for use is faster than its natural replenishment (recharge). Due to the reason that groundwater is incessantly accessed and its reasonable natural quality, it becomes a vital source of water supply, both in urban and rural areas of any country. Bajpai, V. N. (2011[2]) Indeed, due to groundwater being easily diverted directly to poor communities far more cheaply and quickly than surface water, it helps in poverty mitigation and reduction. (Julla Kabeto et al 2023[1].) The Ambala District, located in Haryana is a region that faces significant water resource challenges. With increasing population and expanding urbanization, the demand for water in the district has been rising steadily. Additionally, the district's agricultural practices heavily rely on groundwater irrigation, further stressing the already limited water resources. Consequently, there is a need to understand the groundwater behavior in the Ambala District comprehensively. Geographic Information Systems (GIS) have emerged as powerful tools for analyzing and visualizing spatial data, making them well-suited for studying groundwater behavior. GIS enables the integration of diverse datasets, including hydrogeological parameters, groundwater level measurements, land use/land cover information, and geological data. By combining these datasets and employing spatial analysis techniques, GIS allows for a detailed understanding of the complex interplay between various factors influencing groundwater behavior. This study aims to investigate the behavior of groundwater in the Ambala District using a GIS approach. By utilizing spatial data and GIS tools, the research will analyze the key aspects of groundwater behavior, including recharge mechanisms, flow patterns, aquifer characteristics, and vulnerability to contamination. Additionally, the study will examine the temporal variations in groundwater behavior by analyzing historical groundwater level data. The findings of this study will provide valuable insights into the groundwater dynamics specific to the Ambala District. This information will be crucial for formulating effective strategies for groundwater management, such as identifying suitable locations for recharge structures, assessing sustainable pumping rates, and implementing measures to protect groundwater quality. The GIS-based approach will enable decision-makers, water resource managers, and stakeholders to make informed choices regarding water allocation, land use planning, and environmental conservation, with the aim of ensuring the long-term availability and sustainability of groundwater resources in the Ambala District.

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II. STUDY AREA

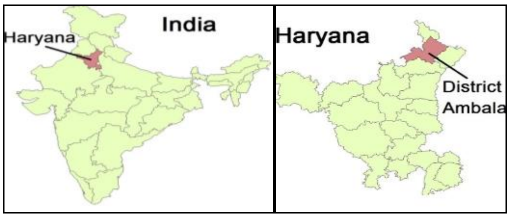
The study area of this research is focused on the Ambala District, which is located in the state of Haryana, India. Ambala District lies between latitude 30° 10’31° 35’ N and and 76° 30’ 77° 10’ E shares borders with the districts of Yamunanagar, Kurukshetra, and Panchkula.

Ambala District is situated in the northern part of Haryana and covers an approximate area of 1574sq.km. The district is characterized by a diverse landscape, including agricultural fields, urban areas, and natural features. It is predominantly an agricultural region, with farming being the primary occupation of the local population.

The district is known for its semi-arid climate, with hot summers and cool winters. The monsoon season, which occurs from June to September, brings the majority of the annual rainfall to the region. The geological composition of the area consists of various soil types, including loam, sandy loam, and clayey soils.

Ambala District faces significant water resource challenges due to its growing population and expanding urbanization. Census of India (2011) [4]. The demand for water has been increasing steadily, leading to stress on the available groundwater resources. Therefore, understanding the behavior of groundwater in this region is crucial for effective water resource management and sustainable development.

The study area of Ambala District provides an ideal context for investigating groundwater behavior using a GIS approach. By analyzing and integrating various spatial datasets specific to this region, the research aims to gain insights into the recharge mechanisms, flow patterns, aquifer characteristics, and vulnerability to contamination in Ambala District. These findings will contribute to the development of targeted strategies for groundwater management and conservation, with the goal of ensuring the long-term availability and sustainability of water resources in the district.



