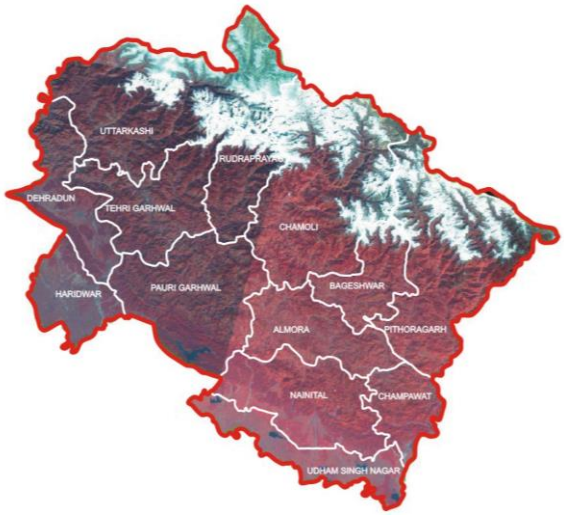
GROUND WATER YEAR BOOK

भू जल वार्षिक पुस्तिका

UTTARAKHAND

उत्तराखण्ड

2023-2024



GOVERNMENT OF INDIA

भारत सरकार

CENTRAL GROUND WATER BOARD

केंद्रीय भूमि जल बोर्ड

UTTARANCHAL REGION, DEHRADUN

उत्तरांचल क्षेत्र, देहरादून

DEPARTMENT OF WATER RESOURCES, RD & GR

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

MINISTRY OF JAL SHAKTI

जल शक्ति मंत्रालय

SEPTEMBER-2024

सितम्बर-२०२४

GROUND WATER YEAR BOOK
भू जल वार्षिक पुस्तिका
UTTARAKHAND
उत्तराखण्ड
(2023-2024)

Contributor

Ms. Anjali Kushwaha, Scientist – 'C' (Hydrogeology*)*

Under the supervision of

Sh. Prashant Rai
Regional Director

Ministry of Jal Shakti
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOMENT AND GANGA REJUVINATION
CENTRAL GROUND WATER BOARD, UTTARANCHAL REGION
GOVERNMENT OF INDIA
Dehradun
Septmeber-2024

प्रस्तावना

जल नीले ग्रह "पृथ्वी" पर जीवन को बनाए रखने के लिए आवश्यक प्राकृतिक संसाधनों में से एक है। जनसंख्या में तेजी से वृद्धि के कारण विश्व स्तर पर ताजे/उपयोग योग्य पानी की मांग में कई गुना वृद्धि हुई है, जिसके कारण कृषि पैटर्न में बदलाव और औद्योगिक गतिविधियों में वृद्धि हुई है। विभिन्न क्षेत्रों के ताजे पानी की मांग को पूरा करने के लिए भूजल संसाधनों पर भारी दबाव है क्योंकि सतही जल प्रदूषण दिन-प्रतिदिन बढ़ता जा रहा है। इसके परिणामस्वरूप देश के कई हिस्सों में जल स्तर में गिरावट आई है क्योंकि भूजल निकासी इसके भरण से आगे निकल गया है।

भूजल एक सीमित संसाधन होने के कारण इसके शासन पर कोई प्रतिकूल प्रभाव डाले बिना दीर्घकालिक आधार पर मांग को पूरा करने के लिए उचित प्रबंधन और इसके भंडारण के विवेकपूर्ण उपयोग की आवश्यकता है। इस उद्देश्य को पूरा करने के लिए, केंद्रीय भूमि जल बोर्ड देश भर में फैले भूजल निगरानी कुओं के नेटवर्क के माध्यम से भूजल शासन के व्यवहार की निगरानी करता है। प्रत्येक राज्य में ऐसे कुओं से एकत्र किए गए आंकड़ो को संकलित, संसाधित करने के पश्चात् मुख्य विशेषताओं को **"भूजल वार्षिक पुस्तिका"** के रूप में प्रकाशित किया जाता है। वर्तमान रिपोर्ट वर्ष 2023-2024 के लिए उत्तराखंड राज्य से संबंधित है। केंद्रीय भूमि जल बोर्ड, उत्तरांचल क्षेत्र, उत्तराखंड राज्य के मैदानी और पहाड़ी क्षेत्रों में 279 भूजल निगरानी कुओं के माध्यम से विभिन्न हाइड्रोजियोलॉजिकल सेटिंग के तहत भूजल संशाधन की निगरानी देहरादून, हरिद्वार, नैनीताल, उधमसिंह नगर, चंपावत, अल्मोड़ा, पौड़ी गढ़वाल और उत्तरकाशी जिले में एक वर्ष में चार बार (जनवरी, मई, अगस्त और नवंबर) कर रहा है। राज्य के पहाड़ी क्षेत्रों में 81 झरनों की भी निगरानी की जा रही है।

माप की विशिष्ट अवधि के साथ-साथ दशक के लिए उतार-चढ़ाव को दर्शाते हुए विषयगत मानचित्रों के साथ जिलेवार भूजल स्तर का विवरण प्रस्तुत किया गया है। भूजल आंकड़ो को क्षेत्रीय कार्यालय, देहरादून के डेटा स्टोरेज सेंटर में उपयुक्त प्रारूप में संग्रहीत किया गया है।

वर्तमान भूजल वार्षिक पुस्तक, 2023-2024 सुश्री अंजली कुशवाहा, वैज्ञानिक-' ग ' (हाइड्रोजियोलॉजी) के द्वारा किए गए प्रयास का परिणाम है। भूजल स्तर के आंकड़ो को फील्ड अधिकारियों के परिश्रम से संकलित किया गया है। पानी के नमूनों का विश्लेषण करने वाले रासायनिक प्रयोगशाला, केंद्रीय भूमि जल बोर्ड, उत्तरी क्षेत्र, लखनऊ के अधिकारियों का प्रयास भी उल्लेखनीय हैं। मानचित्रों के माध्यम से उत्तराखण्ड राज्य के भूजल परिदृश्य को दर्शाने तथा इस रिपोर्ट को उचित रूप देने का प्रयास अत्यंत सराहनीय है।

इस रिपोर्ट में प्रस्तुत जानकारी और डेटा उपयोगकर्ता एजेंसियों, भूजल योजनाकारों और प्रबंधकों के लिए एक डेटाबेस के रूप में काम करेगा और उत्तराखंड राज्य में भूजल विकास के मात्रात्मक और गुणात्मक पहलुओं पर क्षेत्रीय तस्वीर को समझने के लिए अत्यधिक उपयोगी होगा।

स्थान : देहरादून
दिनांक :**04.09.2024**

(प्रशांत राय)
क्षेत्रीय निदेशक

FOREWORD

WATER is one of the essential natural resources for sustaining life on blue planet "**Earth**". The demand of fresh / usable water has increased manifold globally due to rapid growth in population, which in turn caused change in agricultural pattern and increase in industrial activities. To meet the demand of fresh water of various sectors, there is an enormous stress on ground water resources as the surface water pollution is increasing day by day. This has resulted in the water level decline in many parts of the country as the output has outstripped input of this resource.

Ground water being a limited resource requires proper management and judicious use of its storage for meeting out demand on long term basis without putting any adverse impact on its regime. To meet this objective, Central Ground Water Board monitors the behaviour of ground water regime through a network of Ground Water Monitoring Wells spread across the country. The data collected from such wells in each state are compiled, processed and the salient features brought out as a "**Ground Water Year Book**". The present report pertains to the State of Uttarakhand for the year 2023-2024.

Central Ground Water Board, Uttaranchal Region is monitoring the groundwater regime under various hydrogeological setting through **279 ground water monitoring wells** in plain and hilly areas of Uttarakhand State, viz. Dehradun, Haridwar, Nainital, Udham Singh Nagar, Champawat, Almora, Pauri Garhwal and Uttarkashi districts four times in a year (January, May, August and November). In the hilly areas of the State Eighty-one springs are also being monitored.

The district wise details of ground water levels are presented along with thematic maps depicting the fluctuations for specific period of measurement as well as for the decade. The data has been stored in appropriate format in the data storage centre of the Regional Office, Dehradun.

The present Ground Water Year Book, 2023-2024 is the outcome of the effort made by Ms. Anjali Kushwaha, Scientist- 'C' (Hydrogeology). The inputs data is generated by the untiring efforts of officers in the field. The efforts in depicting the groundwater scenario of Uttarakhand State through maps and giving proper shape to this report, is highly appreciable.

The information and data presented in this report will serve as a database to the user agencies, ground water planners and managers and will be of immense use to understand the regional picture on the quantitative and qualitative aspects of ground water development in the State of Uttarakhand.

