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Availability and Use of Groundwater in the Northern Districts, Haryana

Surriender
Research Scholar,
Department of Geography
Baba Mastnath University
Rohtak
Email ID: surenderberwal385@gmail.com

Dr Attar Singh
Professor,
Department of Geography
Baba Mastnath University
Rohtak

Abstract

The northern districts of Haryana, situated in the arid and semi-arid regions of north India, heavily rely on groundwater as a primary source for meeting agricultural, industrial, and domestic water demands. This study aims to provide an in-depth analysis of the availability and utilization of groundwater in the northern districts, shedding light on the socio-economic and environmental implications of its extraction. Additionally, the study investigates the spatial and temporal variations in groundwater levels to understand the dynamics of the groundwater systems. Furthermore, the research delves into the patterns of groundwater use in different sectors, emphasizing agricultural practices as the primary consumer. The assessment includes an examination of water-use efficiency, cropping patterns, and the adoption of water-saving technologies in agriculture. The socio-economic aspect explores the impact of groundwater availability on local communities, addressing issues such as access to water resources, livelihoods, and rural development. Environmental implications are a crucial aspect of this study, encompassing the assessment of groundwater quality, land subsidence, and ecological impacts associated with excessive groundwater extraction. The study also evaluates the role of government policies and regulations in managing and sustaining groundwater resources in the region. The findings of this research are expected to contribute valuable insights for policymakers, water resource managers, and local communities in formulating sustainable water management strategies. Understanding the complex interplay between groundwater availability, utilization, and socio-environmental factors is essential for ensuring the long-term resilience of the Northern Districts in Haryana amid growing water scarcity challenges.

Keywords: Groundwater availability, Groundwater extraction, Water scarcity, Haryana

Introduction

Groundwater availability refers to the presence and accessibility of water stored beneath the Earth's surface within saturated zones of soil and rock, known as groundwaters. This water source plays a crucial role in supporting various human activities, including agriculture, industry, and domestic use. The assessment of groundwater availability involves understanding the quantity, quality, and sustainability of the groundwater resources in a particular region (Dangar et al., 2021).

The water table is the level at which the ground is saturated with water. It represents the boundary between the unsaturated zone, where the soil and rock contain some air along with water, and the saturated zone, where the spaces between particles or fractures in rocks are filled with water. The depth of the water table can vary depending on factors such as precipitation, groundwater recharge, and extraction (Chandra et al., 2015).

Water scarcity is a condition that arises when the demand for water exceeds the available supply or when water is not accessible in sufficient quantity or quality to meet basic human needs. It is a complex and multifaceted issue influenced by various factors, including population growth, climate change, inefficient water use, pollution, and inadequate water management practices. Water scarcity can manifest at local, regional, or global levels and poses significant challenges to social, economic, and environmental sustainability (Saleth, 2011).Economic water scarcity occurs when a region lacks the necessary infrastructure and financial resources to access, distribute, and treat available water sources effectively. This can hinder economic development and exacerbate poverty (Kumar, R. 2019). Poor water management practices, wasteful water use in agriculture, industry, and households, and the lack of water-saving technologies contribute to water scarcity. Improving water use efficiency is crucial for sustainable water management (Dhawan,2017). Excessive pumping of groundwater beyond its replenishment rate can lead to the depletion of groundwaters, contributing to water scarcity issues, particularly in areas heavily reliant on groundwater.Water scarcity can lead to social tensions and conflicts, particularly in regions where competition for limited water resources is high. It can also impact human health, food security, and overall well-being (Sharma et al., 2021).

Objectives

i. To evaluate the spatial and temporal variations in groundwater levels across the selected Northern Districts of Haryana.
ii. To characterize groundwater systems, including their types, properties, and vulnerability to contamination.
iii. To determine the overall availability of groundwater resources in the study areas.

Database and Methodology

The data used in this study originates from secondary sources. Statistical Abstract of Haryana, Department of Economic and Statistical Analysis, Government of Haryana, Chandigarh, provided data on ground water and net irrigated area at the state and district levels in Haryana for the purposes of this study.

The pertaining data related to Net Annual Ground Water Availability (hams), Groundwater Draft for Irrigation (hams), Draft used for Irrigation, (In %, Availability for Future Irrigation (ham), and Stage of Development (In %) calculated for the year 2019-20. The obtained data are compiled and tabulated in m s excel. The thematic maps of Net Annual Ground Water Availability (hams), Groundwater Draft for Irrigation (hams), Draft used for Irrigation, (In %, Availability for Future Irrigation (ham), and Stage of Development (In %) of northern Haryana’s districts are prepared in ArcGis software. The data used in this study originates from secondary sources. For the meaningful conclusions of data, a number of statistical tools have been used at different stages of the analysis in this study. The statistical methods used are as follows.

i. Growth rate has been calculated in two ways.

The average annual growth rate has been computed by computing the simple growth rate by the formula: -

$$R = (X_2 – X_1) / X_1$$

Whereas,

R is annual growth rate of a chosen variable

X_1 is the value of the variable during earlier period

X_2 is the value of the variable during the later period

ii. To find out the Extent of Irrigation following formula is used:

$$\text{Extent of Irrigation} = \frac{\textbf{\textit{Net Irrigated Area}}}{\textbf{\textit{Net Sown Area}}} x100$$

iii. To find out the Irrigation Intensity following formula is used:

$$\text{Irrigation} = \frac{\textbf{\textit{Gross Irrigated Area}}}{\textbf{\textit{Net Sown Area}}} x100$$

iv. To find out the Cropping Intensity following formula is used:

$$\text{Extent of Irrigation} = \frac{\textbf{\textit{Gross Cropped Area}}}{\textbf{\textit{Net Sown Area}}} x100$$

v. To find out the Stage of Groundwater Development following formula is used:

$$\text{Stage of Groundwater Development (\%)} = \frac{\textbf{\textit{Existing Gross Draft for all uses}}}{\textbf{\textit{Net annual availability}}} x100$$

Result and Discussion

An essential natural resource, groundwater is needed to supply water for many uses, such as drinking, irrigation, industrial activities, and environmental support.

The availability and utilisation of it might differ greatly according on factors such as climate, location, hydrogeology, and human activity. An outline of groundwater availability and utilisation is shown below: Karnal district, with 71,946 hams, has the largest ground water availability in the northern Haryana, followed by Ambala (56,306), Kaithal (53,507), and Kurukshetra (51,699 hams) (Table 1).