Map. 1 Study Area

III. METHODOLOGY

Methodology for Groundwater Behavior Analysis:

- **Data Collection:** Collect hydrogeological parameters, including aquifer properties, lithology, and soil types.
- **Gather groundwater** level measurements from monitoring wells across the study area.
- **Acquire land use/land cover data** to understand the influence of surface features on groundwater behavior.
- **Data Preparation**: Organize and compile collected data in a suitable format for GIS analysis.
- Perform data cleaning and quality control procedures to ensure accuracy and consistency.
- **GIS Data Integration**: Integrate the collected datasets within a GIS software platform.
- .**Spatial Analysis**: Conduct spatial analysis to identify spatial patterns and relationships related to groundwater behavior.
- **Perform thematic** layer overlay to determine areas of high groundwater recharge potential.
- **Analyze groundwater** flow direction and convergence/divergence areas using hydrogeological parameters and elevation data.
- **Assess groundwater vulnerability** to contamination by overlaying land use/land cover and hydrogeological data.
- Temporal Analysis:
- **Analyze historical groundwater level** data to identify trends, seasonal variations, and long-term fluctuations.
- **Utilize GIS-based time-series** analysis techniques to detect patterns and changes in groundwater levels over time.
- **Results Interpretation:**

IV. DEPTH TO WATER LEVEL IN 2014

In the study area, during the pre-monsoon season, the Depth to Water Level (DTWL) ranged between 0.74 to 8.71 meters below ground level (mbgl) Table.1 and Map 2, 3 and 4 Showing The water level in the western part (Ambala City) of the study area is relatively shallow. As we move from the western to the eastern part of the study area, a decline in water level can be observed. During the post-monsoon season, the DTWL ranged between 0.54 to 7.27 mbgl. In the northern part of the study area, the depth ranges between 3-6 mbgl, whereas in the eastern and southern parts, DTWL ranges between 3.0 to 7.5 In the western part of the study area, the depth to water level is very shallow, and waterlogging conditions exist, likely due to the low-lying topography and less withdrawal from the shallow aquifer. Moreover, a larger area in the western part (Ambala City) falls under the shallow water level category. Meanwhile, there is a rise in water level in the northern (Ambala Cantonment), northwest, eastern, and overall study area, clearly indicating recharge due to the monsoon. Upon reviewing the DTWL map, it is evident that areas with shallow water levels of less than 1 meter occur mainly in Ambala City, and shallow water levels also exist in Ambala Cantonment. There is an increase in water levels ranging from 0.20 to 2.02 mbgl during the post-monsoon season, primarily due to recharge from monsoon rainfall.

Table.1 Depth to Water Level Pre, Post & Seasonal fluctuation Monsoon.

Block	**Depth to Water Level 2014(mbgl)**		**Seasonal Fluctuation (m)**
Name	Pre Monsoon	Post Monsoon	
Nasir Pur P/T	1.2	0.8	0.4
Balana	0.76	0.4	0.36
Aima	3.37	1.63	1.74
Bhuragn Pur	4.58	3.08	1.5
Pinjola	3.82	2.08	1.74
Khana Majra	2.95	1.5	1.45
Baknaur	9.21	5.71	3.5
Chur Mastpur	8.21	3.99	4.22
Hassanpur	6.51	6.01	0.5
Chhapra	10.67	7.45	3.22
Jansui	3.5	1.48	2.02

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Ugara	7.12	3.8	3.32
Tharwa	3.64	2.52	1.12
Bichpari	11.96	7.8	4.16
Tejan	4.48	2.98	1.5
Behbal Pur	1.95	1.15	0.8
Dukheri	3.1	2.46	0.64
Mohra	3.6	1.66	1.94
Shahpur	10.67	8.82	1.85
Ambala City	1.09	0.54	0.55
Kalu Mazra	3.9	2.4	1.5