Place: Dehradun
Date : **04.09.2024**

(Prashant Rai)
Regional Director

GROUND WATER YEAR BOOK
UTTARAKHAND
(2023-2024)

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

The predominantly hilly Uttarakhand State was carved out of Uttar Pradesh in November 2000. The State comprises thirteen districts - Almora, Bageshwar, Chamoli, Champawat, Dehradun, Haridwar, Nainital, Pauri Garhwal, Pithoragarh, Tehri Garhwal, Rudraprayag, Udham Singh Nagar and Uttarkashi. The state is situated between latitude 28°43'20"N to 31°28'00"N and longitude 77°34'06"E to 81°01'31"E with a total geographical area of 53,483 km^2.

Uttarakhand State is broadly subdivided into two hydrogeomorphic units namely

1) Gangetic Alluvial Plain
2) Himalayan Mountain Belt.

Majority of area in the state falls under hilly terrain, except for Udham Singh Nagar, Haridwar and parts of Dehradun districts. Northern parts of the state remain under snow cover throughout the year. The drainage of the state is controlled by major rivers like Ganga (Gangotri) and Yamuna (Yamnotri), originating from the glaciers in high Himalayan Mountain Range and their tributaries like Ramganga, Kali, Saryu, Pindar etc. A variety of rock units ranging in age from Archean to Quaternary are exposed over the state. The rock units in the Himalayan Mountain regions have undergone repeated phases of deformation and metamorphism after their formation.

In the plain areas, ground water occurs in multi aquifer systems. Perched water bodies lying above the main water bearing formations are frequently encountered in Bhabar Zone and Doon Valley. Contrary to this, the occurrence of ground water in the hilly areas is limited to small, localized aquifers with limited ground water potential. Ground water in hilly terrains is found in the secondary porosity developed in crystalline igneous and metamorphic rocks in the form of fractures, joints and fissures. Low to moderate ground water potential exists in parts of the state where ground water is located in valley fill deposits of the alluvial plains and piedmont zones. The chemical quality of ground water is generally good and the water can be safely used for drinking, domestic and irrigation purpose.

During the period May 2023 to January 2024, ground water monitoring in the state was carried out in parts of Dehradun, Haridwar, Udham Singh Nagar, Nainital, Champawat, Pauri Garhwal, Tehri Garhwal, Almora and Uttarkashi districts. A number of dug wells, hand pumps and few piezometers, which are the part of Ground Water Monitoring Wells of Central Ground Water Board, were monitored in the plain areas of these districts during the months of May, August and November 2023 and January 2024.

The depth to water level maps and water level fluctuation maps viz. decadal, annual and seasonal water level fluctuations were generated by Arc GIS software. These maps were prepared section wise viz. Kumaon Section (Udham Singh Nagar district, Nainital District and Champawat district) and Garhwal Section (Dehradun district and Haridwar district).

To assess the behavior of ground water storage in space and time, the fluctuation in storage for each measurement has been evaluated with respect to decadal average value. A summary of depth to water level data in the State during the period May 2023 to January 2024 and the overall fluctuation pattern of ground water level (rise or decline) during the same period as compared to the long-term data (decadal average) are shown in tabular format below. Moreover, annual fluctuation of water level (for the corresponding periods of May, August, November and January) and the fluctuation pattern of ground water level during the periods August 2023, November 2023 (post monsoon) and January 2024 as compared to May 2023 (pre monsoon) are also given in separate tables.

Summary of Depth to Water Data in Uttarakhand during the Period 2023-2024

State	Range of depth to water level (m bgl)	Percentage of Wells Analyzed			
		Jan 2024	May 2023	August 2023	Nov 2023
Uttarakhand	**0–5**	36.20	15.57	41.76	36.21
	5-10	20.86	28.74	21.18	20.11
	10-15	11.04	14.97	7.65	10.34
	>15	31.90	40.72	29.41	33.33

Fluctuation of Water Level during the Period 2023-2024 (Compared to Decadal Average)

State	Fluctuation (m)	Percentage of Wells Analyzed							
		Avg. Jan		Avg. May		Avg. August		Avg. Nov	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	**0–2**	36.25	36.25	30.06	38.65	43.71	16.77	37.97	29.75
	2–4	8.75	6.88	3.68	14.72	19.76	5.39	13.92	6.33
	>4	7.50	4.38	1.23	11.66	10.18	4.19	8.23	3.80

Annual Fluctuation of Water Level during the Period 2023-2024

State	Fluctuation (m)	Percentage of wells analyzed							
		May 2022 vs. 2023		August 2022 vs. 2023		November 2022 vs. 2023		January 2023 vs. 2024	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	**0–2**	27.16	50.62	37.50	8.13	29.49	38.46	33.54	38.61
	2–4	4.32	5.56	25.63	3.13	10.26	8.33	11.39	6.33
	>4	2.47	8.64	21.25	4.38	7.69	5.77	6.33	4.43

Seasonal Fluctuation of Water Level (Compared to May 2023)

State	Fluctuation (m)	Percentage of wells analyzed					
		August 2023		November 2023		January 2024	
		Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	48.81	1.19	57.40	6.51	60.87	8.07
	2–4	32.74	0.00	18.93	0.00	18.01	1.86
	>4	15.48	0.60	16.57	0.59	10.56	0.62

A perusal of various maps viz. depth to water level maps and water level fluctuation maps reveals that in general, many areas of Doon Valley (Dehradun district), parts of Haridwar district and Tarai Zone in Udham Singh Nagar district have shown both rise and decline in water levels of various magnitudes in different temporal aspects. Fluctuation in water level is more conspicuous in the Bhabar Zone in Nainital and Champawat districts than in the relatively plain areas of Central Ganga Plains in Haridwar district and in the Tarai zone in Udham Singh Nagar district. This Bhabar zone shows high ground water level fluctuation due to steep hydraulic gradient.

CHAPTER 1
INTRODUCTION

Ground water is a very important component of Earth's natural fresh water resource. Hence, ground water regime monitoring on periodic basis becomes essential for a safe and sustainable development and management of ground water resources of the hilly state of Uttarakhand. The directly measurable and often visible physical parameter of the otherwise invisible ground water system is the ground water level. Regular and systematic monitoring of ground water levels and evaluation of chemical parameters of ground water forms the base for scientific planning, development and management programs. Scientific information about the behaviour of water level in time and space becomes an essential exercise in this perspective. Indiscriminate withdrawal of ground water in rapidly developing urban and industrial areas poses a challenge to the scientific community. The challenge can be overcome by adopting sustainable ground water development and management practices.

Uttarakhand State lies between 28°43'20" – 31°28'00" N Latitude and 77°34'06" - 81°01'31" E Longitude and has a total geographical area of 53,483 km^2. The state has been divided into two Divisions and thirteen developmental blocks. Uttarakhand has a diverse hydrogeological set up. In order to assess the impact of continuously increasing stress on the ground water regime and to categorize various hydrogeological units in the State, systematic monitoring of ground water levels and spring discharge are being carried out four times in a year by the Central Ground Water Board, Uttaranchal Region, Dehradun through the Ground Water Monitoring Stations, which included periodic measurement of Springs discharge in the hilly terrain.

As on March 2023, a total of two hundred seventy-nine ground water monitoring stations exists in Uttarakhand State, which are being monitored by the regional office four times in a year. The map showing locations of Ground Water Monitoring Wells and Springs in Dehradun, Haridwar, Nainital, Udham Singh Nagar, Champawat, Almora and Pauri Garhwal districts is shown as ***Fig. 1.***

Chemical analysis of water samples, collected from selected locations within the state once in a year during the month of May (pre-monsoon monitoring), is being carried out to check whether any significant change is taking place in groundwater quality in time and space.

The main objectives of ground water regime monitoring in Uttarakhand may be summarized as follows:

1. To study the fluctuation of water level, both spatially and temporally, in response to ground water recharge and/or discharge.
2. To evaluate changes in ground water level with respect to the preceding year for the same period.
3. To evaluate changes in ground water level with respect to a long-term average water level such as the decadal mean.
4. To study the fluctuation of water level during different seasons of the period 2023.

The district wise break up of Ground Water Monitoring Stations (including the springs in hilly terrain), which were monitored during the period from May 2023 to Jan 2024 is given in **Table 1.**

Table 1: District wise break up of active Ground Water Monitoring Stations (including Springs) monitored in Uttarakhand State

Sl. No	District	Number of Ground Water Monitoring Stations			
		Jan-24	May-23	Aug-23	Nov-23
1	Dehradun	51	53	56	53
2	Haridwar	39	42	42	41
3	Udham Singh Nagar	54	54	52	52
4	Nainital	18	18	19	19
5	Champawat	4	4	3	4
6	Pauri Garhwal	1	2	2	2
7	Bageshwar	12	0	0	12
8	Rudraprayag	7	0	0	7
9	Tehri Garhwal	12	5	5	8
10	Pithoragarh	7	0	0	0
11	Champawat	14	3	3	3
12	Chamoli	14	0	0	6
13	Almora	25	25	26	25
14	Uttarkashi	13	13	13	13
TOTAL		271	219	221	245

Apart from the dug wells, hand pumps and piezometers, a total of eighty-one springs in hilly areas of Uttarakhand were also monitored (as on March 2024). The details of these springs during the period May 2023 Jan 2024 are given in ***Table 2.***

Table 2: District wise break up of springs in Uttarakhand State

Sl. No.	District	Number of Springs			
		Jan 2024	May 2023	Aug 2023	Nov 2023
1.	Dehradun	3	3	3	3
2.	Nainital	7	7	7	7
3.	Almora	25	25	26	25
4.	Pithoragarh	4	0	0	0
5.	Champawat	6	0	0	0

6.	**Rudraprayag**	5	0	0	5
7.	**Bageshwar**	10	0	0	9
8.	**Tehri Garhwal**	7	0	0	3
9.	**Chamoli**	10	0	0	4
10.	**Uttarkashi**	4	4	4	4
TOTAL		**81**	**39**	**40**	**60**

District wise locations of the monitoring stations including springs of Uttarakhand State in given in the **figure 1**.