Groundwater characteristics, rainfall patterns, and geological formations are some of the elements that affect groundwater availability, which varies by area. While groundwater resources may be plentiful in certain places, they may be scarce in others.

Millions of people throughout the world rely on groundwater for their drinking water, particularly in rural areas and other places where access to surface water is scarce (Table 1 & Map 1). The net groundwater availability varies from 14,553 hams in the Panchkula district to 71,946 hams in the Karnal district. Some locations have significant tubewell irrigation because of the canals' gradual degradation. With the exception of Kurukshetra, every district in northern Haryana has negative groundwater availability and balances for potential irrigation usage. In agriculture, groundwater is often utilised for irrigation, which raises crop yields and food production. But relying too much on groundwater for irrigation might cause problems with sustainability in the long run.

The entire groundwater development in the northern district is 157.50 percent; yet, the districts' variety is higher. The districts with the highest groundwater development are Kurukshetra (281 percent), Kaithal (226 percent), and Yamunanagar (135 percent). The district with the least level of groundwater development is Panchkula (80 percent). Nonetheless, it is noteworthy that over 100% of the northern Haryana's six districtsfive of themreported having high groundwater development.

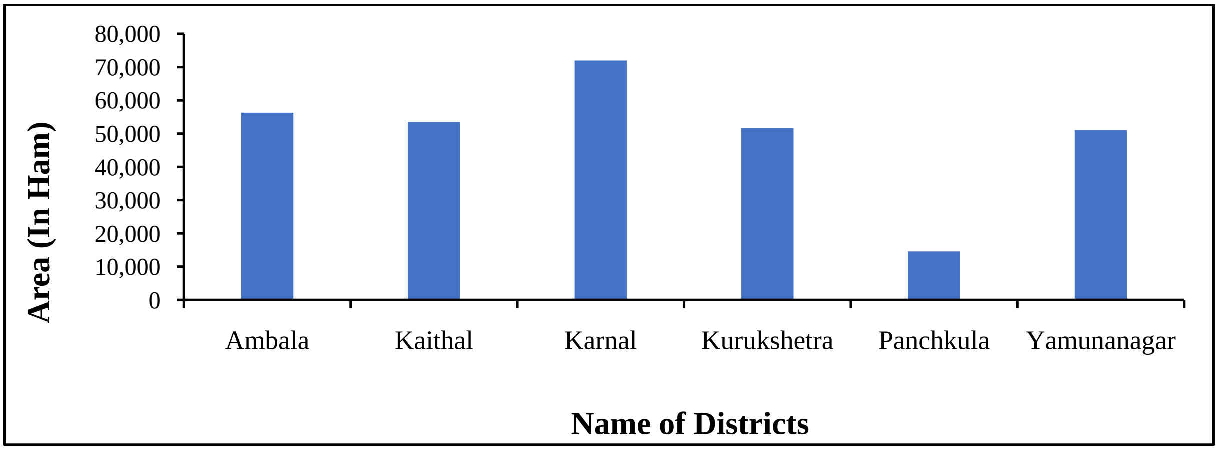
The net annual groundwater availa'ility in a number of Haryana, India, districts is shown in table 1. The supply of groundwater is essential to the long-term viability of several industries, including agriculture, which primarily depends on it for irrigation. With a net annual availability of 71,946 hams, this information shows that Karnal is a district with significant groundwater resources. This is consistent with a strong water supply that can sustain agricultural operations and other water-dependent industries. In a similar vein, Ambala and Kaithal, with 56,306 and 53,507 hams, respectively, also show notable groundwater availability, underscoring their respective reliance on groundwater for a range of purposes.

Table 1:*District-Wise Groundwater Resources Availability, Utilizations and Stage of Groundwater Development in Northern Haryana, 2020*

Sr. No.	Districts	Net Annual Ground water Availability (hams)	Groundwater Draft for Irrigation (hams)	Draft used for Irrigation (In %)	Availability for Future Irrigation (ham)	Stage of Development (In %)
1.	Ambala	56,306	49,756	86.58	1,675	102.00
2.	Panchkula	14,553	8,862	76.05	5,314	80.00
3.	Kaithal	53,507	1,14,114	94.55	-68,845	226.00
4.	Karnal	71,946	85,311	97.87	-15,120	121.00
5.	Kurukshetra	51,699	1,35,122	93.11	-94,516	281.00
6.	Yamunanagar	51,040	58,647	85.17	-14,161	135.00
Northern Haryana		**2,99,051**	**4,51,812**	**88.88**	**-1,85,653**	**157.50**