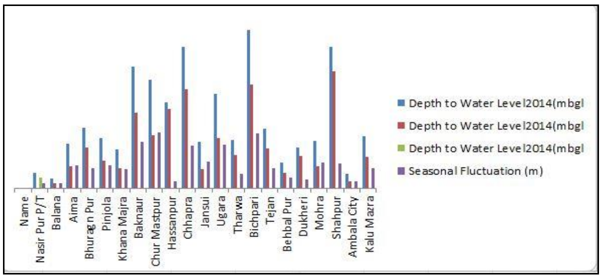
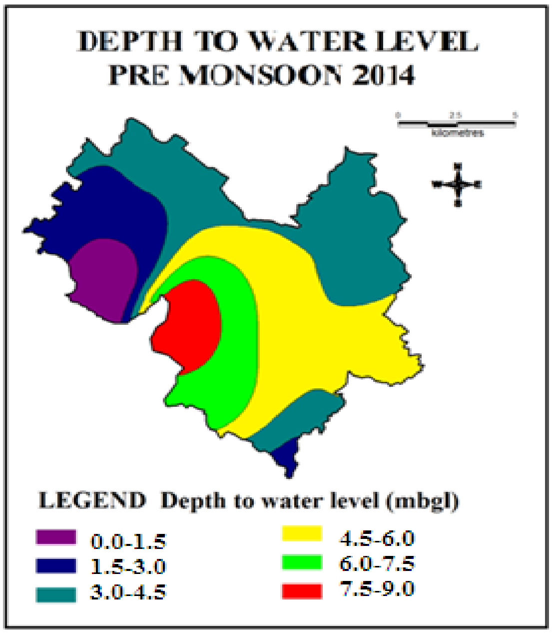
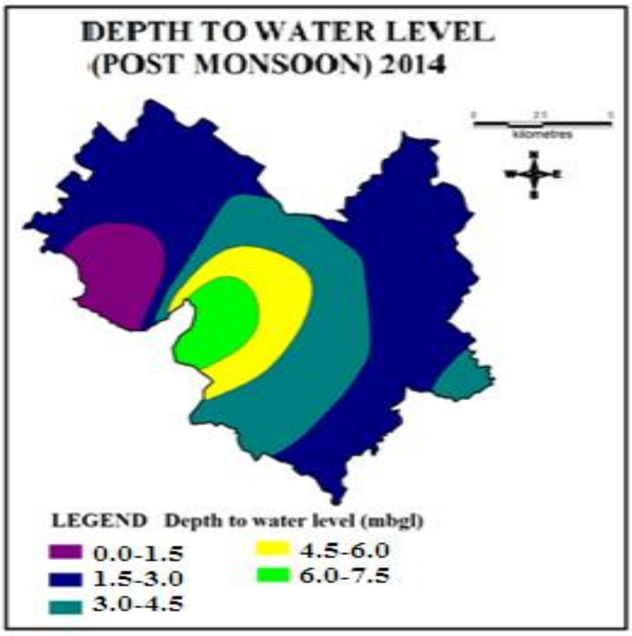


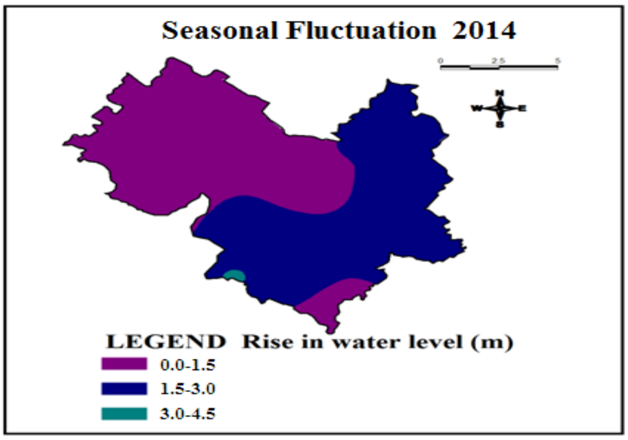
Chart. 1 Depth to Water Level Pre, Post & Seasonal Fluctuation Monsoon