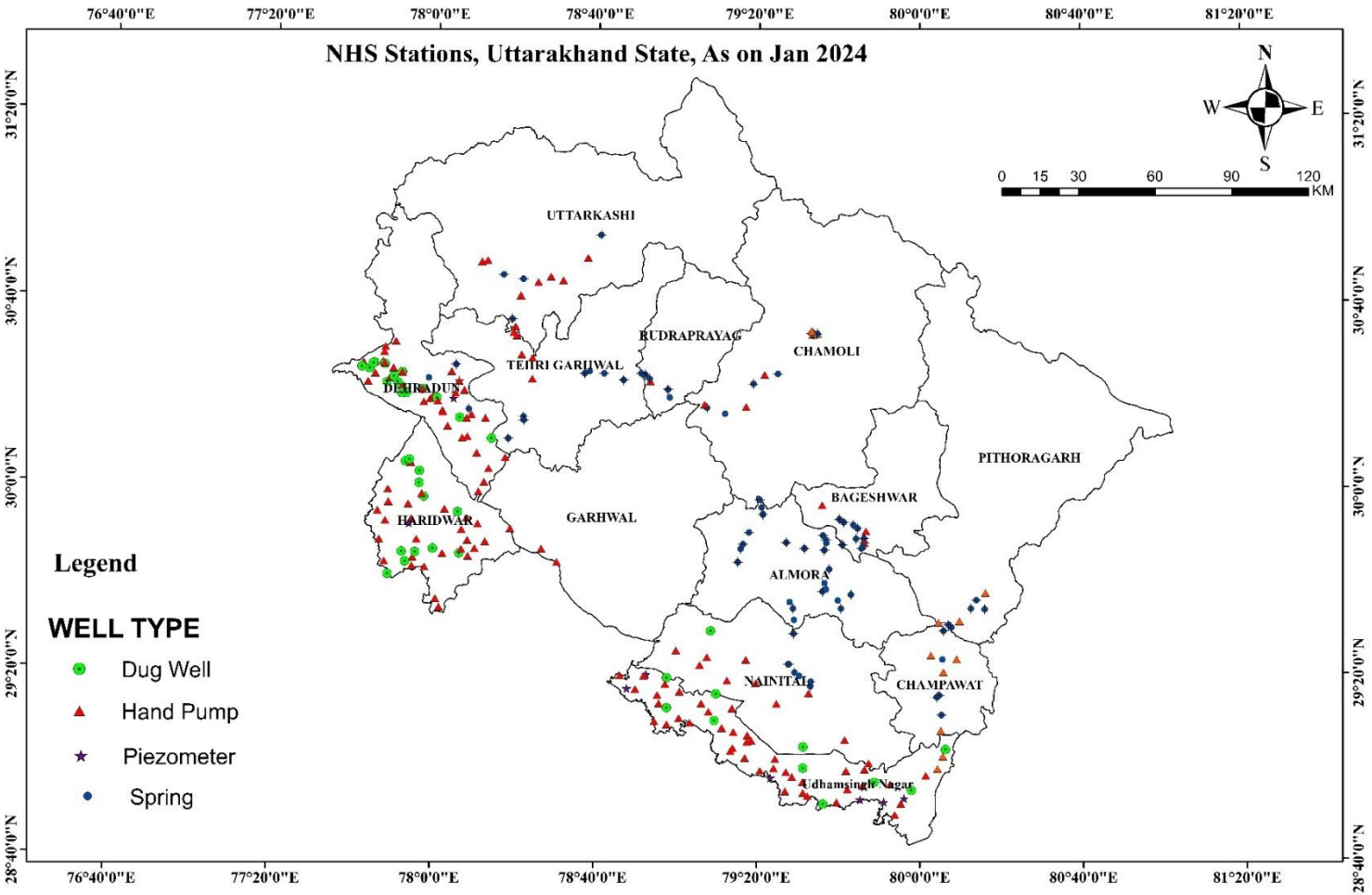


Figure 1: Location of Ground Water Monitoring Stations in Uttarakhand (As on March 2024)

CHAPTER 2
CLIMATE

The hilly parts of Uttarakhand experience cold climate and high rainfall. Significantly large part of the state remains under snow cover throughout the year. The intermontane valleys and the plain area in the southern part of the state experience a sub-tropical climate with three seasons – summer, monsoon and winter. The normal annual rainfall varies from 1182 mm in Haridwar district to 1927.30 mm in Pithoragarh district. The average annual rainfall varies from 1067.70 mm at Joshimath (Chamoli district) to 1927.30 mm at Munsyari (Pithoragarh district). Most of the rainfall occurs as monsoon rainfall during the months of July and August. The Isohyetal Map of Uttarakhand prepared using mean normal rainfall is given in **Fig. 2**. The map reveals that intensity of rainfall increases from SW to NW in a broadly linear pattern with high rainfall prevailing in both the eastern and the western parts of the state. The district wise normal monthly and annual rainfall data, available for fifty years (**1971 to 2020**) is given in **Table 3.**