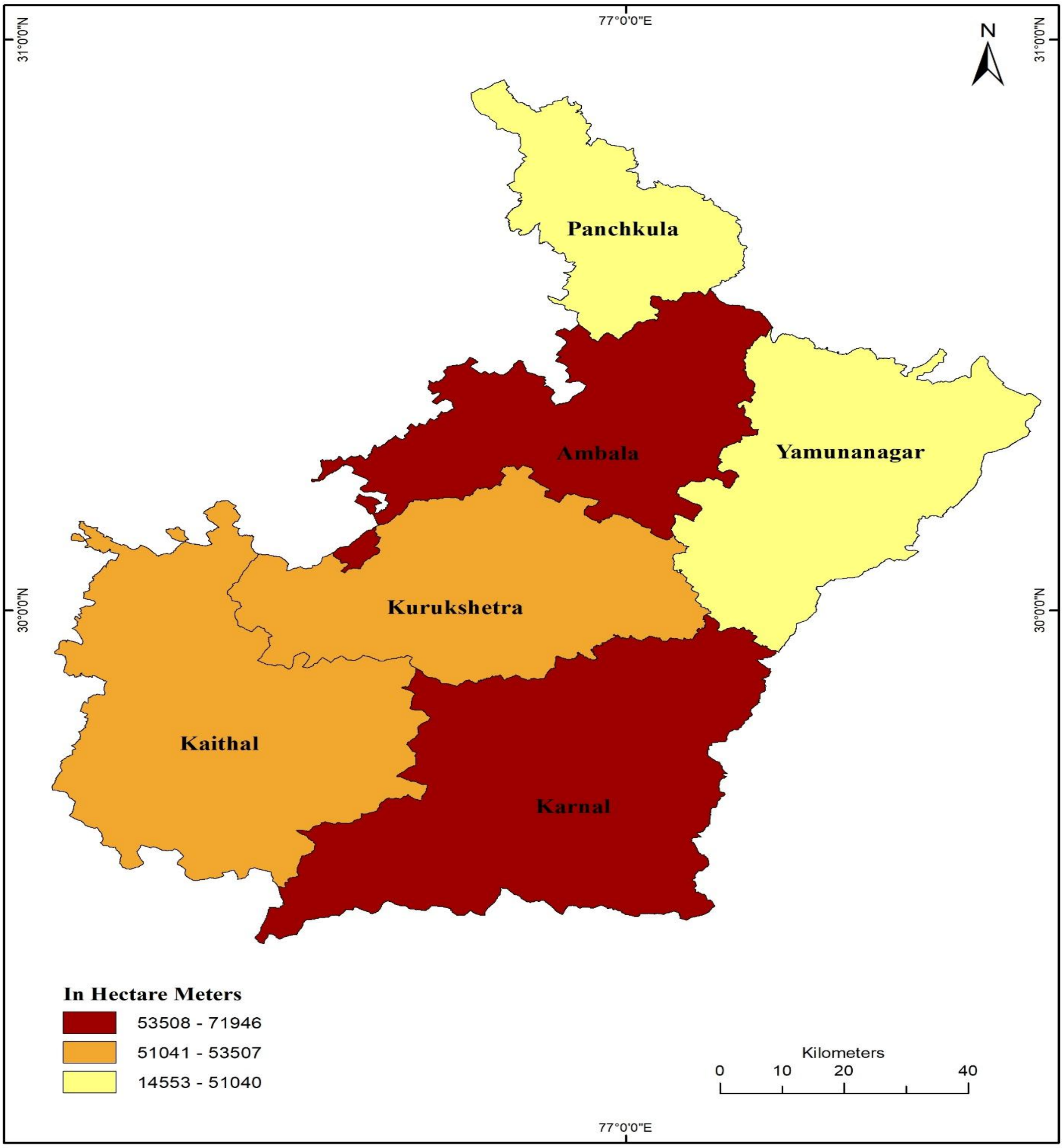
Source: Central Ground Water Board, Ministry of Water Resources, 2021

Figure 1:*Net Annual Groundwater Availability (hams)in Northern Haryana, 2020*



Source: Based on table 1

Map 1:*Net Annual Groundwater Availability in northern Haryana, 2020*



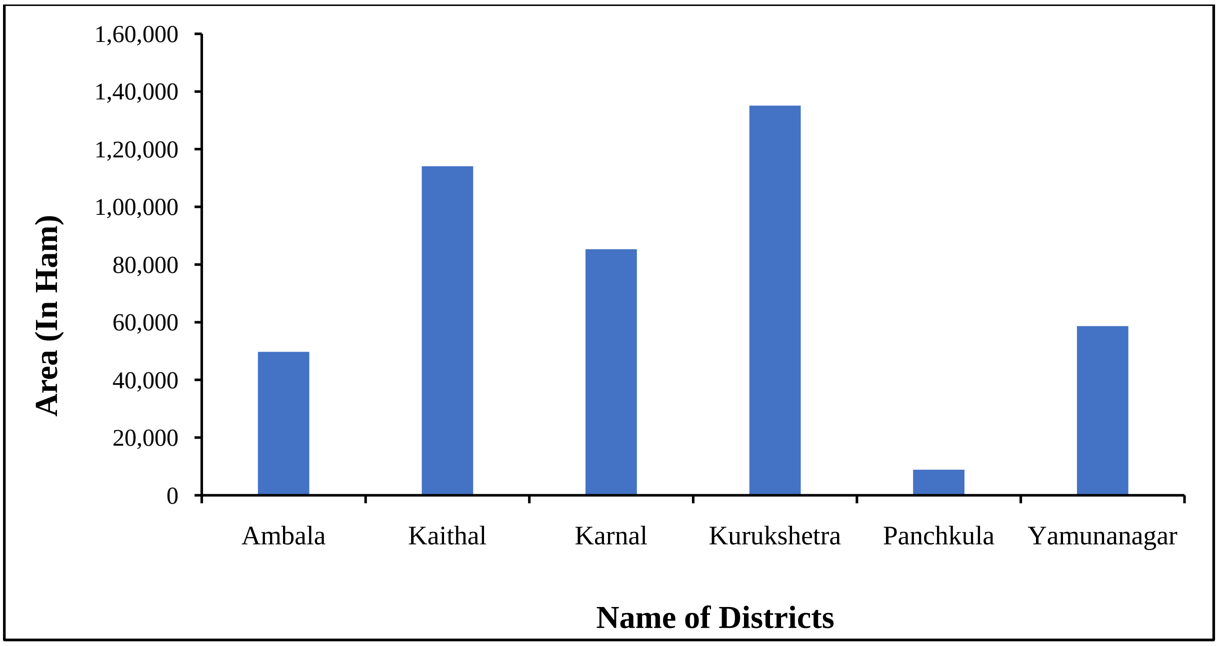
Source: Based on table 1

However, Panchkula estimates a significantly lower net annual groundwater availability of 14,553 hams, indicating that this district may face difficulties in satisfying its water demands. The geographical variations in groundwater resources are shown by this data, highlighting the necessity of district-specific water management plans to guarantee sustainable usage and conservation. With 51,040 and 51,699 hams, respectively, Yamunanagar and Kurukshetra are in an intermediate range of groundwater supply. These districts show a modest reliance on groundwater, and a balanced approach to the use of water resources has probably affected their growth and agricultural methods. In conclusion, the data offers an overview of the availability of groundwater in a few districts of Haryana and offers important information on the distribution of this essential resource. It emphasises how crucial region-specific water management strategies are to addressing variations in groundwater supply and advancing sustainable development throughout the state's many regions (Map 2).

The data presented in Table 1 illustrates the groundwater draw for irrigation across several districts in Haryana, providing valuable insights into the degree of dependence on groundwater to support agricultural practises. The districts with the largest groundwater draws are Kurukshetra and Kaithal, with significant numbers of 1,35,122 and 1,14,114 hams, respectively. These districts most likely have a heavy agricultural component, as irrigation in these areas mostly uses groundwater. The significance of sustainable water management techniques in preventing over-extraction and guaranteeing long-term water supplies is highlighted by such significant groundwater draws.