Map. 2: Depth to Water Level (Pre Monsoon)



Map. 3: Depth to Water Level (Post Monsoon)



Map. 4 Seasonal Fluctuation Map

V. WATER LEVEL FLUCTUATIONS

A. Groundwater Elevation map of the study area during May 2014 and November

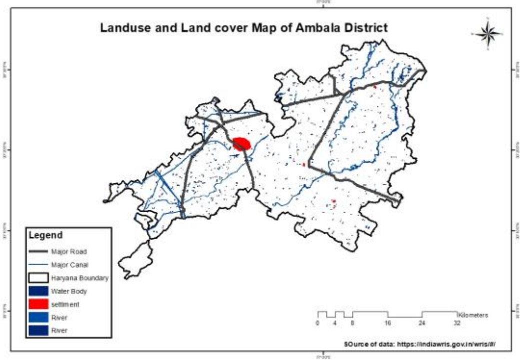
The findings from the analysis of depth to water level and water table elevation maps suggest that in the study area the flow of water is from north east to south west. Both the Ambala City and Ambala Cantonment falls under water logged and potential water logging category. Although depth to water level is more in Ambala Cantonment, this may be due to more extraction of groundwater due to presence of large number of tube wells and a better water quality.

- The problem of water logging and salinity exist in the study area especially in and around City which is due to its low lying topography. This topography is major cause of quality deterioration also. This condition becomes more aggravated during monsoon season when flood conditions observed which creates hostile conditions of living to the local population. This provides an ideal breeding ground for mosquitoes and various other harmful insects.
- Most of the water supply tube wells in the study area are tapping either second group or third group of aquifers and owing to presence of comparatively fine sand, most of the tube wells are not successful and within short period of time either silting or sand pumping has been observed in these tube wells.
- Few observation wells in the study area have shown declining trend (Ugra -2.5m/ year, Ambala Cantonment -0.22 m/year, Bara Khuda 0.20 m/year) which is due to the construction of large number of tube wells in haphazard manner which may cause various problems in near future.
- More installation of pumps to fetch more water will result into more power consumption
- More deepening of bore wells leading to more extraction from deeper aquifers resulting in over exploitation of groundwater resources. Apart from agricultural land, Ambala District may also include various other land use and land cover categories, such as:

B. Land use Land Cover of Ambala District

Map .5 showing the landuse land cover parameters**.**

- Urban Areas: Ambala City, Ambala Cantonment, and other urban settlements within the district are characterized by residential, commercial, industrial, and institutional land uses.
- Forests and Vegetation: Forested areas and natural vegetation can be found in certain parts of the district, including protected forest reserves and green belts.
- Water Bodies: Ambala District may have rivers, canals, ponds, and reservoirs that contribute to the water resources and play a role in the district's land cover.
- Transportation Infrastructure: Land dedicated to transportation infrastructure such as roads, highways, railways, and airports.
- Barren or Wasteland: Some areas in Ambala District may have barren or uncultivated land with limited vegetation cover.
- It's important to note that the actual land use and land cover patterns can vary over time due to factors such as urbanization, agricultural practices, and environmental changes. For detailed and up-to-date information on land use and land cover in Ambala District, it is recommended to consult official reports, land use maps, or contact the relevant government agencies responsible for land management and planning in Haryana.



Map. 5 Land use and Land Cover Map of Ambala District

VI. CONCLUSION

Above study suggests that the due to the increase in population, more water demanding crops, there is a possibility of increase in groundwater extraction and further lowering of water table. The gradual increase in settlement area, industries, roads and other infrastructure facilities will lead to less groundwater recharge. Adopting rainwater harvesting, growing less water demanding crops and planned urbanization will lead o sustainable development in the study area.

DECLARATION STATEMENT

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Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article

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