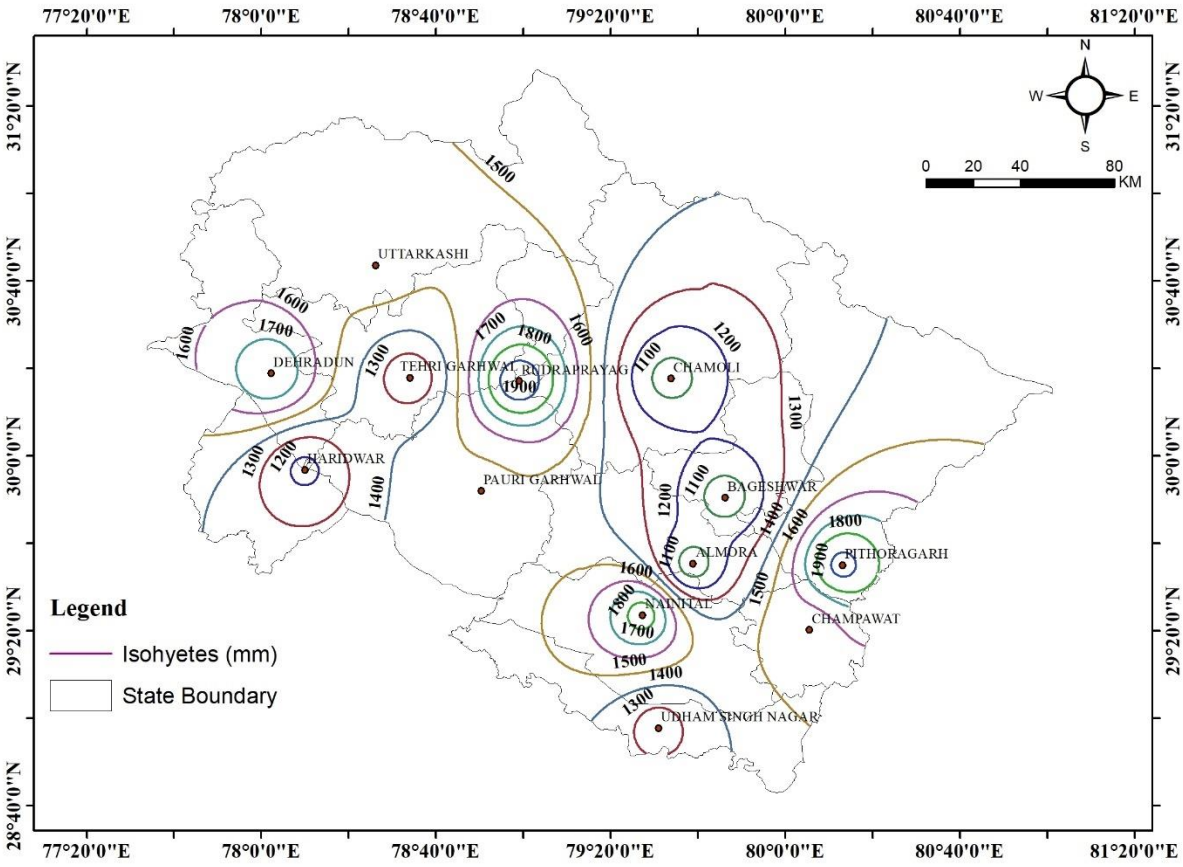
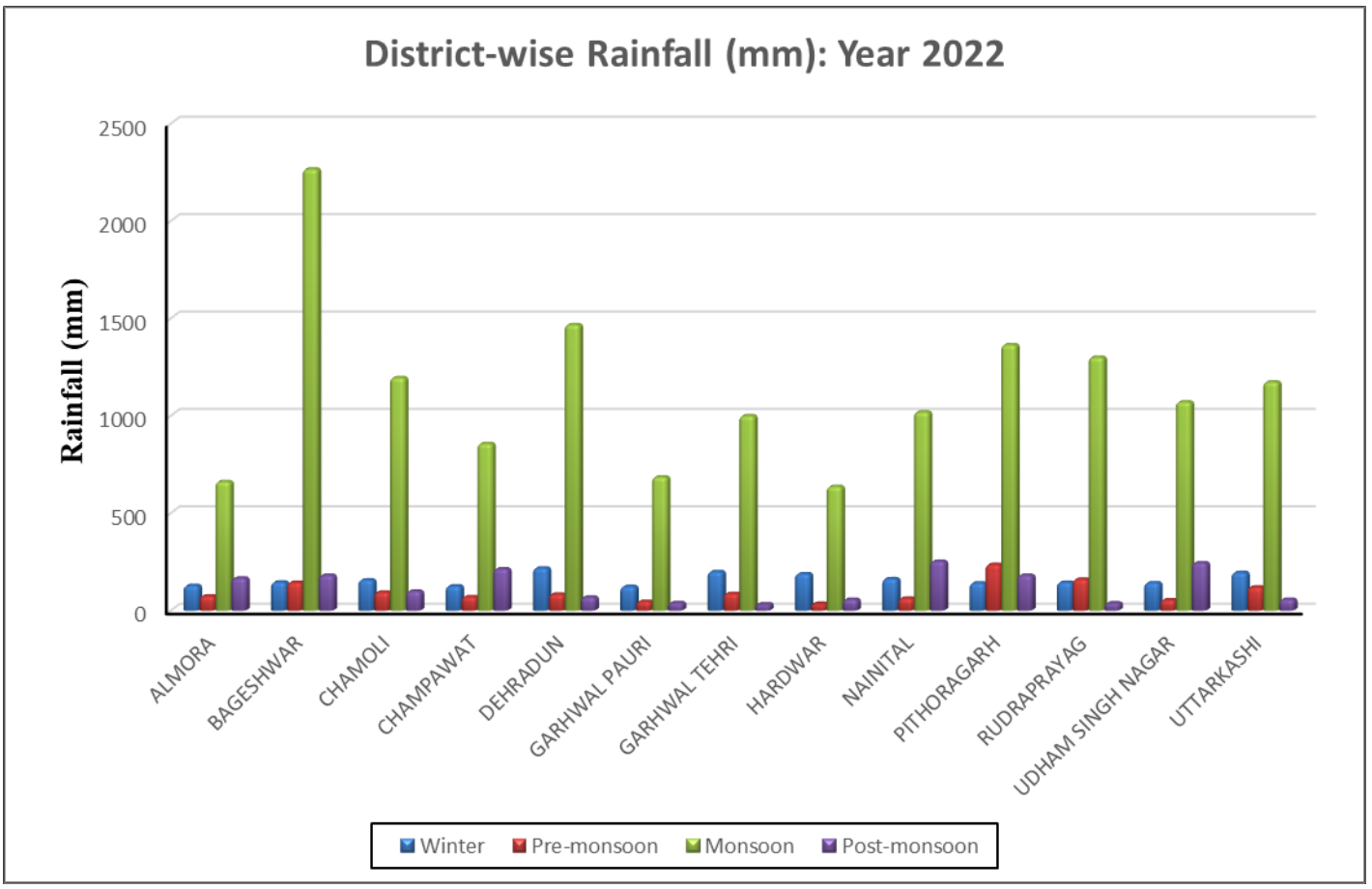


Fig. 2: Mean Isohyetal Map of Uttarakhand State



District-wise Actual Rainfall (mm) (Source: IMD)

Table 3: District wise normal monthly and annual rainfall (mm) in Uttarakhand State (Source: IMD)(1971-2020)

District	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Annual
ALMORA	35.1	53.3	45	31.1	50.3	146.3	274.2	241.8	130	20.4	5.1	18.3	1050.9
BAGESHWAR	35.1	53.3	45	31.1	50.3	146.3	274.2	241.8	130	20.4	5.1	18.3	1050.9
CHAMOLI	42.6	70.3	74	47	64	104.7	263.5	248.2	105	20.5	7.3	20.6	1067.7
CHAMPAWAT	37.4	46	28.6	25.2	51.2	211.9	473.8	397.6	230.5	43.9	4.6	15	1565.7
DEHRADUN	46.2	65.4	62.2	36.3	56.9	193.4	533.6	498.4	217.5	36.4	11.7	21.1	1779.1
PAURI GARHWAL	36.2	54.2	27.2	18.8	33.3	150.8	445.4	472.1	205	23.6	2.6	11.5	1480.7
TEHRI GARHWAL	47	58.5	54	34.6	50.1	129.5	332.6	333.1	152.8	22.8	5.1	18.2	1238.3
HARIDWAR	25.7	58.6	27.7	18.5	28.6	134.3	333.6	355.7	166.2	16	3.5	13.6	1182
NAINITAL	34.7	56	49.8	34.8	72.2	265.8	566.1	444.3	261.7	39	5.1	15.8	1845.3
PITHORAGARH	48.4	61.7	67	61.5	113.1	248.9	542.2	475.7	235.7	48.2	9.7	15.2	1927.3
RUDRAPRAYAG	58.7	66.7	72.6	67.1	105.7	220	552.7	568.8	207.6	20.4	8.4	21.2	1969.9
UDHAM SINGH NAGAR	20.4	17.6	13.8	11.2	37.1	174.5	390.2	375.5	185.3	35.3	0.9	7.9	1269.7
UTTARKASHI	54.7	71.4	71.2	49.2	70.4	176.6	425.4	380.9	168.3	38	8.3	23.7	1538.1

CHAPTER 3
GEOLOGY

The state of Uttarakhand has distinct geological attributes with a wide spectrum of rock types ranging in age from Achaean to Quaternary. Based on the diversity of geological processes in time and space, the state can be subdivided into two major physiographic-cum-tectonic units, viz.

1) Gangetic Alluvial Plain
2) Himalayan Mountain Belt.

A brief description of the geology of Uttarakhand is given below.

1) Gangetic Alluvial Plain

Gangetic Alluvial Plain, a part of the Indo-Gangetic Foreland Basin, occupies the southernmost part of the state. This zone consists of Quaternary fluvial sediments also known as Ganga Alluvium. Subsurface investigations in this belt have revealed a thick pile of alluvium resting unconformably over the Siwalik succession of Neogene to early Pleistocene Period. The thickness of alluvium increases towards north and attains its maximum adjacent to the *Foot Hill Fault* (FHF), which marks the northern limit of the youngest foreland basin in India i.e. the Ganga Fore deep Basin. The Ganga Fore deep sediments extend up to the south of depositional boundary of the Siwalik succession and rests over Precambrian cratonic rocks of Peninsular Indian Shield.

2)Himalayan Mountain Belt.

The Himalayan Mountain Belt is a part of the global mobile belt of Mesozoic to Cenozoic age that is believed to have evolved through the convergence of active Indian Plate and passive Eurasian Plate during the continent-continent lithospheric collision. It has a wide spectrum of rocks of sedimentary, metamorphic and igneous origin. Late Proterozoic (Neoproterozoic) to early Cenozoic crustal sequences form a small part of Himalaya, whereas the main mountain chain consisting predominantly of Proterozoic rocks represents a part of the Indian Shield. The Proterozoic crystalline rocks have been affected by various orogenic episodes of Mesozoic to Cenozoic Period and show signs of multiple phases of deformation and metamorphism.