The groundwater draws for irrigation in Yamunanagar, Karnal, and Ambala is moderate, ranging from 49,756 hams to 85,311 hams. These districts find a balance between the prudent use of groundwater and the demands for agricultural water. The information indicates that although groundwater is an important resource for irrigation, these districts should also be taking steps to encourage water conservation and even looking into other water sources (Fig. 2). With 8,862 hams, Panchkula stands out for having a comparatively reduced groundwater draw for agriculture. This may point to a decreased reliance on groundwater for farming, maybe as a result of the adoption of water-saving techniques or the availability of substitute water sources. In order to make educated judgments about water resource management and guarantee that agricultural activities are sustainable and in line with the total amount of water available in each region, it is imperative to comprehend these differences in groundwater draught among districts (Map 3).

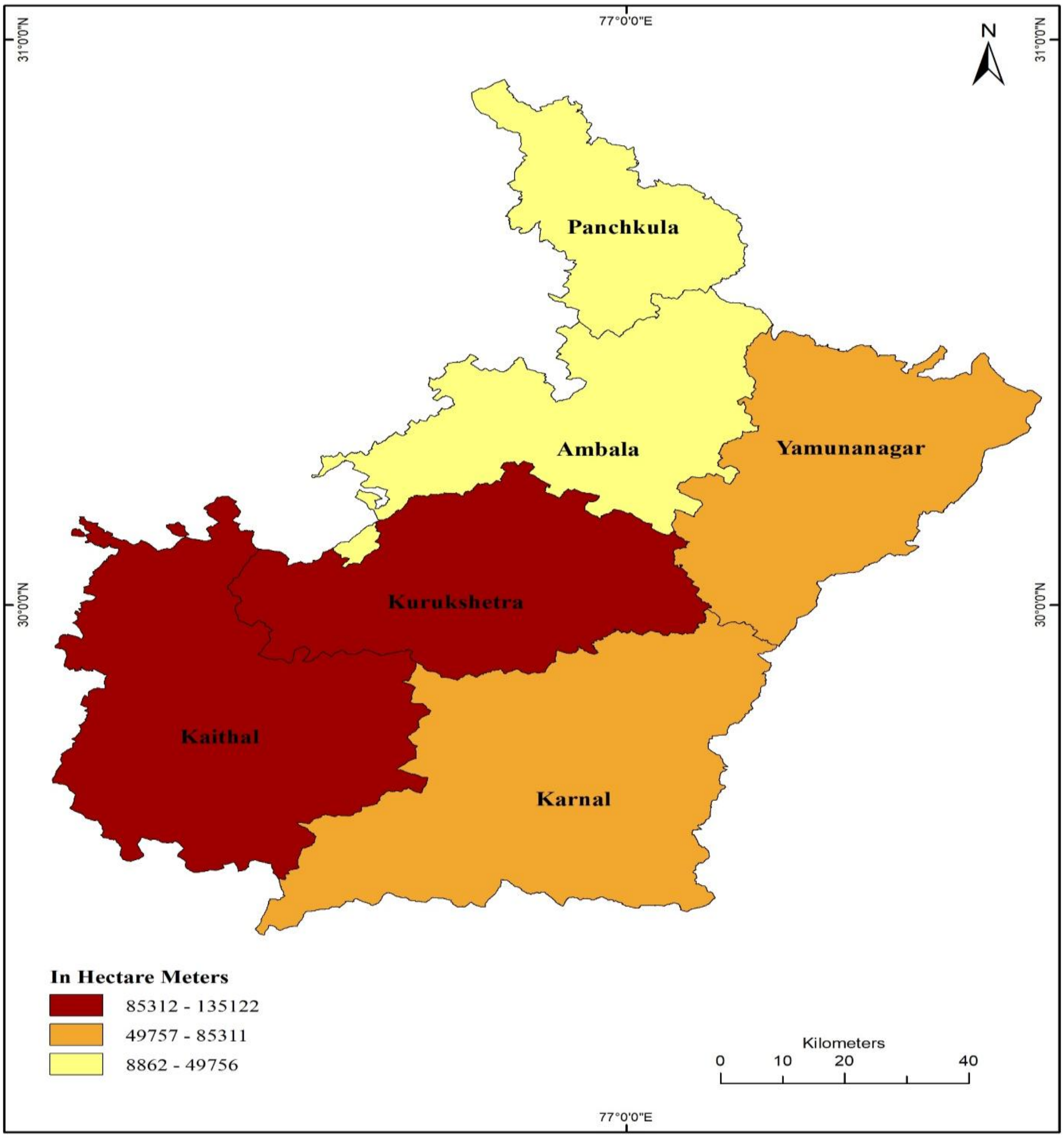
Figure 2:*Groundwater Draft for Irrigation (hams)in Northern Haryana, 2020*