Uttarakhand State is a part of Western Himalaya. Four distinct tectonic zones, each characterized by specific geological attributes and bounded by prominent dislocation zones can be recognized in Uttarakhand Himalaya from south to north. A brief description of the zones is given below:

2.1) Outer Himalaya or Sub Himalaya

This zone constitutes of a thick Cenozoic sedimentary pile ranging in age from Paleocene to Upper Pleistocene. Its northern and southern boundaries are delimited by the *Main Boundary Thrust* (MBT) and the *Foot Hill Fault* (FHF) also known as the *Main Frontal Thrust* (MFT), respectively. This zone consists predominantly of continental molasses sediments of Siwalik Group ranging in age from Middle Miocene to Upper Pleistocene. The Siwalik Group has been subdivided into the Lower Siwalik, Middle Siwalik and Upper Siwalik. The Lower Siwalik consists of fine to medium grained sandstone with clay, the Middle Siwalik is formed of medium grained sandstone with calcareous concretions and sandy clay and the Upper Siwalik consists predominantly of conglomerate with lenticular outcrops of sandstone and minor clay. The

elevation of this zone ranges from 250 to 800 m above mean sea level and width varies from 25 to 100 km. This zone is also characterized by a number of flat-floored structural valleys such as the *Doon Valley.*

2.2) Lesser Himalaya

The litho-units lying between the Main Boundary Thrust (MBT) in the south and the *Main Central Thrust* (MCT) in the north are included under the Lesser Himalayan Zone, which has the greatest exposed width of about 80 km in the Garhwal and Kumaun regions of Uttarakhand. The rocks of this zone are overlain by crystalline thrust sheets in the form of large klippe masses occupying mostly the higher topographical levels of the mountain ranges. Regionally metamorphosed Proterozoic rocks emplaced by granites of variable ages along with weakly metamorphosed to unmetamorphosed sedimentary rocks (quartzites with interbedded volcanics, carbonates associated with slate, quartzite and shale) occur extensively in this zone. The granitoids are associated with volcano sedimentary sequence (Bhimtal Formation) and are emplaced along with the predominantly metamorphic and metasedimentary rocks of this zone, forming large-scale nappes like the Almora- Ramgarh nappe, Baijnath-Askot nappe and Garhwal nappe.

2.3) Central or Higher Himalaya

This zone consists of thick slabs of Proterozoic crystalline rocks, which thrust southward along the *Main Central Thrust* (MCT), over-riding the Lesser Himalayan Zone. This zone is a 10-15 km wide sequence of metamorphic rocks and granites. This zone represents the Proterozoic basement that has been reactivated due to crustal shortening during the continent-continent collision of the Himalayan Orogeny. The metamorphic rocks exposed in this zone show progressive regional metamorphism ranging from green schist facies to upper amphibolite facies. Both foliated and non- foliated granitoids are emplaced in different structural and tectonic levels within the regionally metamorphosed crystalline.

2.4) Tethys Himalaya

This zone is occupied by the thick sedimentary sequence ranging in age from Late Precambrian (Neoproterozoic) to Lower Eocene. Sediments of marine facies, characteristic of continental shelf to continental slope environments of the Tethys Sea regime, are the predominant litho types of this zone. In Uttarakhand, this zone is well exposed in the Zanskar Mountains and mountain ranges of Kumaun region. This zone is separated from the Central Crystalline by Dar-Martoli Fault, with the Lower Martoli Formation representing the base of Phanerozoic, which is broadly folded and faulted with several local thrusts. The rock sequence comprises phyllite, mica schist and quartzite with lenticular outcrops of limestone.

.

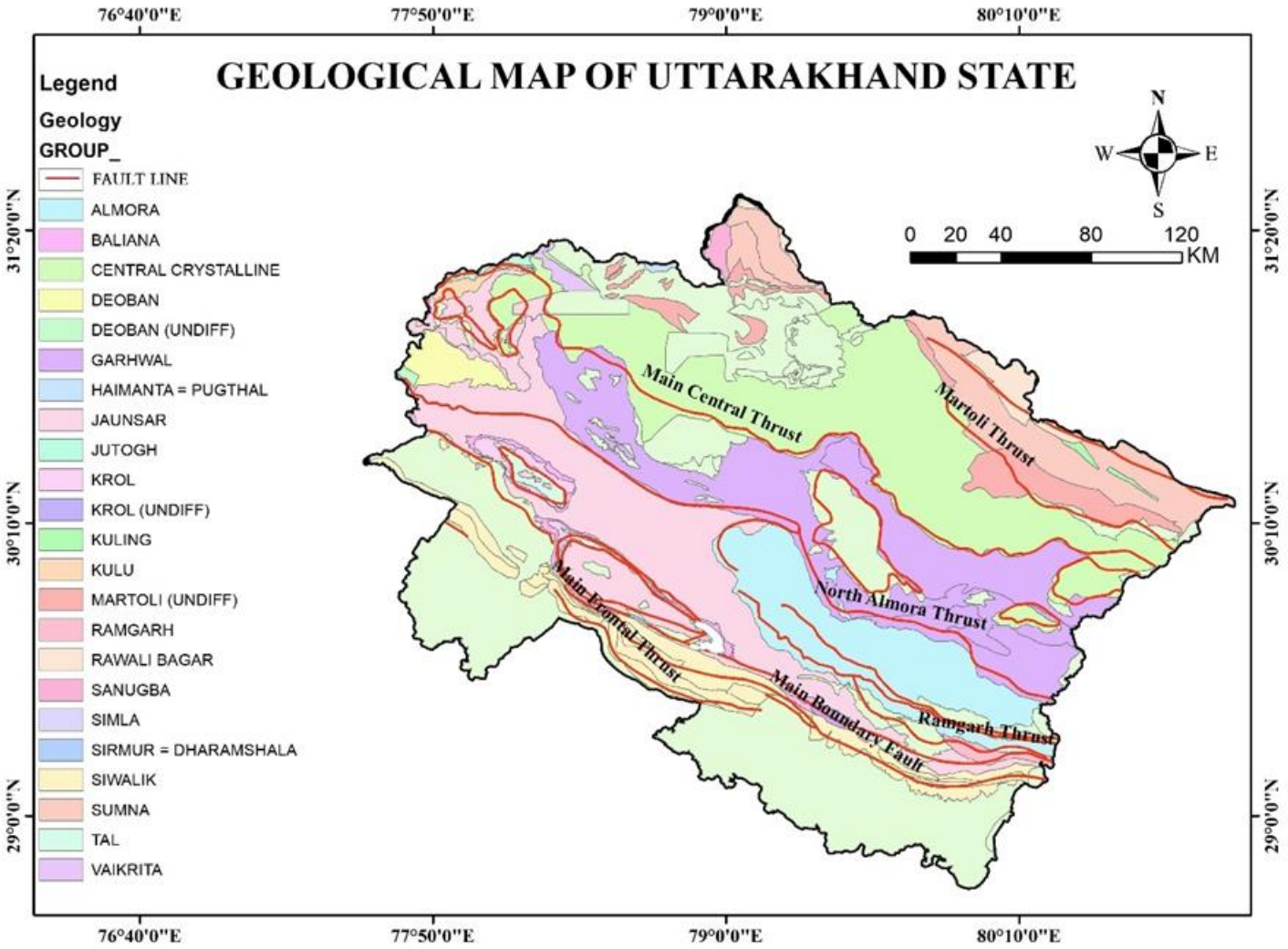


Fig.3: Geological Map of Uttarakhand State

CHAPTER 4
HYDROGEOLOGY

Uttarakhand State has a very diverse hydrogeological set-up. However, this hilly state can broadly be classified into two hydrogeological regimes namely Gangetic Alluvial Plain and Himalayan Mountain Belt. The description of these two types of hydrogeological-cum-physiographic units with further subdivisions is given below:

1. Gangetic Alluvial Plain

The Gangetic Alluvial Plain is a vast expanse of alluvium of Tertiary and Quaternary age. Alluvium is a generalized term for detrital unconsolidated sediments comprising predominantly of clay, silt, sand and gravels formed on river beds, flood plains, alluvial fans etc. This zone is very promising from the hydrogeological point of view having substantial water resource. This unit can be subdivided into three distinct hydrogeological regimes from south to north, viz. Axial Belt, Tarai and Bhabar.

1.1 Axial Belt

This unit, also called as the Alluvial Plains, is demarcated by the termination of alluvial fans that grade further down slope into vast alluvial plains. This zone is composed of a mixture of gravel, sand, silt and clay deposited in alternating layers. The aquifers present in this zone are of unconfined to confined nature. The area, in general, has good ground water resource potential but overexploitation of ground water reserve at places has resulted in the decline of water levels and needs implementation of artificial recharge methods. Drilling in this zone can be best accomplished by Rotary Drilling method having high drilling rate and hence, requiring less time for drilling.

1.2 Tarai

This is a generalized term for a sedimentary unit consisting of a mixture of gravel, sand and clay (sometimes also referred to as Tarai Formation). The boundary between Tarai and Bhabar is
demarcated by the presence of springs forming a linear pattern, thus delineating a "spring line". Due to the highly porous and permeable nature of the constituting material of sedimentary origin, many potential aquifers having groundwater of good chemical quality exist in this area. Two types of aquifers can be found in this zone –
a) Unconfined Aquifers down to depths of 30 meters below ground level (m bgl) and
b) Confined Aquifers that occur at depths greater than 30 m bgl under very high hydrostatic pressure.

The tubewell tapping these aquifers generally exhibit free flowing conditions with hydraulic head sometimes as high as 10 m agl and discharge of 5000 lpm.

1.3 Bhabhar

A mixture of clastic material having different size fractions (e.g., boulder, pebble, gravel, sand, silt and clay) constitutes this unit, which is also referred to as Bhabar Formation. Bhabar zone is also a promising hydrogeological entity though the occurrence of ground water at deeper levels (generally greater than 100 m bgl) poses a problem for ground water exploitation. Central Ground Water Board has constructed 28 deep tube wells (with discharge as high as 5540 lpm) by percussion drilling method in this zone of the state. Perched water bodies having smaller water resource potential are frequently encountered in this zone.

2. Himalayan Mountain Belt

This is a part of the Alpine-Himalayan Mountain Chain and constitutes a major part of the total geographical area of Uttarakhand. This zone is also known as Extra-Peninsular Region. The belt trends northwest – southeast with roughly parallel mountain ranges spanning across the state. This region can be further subdivided into five tectonic units from south to north. These units are Outer Himalaya, Lesser Himalaya, Central Himalaya, Tethyan Himalaya and Indus Suture Zone. However, the Indus Suture Zone does not fall within the geographical area of Uttarakhand State. A brief description of the remaining four units that falls in the state is as follows:

2.1 Outer Himalaya (Siwalik Mountain Range)

This unit is composed dominantly of sandstone, ferruginous shale and clay and is younger in age as compared to the other units of the belt. The general elevation of the zone is less than 1000 m above mean sea level. Due to the semi-consolidated nature of rocks, potential ground water bearing formations are present in areas, which have a good weathered mantle and highly fractured/jointed rocks. In the Siwaliks, a number of valleys have also been developed as a result of tectonic activities (e. g. Doon Valley), which are very important from the hydrogeological point of view. The Doon Valley was formed as an Intermontane Valley within the Siwalik Group of rocks in a foreland propagating thrust system. The Lower, Middle and Upper Siwaliks are exposed in the area, and the Doon Gravels, a post-Siwalik Formation, were deposited with the evolution of the valley. The Doon Gravels are thickly bedded coarse clastic fan deposit of late Pleistocene and Holocene age. The Central Ground Water Board has successfully constructed 11 deep tubewell, with discharge ranging from 252 to 3197 lpm in the Doon Valley of Dehradun district. The water levels in these aquifers range from 20 m bgl in the southern part of the valley to about 100 m bgl in the northern part.

2.2 Lesser Himalaya

This zone is represented by mountains bounded by Main Boundary Thrust (MBT) in the south and Main Central Thrust (MCT) in the north having an elevation ranging between 1000 and 3000 m above mean sea level. This unit is dominantly composed of metasedimentary rocks and minor plutonic intrusive (granitoids). Springs form the most important source of ground water in this zone. In these formations, ground water occurrence is restricted to the weathered residuum and the highly fractured/jointed zones of the area. Several hand pumps have been installed successfully in this zone. At a few places, especially in the river valleys, tubewell having low to moderate discharges have also been successfully constructed.

2.3 Central Himalaya

The Central Himalayan zone lies to the north of Main Central Thrust (MCT) with an elevation ranging from 5000 to 8000 m above mean sea level. Both cold water and hot water (thermal) springs are present in this zone. So far, a total of 25 thermal springs have been investigated with temperatures ranging from 32°C to 70°C and discharge varying between 60 to 600 lpm, corresponding to 5th order and 4th order as per Meinzer's Classification of spring discharge. Due to highly inaccessible, snow-covered areas in this zone and a very steep hydraulic gradient, the possibility of ground water development is negligible.

2.4. Tethys Himalaya

Situated to the north of Central Himalayan zone, this zone is predominantly occupied by the highly fossiliferous sedimentary rocks ranging in age from Precambrian to Jurassic.

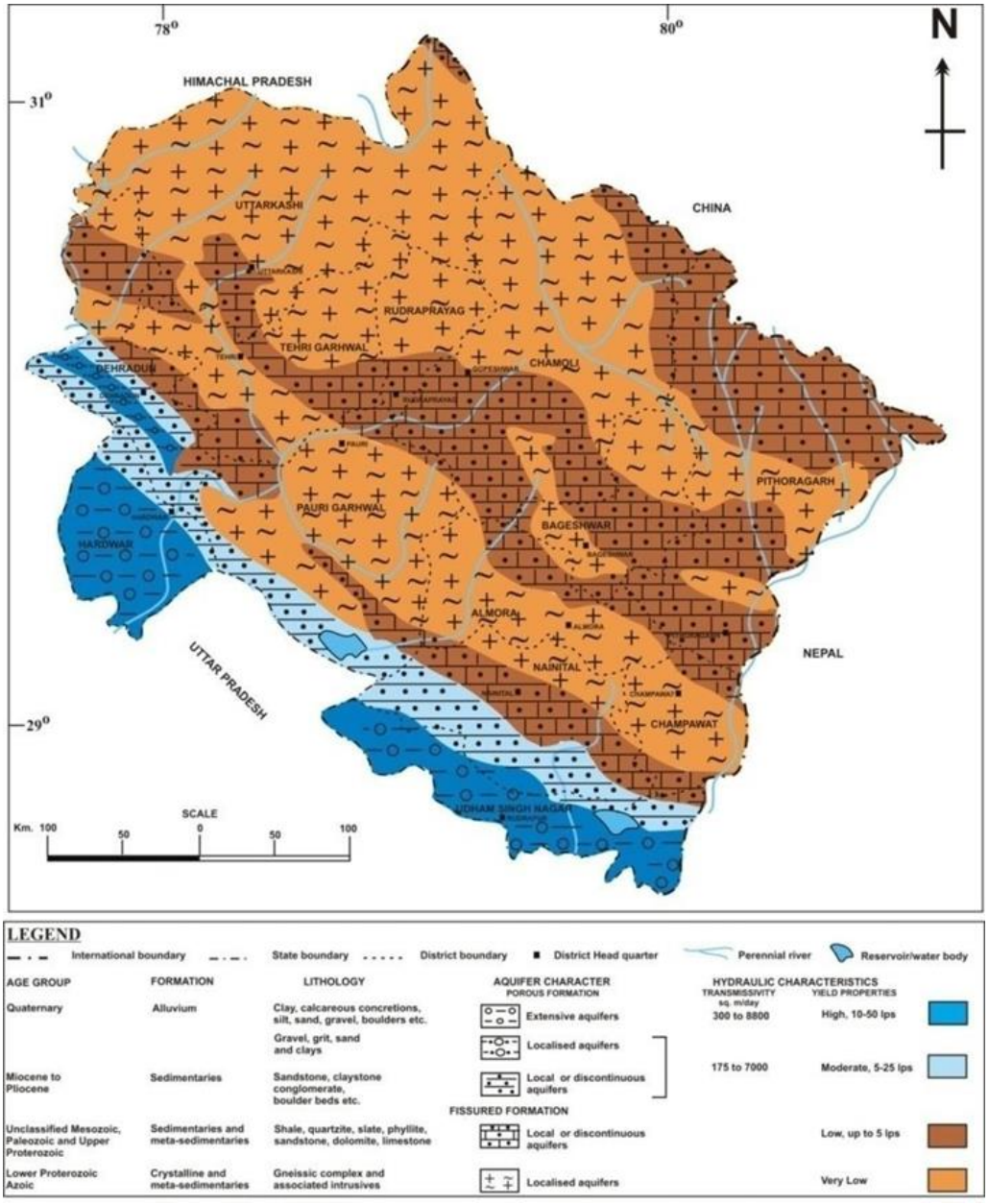


Fig.4: Hydrogeological Map of Uttarakhand State

CHAPTER 5
BEHAVIOUR OF WATER LEVEL AND SPRING DISCHARGE

The water levels and spring discharge of Ground Water Monitoring Wells of Uttarakhand were measured four times during the year 2023-2024 (January 2024, May 2023, August 2023, and November 2023) as shown in Table 4. The ground water levels in different seasons were analyzed to evaluate the temporal behavior of water level. The behavior of water levels in each season during the period May 2023-January 2023 has been compared with the water levels of previous year as well as with average water level for the last decade to ascertain the changes in ground water regime.

Apart from this, the fluctuation of water levels during the current year and previous year has also been evaluated in order to assess the adverse impact on hydrogeological regime, if any.