Source: Based on table 1

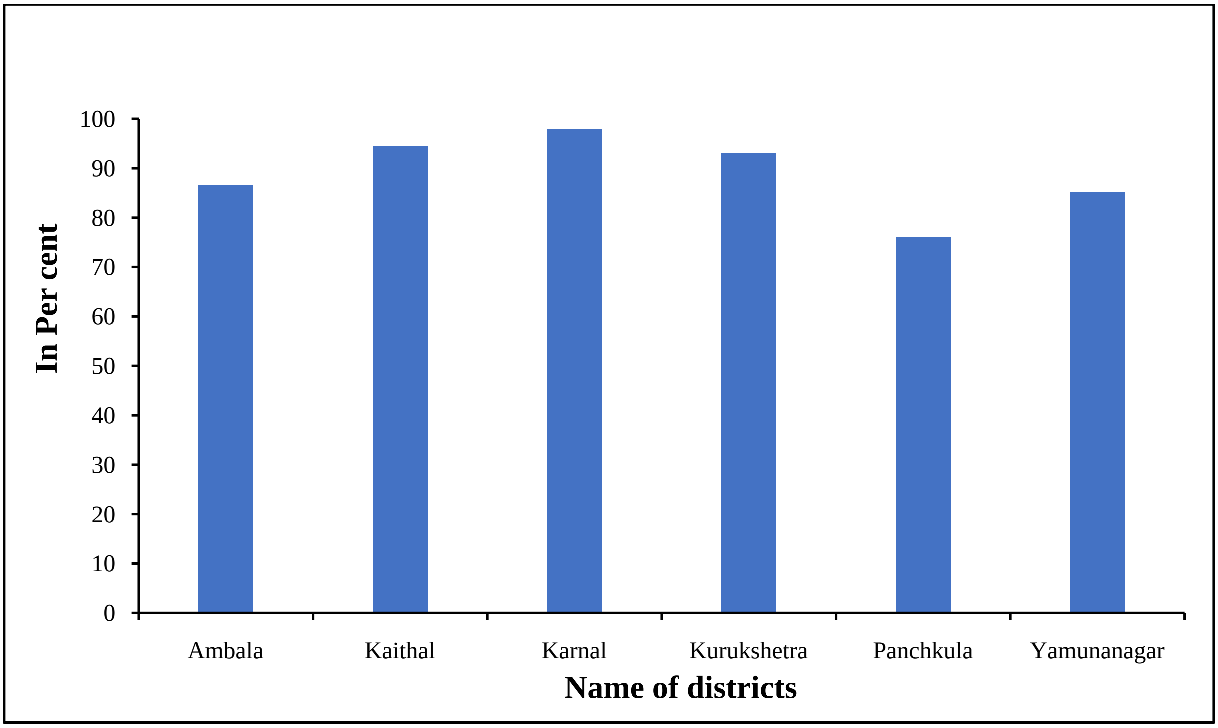
The report sheds light on the percentage of groundwater used for agriculture by showing the percentage of draw used for irrigation in different Haryana districts. Kaithal and Karnal have high percentages of 94.55 percent and 97.87 percent, respectively, of draught utilised for irrigation. These numbers show that a significant portion of agricultural water demands are met by groundwater. It suggests that these areas use a sizable amount of the groundwater that is accessible for irrigation, underscoring the significance of sustainable water management techniques. Yamunanagar and Kurukshetra, with values of 85.17 percent and 93.11 percent, respectively, indicate moderate to high percentages of draught used for irrigation. These districts achieve a balance between the need for groundwater utilisation and agricultural water demand. The information points to groundwater as a major factor in these regions' irrigation strategies.The percentages of draught utilised for irrigation in Ambala and Panchkula, at 86.58 percent and 76.05 percent, respectively, are modest. Although these numbers indicate a significant reliance on groundwater for farming, they also point to a more cautious approach when compared to areas with greater percentages. It can mean that there are other water sources available or that there is a stronger emphasis on using water efficiently. Determining the proportion of draught utilised for irrigation is essential for evaluating the long-term viability of groundwater usage in agriculture.

Map 2:*Groundwater Draft for Irrigation (hams) in northern Haryana, 2020*



Source: Based on table 1

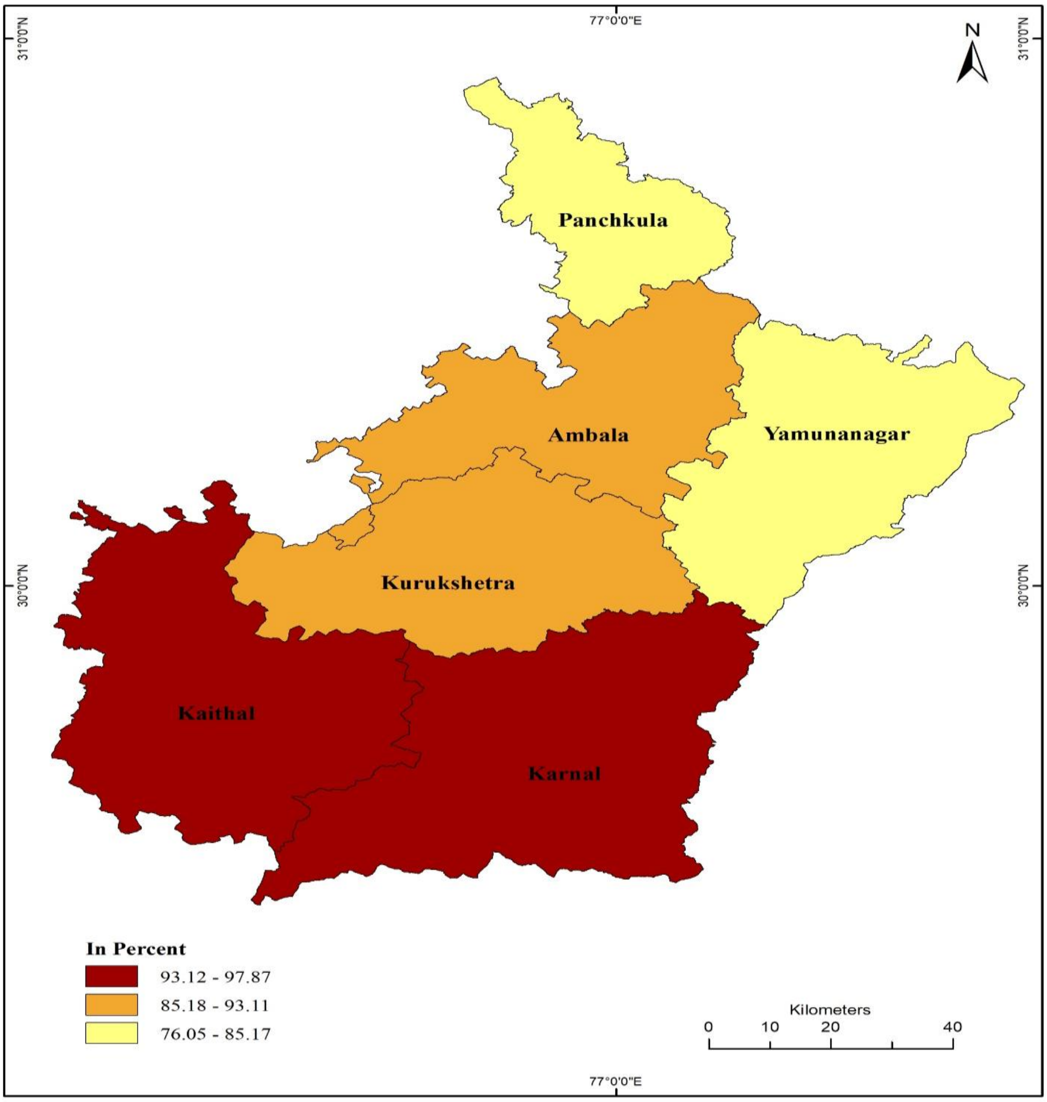
Figure 3: *Groundwater Draft for Irrigation (hams) in Northern Haryana, 2020*



Source: Based on table 1

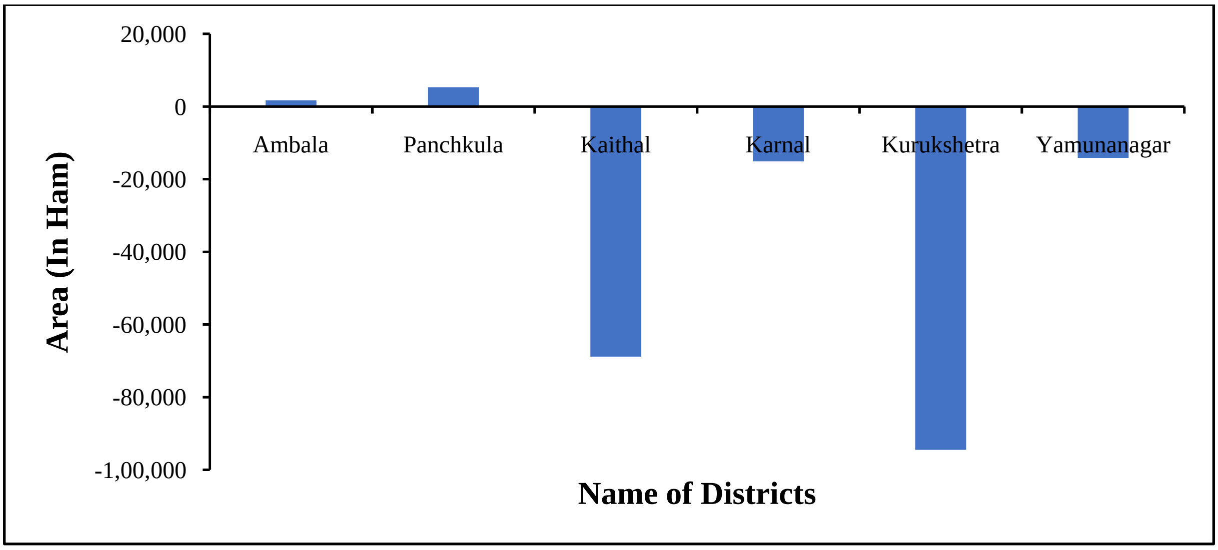
Elevated proportions might potentially give rise to worries over excessive extraction and depletion of groundwater, whilst moderate percentages indicate a more equitable strategy. In areas with greater draught usage percentages, policymakers and managers of water resources can utilise this data to promote water conservation practises and adopt focused programmes for responsible groundwater use (Map 3). Table 1 presents data on the potential for irrigation in the future in several districts of Haryana, expressed in terms of "ham" (presumably a unit of water availability). The numbers show if groundwater supply is sufficient or insufficient for anticipated future irrigation demands. Ambala and Panchkula indicate 1,675 and 5,314 ham, respectively, as favourable available for irrigation in the future. These positive numbers point to a possible groundwater surplus that these areas may be able to use for irrigation demands in the future, supporting sustainable water management techniques. The negative availability for future irrigation in Kaithal, Karnal, and Yamunanagar suggests possible difficulties or shortages in groundwater supplies to satisfy future irrigation demands. In contrast to Karnal and Yamunanagar, which show deficits of -15,120 and -14,161 ham, respectively, Kaithal has a significant deficit of -68,845 ham. In order to solve the problems associated with water shortage in these regions, negative values emphasise the significance of prudent water management techniques and possible remedies. Kurukshetra, with a shortfall of -94,516 ham, forecasts the most negative availability for irrigation in the future.

Map 3:*Ground WaterDraft used for Irrigation in northern Haryana, 2020*



Source: Based on table 1

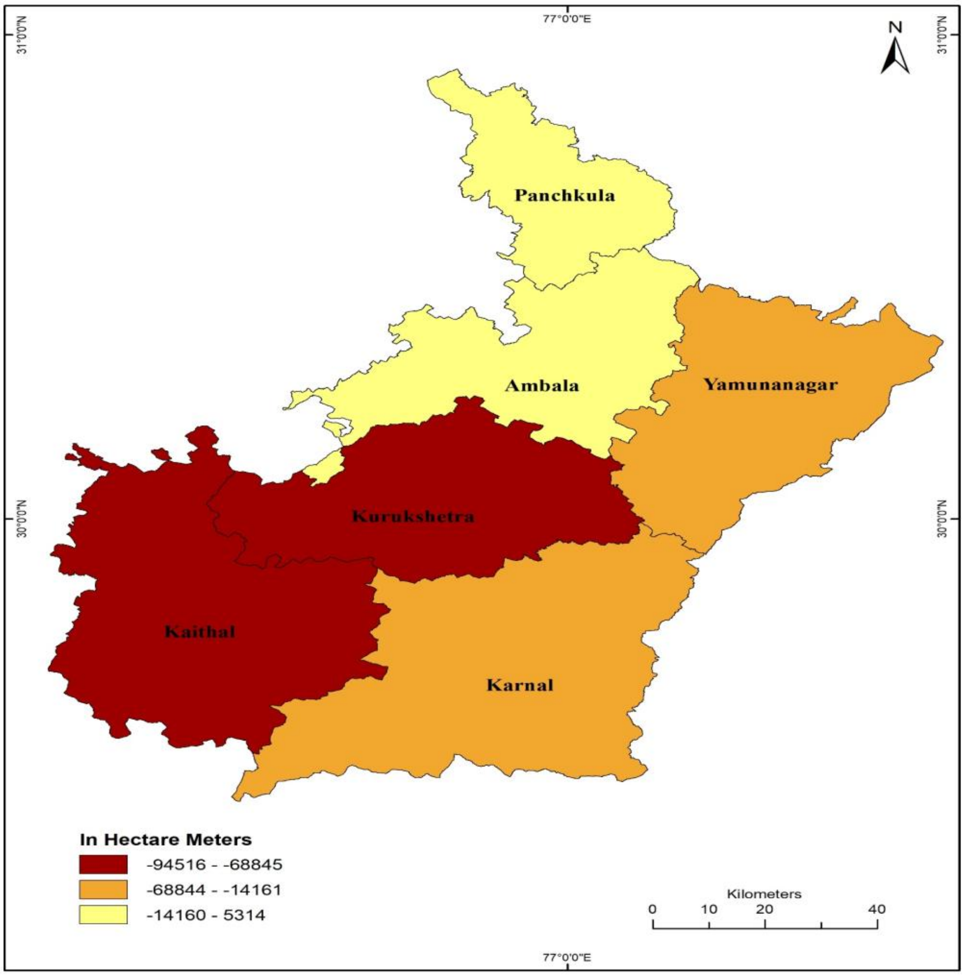
Figure 4: *Availability for Future Irrigation (ham)in Northern Haryana, 2020*