Table 4: Monitoring data of Ground Water Monitoring Wells, Uttarakhand

Sl No.	District	Block	Location Details	Jan-24	Nov-23	Aug-23	May-23
1	Dehradun	Doiwala	Khandgaon	6.66	4.23	1.22	13.14
2	Dehradun	Doiwala	Khadiri (Khadak Maf)	13.47	13.39	9.2	14.78
3	Dehradun	Doiwala	Rishikesh	4.62	4.13	3.14	8
4	Dehradun	Doiwala	Lal Tappar	12.62	11.78	13.35	18.88
5	Dehradun	Doiwala	Bhaniawala	23.2	21.72	26.76	40.35
6	Dehradun	Doiwala	Dudhli	29.69	24.58	37.06	41.4
7	Dehradun	Doiwala	Kotimachak	19.31	16.48	8.42	21.12
8	Dehradun	Doiwala	Chandmari	28.29	25.98	34.31	37.69
9	Dehradun	Doiwala	Duggiawala	6.45	5.9	4.9	7.4
10	Dehradun	Doiwala	Mathrowala	9.81	8.89	8.52	12.02
11	Dehradun	Raipur	Kuanwala	3.49	1.67	0.65	5.95
12	Dehradun	Raipur	Gularghagti	11.83	10.01	5.95	14.02
13	Dehradun	Raipur	Maldeota	12.21	7.95	4.47	12.05
14	Dehradun	Raipur	Nanurkhera	61.31	57.98	57.21	67.68
15	Dehradun	Raipur	Tarla Nagal	71.41	67.11	62.43	75
16	Dehradun	Raipur	Tarla Nagal	52.4	49.37	43.99	53.11
17	Dehradun	Raipur	Purukulgaon	25.55	24.28	17.78	26.31
18	Dehradun	Raipur	Niranjanpur	33.29	NA	30.49	36.79
19	Dehradun	Raipur	CGWB Office	NA	52.43	54.54	60.88
20	Dehradun	Raipur	Harbanswala	45.95	44.07	46.1	51.52
21	Dehradun	Raipur	Kanwali	12.27	12.2	7.05	12.05
22	Dehradun	Raipur	Bhopalpani (Badawali)	7.32	2.72	0.44	8.81
23	Dehradun	Raipur	Ladpur	82.61	78.85	81.4	89.93
24	Dehradun	Sahaspur	Singhniwala	9.36	7.74	6.95	9.54
25	Dehradun	Sahaspur	Baronwala	22.87	22.09	8.44	33.7
26	Dehradun	Sahaspur	Ramgarh	NA	6.06	5.8	NA
27	Dehradun	Sahaspur	Jhajra	9.37	6.32	6.26	13.33
28	Dehradun	Sahaspur	Jhajra	10.59	6.29	5.15	15.77
29	Dehradun	Sahaspur	Nanda ki Chowki	9.4	8.7	8.63	15.7

30	**Dehradun**	**Sahaspur**	**Nanda ki Chowki**	10.16	8.99	9.77	20
31	**Dehradun**	**Sahaspur**	**Selakui**	9.85	8.84	6.66	NA
32	**Dehradun**	**Sahaspur**	**Selakui**	15.56	14.56	12.92	16.68
33	**Dehradun**	**Sahaspur**	**Sabhawala**	8.11	6.86	4.62	8.86
34	**Dehradun**	**Sahaspur**	**Rampura**	10.47	9.99	7.74	11.33
35	**Dehradun**	**Sahaspur**	**Shankarpur**	18.78	17.2	16.35	22.5
36	**Dehradun**	**Sahaspur**	**Redapur**	6.64	6.35	6.35	9.62
37	**Dehradun**	**Sahaspur**	**Sahaspur**	3.64	3.36	3.75	6.45
38	**Dehradun**	**Sahaspur**	**Chhorba**	29.98	29.83	32.42	37.43
39	**Dehradun**	**Sahaspur**	**Telpura**	33.75	32	33.25	38.68
40	**Dehradun**	**Vikas Nagar**	**Badripur**	9.09	8.87	4.73	9.19
41	**Dehradun**	**Vikas Nagar**	**Judli**	13.39	12.81	11.7	13.64
42	**Dehradun**	**Vikas Nagar**	**Herbertpur**	9.69	9.24	6.29	10.25
43	**Dehradun**	**Vikas Nagar**	**Vikas Nagar**	26.92	25.62	22.46	28.04
44	**Dehradun**	**Vikas Nagar**	**Dakpatthar**	26.67	25.03	22.37	26.77
45	**Dehradun**	**Vikas Nagar**	**Barothiwala**	4.15	4.67	5.06	23.25
46	**Dehradun**	**Vikas Nagar**	**Dhakrani**	16.49	12.49	8.51	19.8
47	**Dehradun**	**Vikas Nagar**	**Timli**	64.79	66.66	68.9	69.35
48	**Dehradun**	**Vikas Nagar**	**Baluwala**	35.45	34.69	35.4	40.07
49	**Dehradun**	**Vikas Nagar**	**Luxmipur**	28.8	26.79	25.68	30.52
50	**Dehradun**	**Vikas Nagar**	**Haripur**	10.76	10.11	7.42	11.1
51	**Dehradun**	**Vikas Nagar**	**Jamuna Pull**	NA	14.1	11.82	13.6
52	**Haridwar**	**Bhagwanpur**	**Shahidwala Grant**	11.75	10.8	10.9	14.1
53	**Haridwar**	**Bhagwanpur**	**Sahidwala Grant**	11.65	10.46	11.51	14.24
54	**Haridwar**	**Bhagwanpur**	**Budhwa Shahid**	4.07	2.99	2.2	6.2
55	**Haridwar**	**Bhagwanpur**	**Bugawala**	7.02	6.57	7.8	9.47
56	**Haridwar**	**Bhagwanpur**	**Bahabalpur**	6.35	3.84	2.14	3.81
57	**Haridwar**	**Bhagwanpur**	**Bhagwanpur**	1.55	0.17	18.78	24.59
58	**Haridwar**	**Bhagwanpur**	**Chudiala**	18.98	20.1	19.07	21.44
59	**Haridwar**	**Bhagwanpur**	**Iqbalpur**	16.17	17.59	10.93	17.36
60	**Haridwar**	**Bhagwanpur**	**Jaswawala**	3.1	2.33	2.08	3.97
61	**Haridwar**	**Bhagwanpur**	**Kota Muradnagar**	10.82	8.65	3.98	8.83
62	**Haridwar**	**Bahadrabad**	**Bandarjud**	NA	7.2	9.05	11.96
63	**Haridwar**	**Bahadrabad**	**Rathora**	3.84	2.95	1.25	4.35
64	**Haridwar**	**Bahadrabad**	**Bahadrabad**	5.43	4.93	2.82	14.19
65	**Haridwar**	**Bahadrabad**	**Sarai**	12.26	10.43	8.01	15.04
66	**Haridwar**	**Bahadrabad**	**Dhanpura**	6.84	5.4	2.64	8.26
67	**Haridwar**	**Bahadrabad**	**Shahpur Shitlakhera**	4.73	4.06	1.95	5.72
68	**Haridwar**	**Bahadrabad**	**Laldhang**	53.42	51.1	52.62	62.13
69	**Haridwar**	**Bahadrabad**	**Bhogpur**	4.68	4.36	0.99	4.41
70	**Haridwar**	**Bahadrabad**	**Dalupuri**	21.74	19.84	21.8	28.55
71	**Haridwar**	**Bahadrabad**	**Panjaheri**	6.66	5.82	3.02	7.95
72	**Haridwar**	**Bahadrabad**	**Rasiyabad Choraha**	16.34	16.06	19.73	20.93
73	**Haridwar**	**Bahadrabad**	**Shyampur**	9.79	8.7	7.75	11.56