Source: Based on table 1

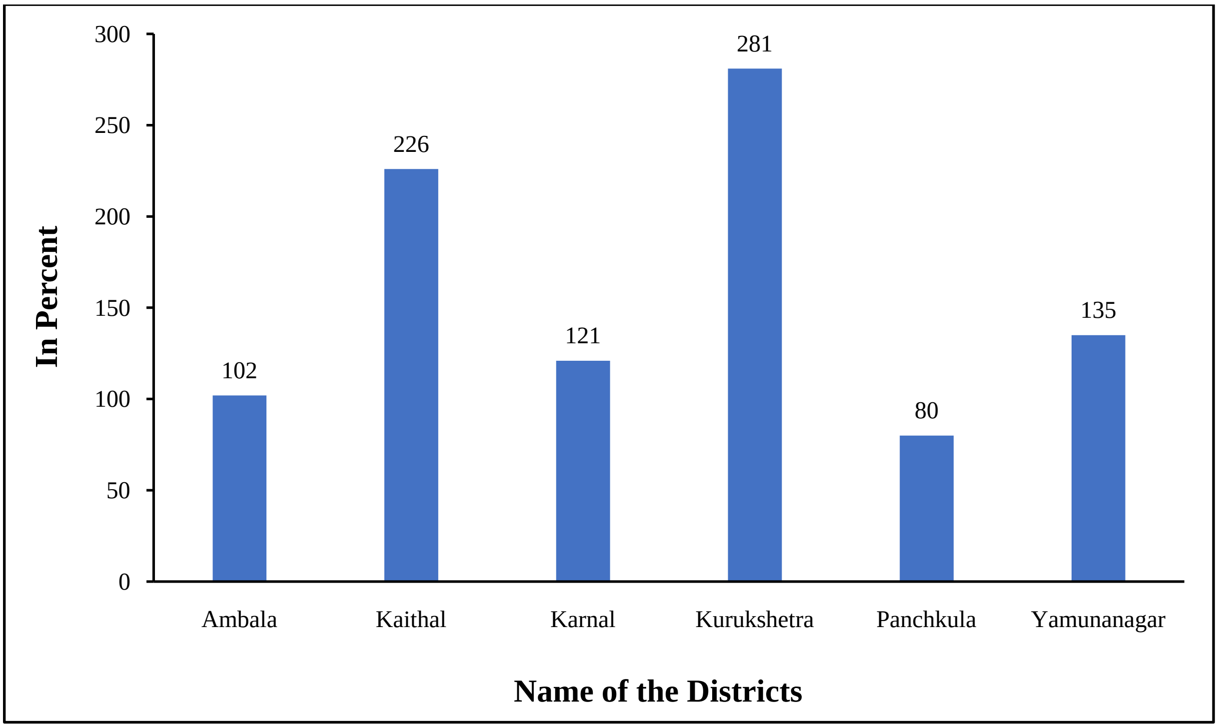
This shows that there is a significant deficiency in groundwater resources for anticipated future irrigation demands, underscoring the urgent necessity of proactive water management and conservation efforts in this region. Kurukshetra is notable for having the greatest proportion of development (281%) of any city. This shows a very high degree of growth in a number of areas, such as social indices, economic activity, and infrastructure. The large proportion points to a prosperous and well-established district. According to Kaithal, he is at a 226 percent developmental stage, which is a significant amount of advancement. The development stage of Yamunanagar is 135 percent, which indicates a moderate to high degree of overall development in these districts. According to Karnal, development is at 121 percent, which indicates a moderate stage of development. This shows some development, but not as much as in districts with larger percentages. The percentages of development in Ambala and Panchkula are reported at 102% and 80%, respectively. Based on these statistics, it appears that these districts have a modest level of overall development. Although progress is being made, it might not be as noticeable as in areas where the proportion is larger. The different levels of development in each of Haryana's districts are shown in table 1.

Map 4:*Ground Availability for Future Irrigation (ham) in northern Haryana, 2020*



Source: Based on table 4.1

Figure 5:*Groundwater Stage of Development in Northern Haryana, 2020*

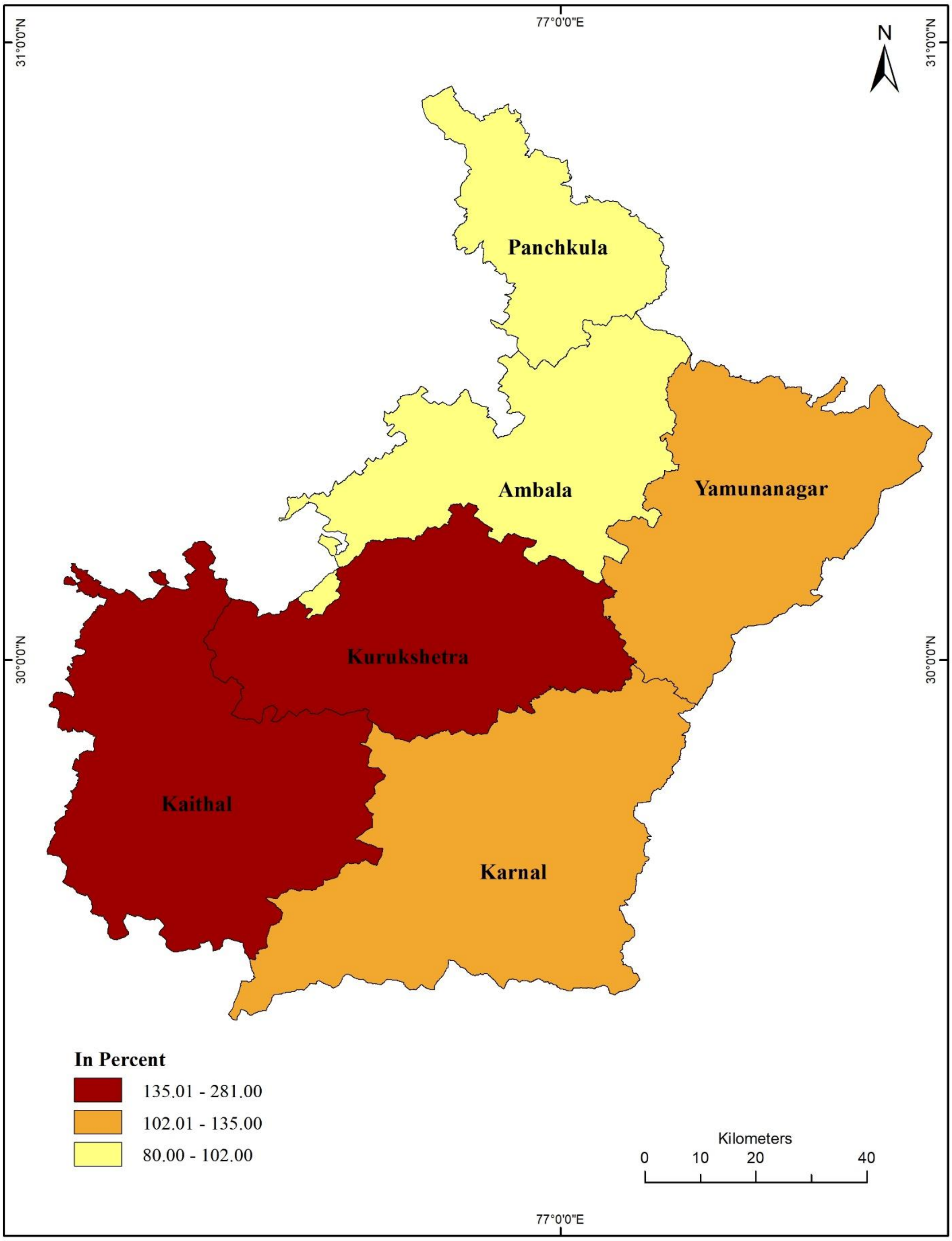


Source: Based on table 1

Lower percentages indicate locations that would need focused development efforts, while higher percentages indicate more advanced development. It is crucial that local government officials and policymakers use this data for strategic planning and well-informed decision-making to meet the unique development needs of each district.

In the Karnal area of northern Haryana, which heavily relies on groundwater irrigation, more than 97.87 percent of the groundwater draw is used for irrigation. The districts of Karnal (97.87 percent), Kaithal (94.55 percent), Kurukshetra (93.11%), Ambala (86.58 percent), Yamunanagar (85.17 percent), and Panchkula (76.05 percent) had the highest proportion of groundwater used for irrigation (Map 5). The conclusions that follow suggest that a generalised dependence on groundwater irrigation has led to a generalised development of groundwater to the extent that groundwater demand has exceeded net groundwater availability, hence reducing groundwater availability for future irrigation. Stated differently, the escalation of tubewell irrigation has raised the potential for unsustainable irrigation practises due to the over utilisation of groundwater resources, hence implicating groundwater mining. Land subsidence, saltwater intrusion in coastal areas, and groundwater depletion can result from excessive groundwater pumping, which is frequently caused by rising water needs.

Map 4.15: *Stage of Ground Water Development in northern Haryana, 2020*



Source: Based on table 1

Pollutants including industrial chemicals, fertilisers, and untreated wastewater can contaminate groundwater, rendering it unfit for drinking and other uses. Groundwater recharge rates may be impacted by altered precipitation patterns and increased evaporation brought on by climate change, which might exacerbate problems with water scarcity (Map 5).

To provide sustainable access, groundwater usage must be properly managed and regulated. Groundwater usage is governed by licences and laws in many locations in order to prevent overuse and safeguard the resource. According to Map 5, one-third of the northern Haryana districts have extremely high groundwater recharge rates. In the northern part of Haryana, districts like Yamunanagar and Karnal get a modest amount of groundwater recharge. The lowest rates of ground water recharge are found in Ambala and Panchkula, where values range from 80.00 to 1021.00. An essential resource for supplying many demands of the environment and of humans alike is groundwater. Its availability and sustainable usage depend on careful management, conservation initiatives, and a thorough comprehension of the hydrogeological conditions in the area (Map 5).

Conclusion

The present study aimed tostudy a comprehensive overview of the current status of groundwater availability and its utilization for irrigation in the northern districts of Haryana. Ambala, Panchkula, Kaithal, Karnal, Kurukshetra, and Yamunanagar collectively contribute to the groundwater resources in the region. The table reveals substantial groundwater draft for irrigation across the districts, with Ambala, Kaithal, Karnal, Kurukshetra, and Yamunanagar exhibiting varying degrees of extraction.The percentage of groundwater draft used for irrigation provides insights into the efficiency of water use. Districts like Karnal and Panchkula show high percentages, indicating intensive utilization.Kaithal, despite having a significant draft for irrigation, shows a negative availability for future irrigation, highlighting potential challenges in sustaining current extraction rates. The stage of development, expressed as a percentage, indicates the current level of utilization relative to the availability. Values above 100% suggest that the groundwater extraction exceeds the natural replenishment, raising concerns about long-term sustainability.Kurukshetra and Yamunanagar exhibit values significantly above 100%, signaling a critical stage of development and potential risks of over-exploitation. The overall picture for northern Haryana suggests a high level of groundwater exploitation, with a collective stage of development reaching 157.50%.

The negative availability for future irrigation underscores the need for immediate attention to ensure the sustainable management of groundwater resources in the region. In conclusion, the data underscores the importance of implementing effective water management strategies in Northern Haryana. It is imperative to strike a balance between groundwater extraction for irrigation and ensuring the long-term sustainability of this vital resource. Policymakers, local authorities, and stakeholders should collaborate to develop and implement sustainable groundwater management practices to safeguard water availability for future generations.

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