74	**Haridwar**	**Bahadrabad**	**Jassodharpur**	4.1	3.67	1.62	6.62
75	**Haridwar**	**Bahadrabad**	**Bhoopatwala**	NA	7.74	5.22	10.61
76	**Haridwar**	**Roorkee**	**Imlikhera**	22.3	19.64	18.94	25.61
77	**Haridwar**	**Roorkee**	**Roorkee**	4.89	4.36	3.39	7.6
78	**Haridwar**	**Roorkee**	**Sikhar**	13.9	13.19	13.61	17.47
79	**Haridwar**	**Roorkee**	**Khera Jat**	4.75	4.13	3.21	7.91
80	**Haridwar**	**Roorkee**	**Nizampur**	NA	12.23	9.02	10.8
81	**Haridwar**	**Roorkee**	**Malakpur Mazra**	4.73	4.62	2.71	7.32
82	**Haridwar**	**Narsan**	**Jhabreda**	10.25	6.73	6.79	9.59
83	**Haridwar**	**Narsan**	**Landhaura**	16	14.84	15.42	18.07
84	**Haridwar**	**Narsan**	**Lakhnauta**	6.09	5.81	4.71	7.71
85	**Haridwar**	**Narsan**	**Gurukul Narsen**	4.92	NA	2.64	5.49
86	**Haridwar**	**Narsan**	**Libhrahedi**	5.42	4.84	3.29	7.32
87	**Haridwar**	**Narsan**	**Mudlana**	16.28	16.32	15.67	18.88
88	**Haridwar**	**Laksar**	**Hussainpur**	2.03	1.91	0.51	2.31
89	**Haridwar**	**Laksar**	**Laksar**	2.68	2.62	1.22	6.39
90	**Haridwar**	**Laksar**	**Bhikkampur**	4	3.4	1.59	4.35
91	**Haridwar**	**Khanpur**	**Govardhanpur**	2.17	2.39	0.19	2.53
92	**Haridwar**	**Khanpur**	**Dallawala**	1.13	0.4	0.86	0.88
93	**Haridwar**	**Khanpur**	**Khanpur**	3.8	3.85	1.94	5.38
94	**Nainital**	**Haldwani**	**Khaat Baans**	31.42	28.34	25.47	37.48
95	**Nainital**	**Haldwani**	**Lalkuan**	11.4	6.92	14.44	15.78
96	**Nainital**	**Haldwani**	**Lamachaur**	48.53	48.88	58.44	56.81
97	**Nainital**	**Haldwani**	**Kaladungi**	27.39	26.15	26.26	29.25
98	**Nainital**	**Haldwani**	**Kathgodam**	18.19	16.47	15.11	18.69
99	**Nainital**	**Ramnagar**	**Belparao**	52.09	52.56	53.67	NA
100	**Nainital**	**Ramnagar**	**Peeru Madara**	21.77	NA	NA	27.4
101	**Nainital**	**Ramnagar**	**Maldhan Colony**	3.1	3	0.06	6.43
102	**Nainital**	**Ramnagar**	**Dhela**	NA	64.58	67.08	67.45
103	**Nainital**	**Ramnagar**	**Ram Nagar**	5.36	5.21	4.4	6.46
104	**Nainital**	**Ramnagar**	**Garjiya**	NA	3.63	3.43	NA
105	**Nainital**	**Ramnagar**	**Dohniya**	48.14	41.98	39.46	69.79
106	**Nainital**	**Ramnagar**	**Chilkiya**	51.83	49.94	52.78	57.13
107	**US Nagar**	**Khatima**	**Kanchanpur (Majhola)**	4.56	4.23	4.08	6.39
108	**US Nagar**	**Khatima**	**Khatima**	250.7	1.78	0.77	2.92
109	**US Nagar**	**Khatima**	**Sarasariya**	4.95	5.39	5.53	7.64
110	**US Nagar**	**Khatima**	**Chakarpur**	6.44	4.12	4.27	7.41
111	**US Nagar**	**Khatima**	**Barianjaniya**	4.17	3.3	1.63	5.87
112	**US Nagar**	**Sitarganj**	**Sitarganj**	1.67	2.1	0.65	3.92
113	**US Nagar**	**Sitarganj**	**Nanak Mata**	3.31	4.97	1.63	3.91
114	**US Nagar**	**Sitarganj**	**Kalyanpur**	2.96	1.54	1.16	4.14
115	**US Nagar**	**Sitarganj**	**Tukri**	2.5	2.28	2.73	5.06
116	**US Nagar**	**Sitarganj**	**Begur Mod**	3.65	3.84	2.18	4.43

117	**US Nagar**	**Sitarganj**	**Bidora**	2.33	2.02	2.91	5.26
118	**US Nagar**	**Sitarganj**	**Dhyanpur**	2	1.32	0.85	4.48
119	**US Nagar**	**Rudrapur**	**Bara**	2.01	1.75	1.11	2.1
120	**US Nagar**	**Rudrapur**	**Kichha**	8.43	10.93	4.48	10.04
121	**US Nagar**	**Rudrapur**	**Kamaria Pakki**	4.99	3.05	3.28	9.32
122	**US Nagar**	**Rudrapur**	**Gangapur**	2.75	2.75	1.85	5.18
123	**US Nagar**	**Rudrapur**	**Shantipuri**	1.56	1.77	0.16	2.1
124	**US Nagar**	**Rudrapur**	**Patthar Chatta**	2.25	2.78	1.48	3.32
125	**US Nagar**	**Rudrapur**	**Rudrapur**	4	2.12	4.6	8.09
126	**US Nagar**	**Rudrapur**	**Kanakpur**	3.01	2.14	1.5	3.62
127	**US Nagar**	**Rudrapur**	**Rajpura**	2.68	1.85	3.6	5.02
128	**US Nagar**	**Rudrapur**	**Pipaliya**	3.68	2.43	3.39	9.85
129	**US Nagar**	**Gadarpur**	**Jhagarpuri**	8.11	7.58	2.61	7.46
130	**US Nagar**	**Gadarpur**	**Mahabir Nagar**	0.05	0.98	0.06	3.05
131	**US Nagar**	**Gadarpur**	**Kopa Signal**	3	0.46	0.07	0.7
132	**US Nagar**	**Gadarpur**	**Beria Daulat**	0.33	2.96	1.88	4.45
133	**US Nagar**	**Gadarpur**	**Bhagwanpur**	3.46	3.52	5.76	14.29
134	**US Nagar**	**Gadarpur**	**Pattharpui**	3.13	3.36	2.8	3.92
135	**US Nagar**	**Gadarpur**	**Lalpuri**	1.46	1.64	0.79	3.16
136	**US Nagar**	**Bazpur**	**Bazpur**	1.36	1.05	0.07	1.88
137	**US Nagar**	**Bazpur**	**Jharkhandi**	0.53	0.49	0.07	3.02
138	**US Nagar**	**Bazpur**	**Jogipura**	4.46	4.09	3.51	5.53
139	**US Nagar**	**Bazpur**	**Banna Khera**	3.72	3.88	2.96	6.03
140	**US Nagar**	**Bazpur**	**Pritpur**	4.17	3.54	2.5	7.17
141	**US Nagar**	**Bazpur**	**Badaripur**	4.38	NA	6.92	9.85
142	**US Nagar**	**Kashipur**	**Barkhare Pande**	5.66	1	6.72	16.8
143	**US Nagar**	**Kashipur**	**Sultanpur Patti**	3.68	4.5	3.46	9.53
144	**US Nagar**	**Kashipur**	**Kashipur**	4.81	4.75	0.35	7.62
145	**US Nagar**	**Kashipur**	**Bharatpur**	9.21	10.73	11.37	16.09
146	**US Nagar**	**Kashipur**	**Dhanauri Patti**	0.21	0.42	0.33	4.4
147	**US Nagar**	**Kashipur**	**Durgapur**	3.52	2.88	2.5	6.32
148	**US Nagar**	**Kashipur**	**Shand Khera**	5.64	5.44	5.58	13.26
149	**US Nagar**	**Jaspur**	**Jaspur**	15.96	17.26	17.58	17.28
150	**US Nagar**	**Jaspur**	**Patrampur**	6.33	9.5	5.72	13.49
151	**US Nagar**	**Jaspur**	**Angadpur**	6.86	7.1	5.75	11.19
152	**US Nagar**	**Jaspur**	**Missarwala**	9.27	11.27	11.3	20.74
153	**Champawat**	**Champawat**	**Tanakpur**	10.63	9.55	5.92	NA
154	**Champawat**	**Champawat**	**Banbasa**	4.99	NA	NA	5.71
155	**Champawat**	**Champawat**	**Bastia**	38.72	28.68	26.31	39.34
156	**Champawat**	**Champawat**	**Bichai**	9.37	8.41	5.52	10.29
157	**Pauri Garhwal**	**Dugadda**	**Kaudia (Kotdwar)**	47.83	43.2	47.21	58.48
158	**Pauri Garhwal**	**Dugadda**	**Trilokpur**	NA	97.14	96.09	97.43

159	**Pauri Garhwal**	**Dugadda**	**Chinyalisaur**	11.69	10.93	11.01	18.31
160	**Uttarkashi**	**Dunda**	**Devidhar**	12.08	9.13	8.3	9.2
161	**Uttarkashi**	**Dunda**	**Uttarkashi**	24.91	16.29	14.71	20.21
162	**Uttarkashi**	**Naugaon**	**Barkot**	16.87	16.65	15.71	17.6
163	**Uttarkashi**	**Naugaon**	**Sharukhet**	34.73	31.77	28.27	43.8
164	**Uttarkashi**	**Naugaon**	**Ganeshpur**	10.05	9.63	15.23	18.2
165	**Uttarkashi**	**Bhatwari**	**Maneri**	27.48	28.41	24.21	30.2
166	**Uttarkashi**	**Bhatwari**	**Charethi**	27.08	23.38	23.07	24.6
167	**Uttarkashi**	**Bhatwari**	**Dunda**	37.06	32.08	29.14	33.4
168	**Tehri Garhwal**	**Tehri Garhwal**	**Chinyaligaud (TH-44)**	32.3	27.08	23.79	28.24
169	**Tehri Garhwal**	**Tehri Garhwal**	**Uniyalgaon (TH-40)**	39.43	33.77	32.82	34.9
170	**Tehri Garhwal**	**Tehri Garhwal**	**Kotidobhal (TH-19)**	43.57	43.55	39.43	41
171	**Tehri Garhwal**	**Tehri Garhwal**	**Kunar Valley (TH-12)**	31.27	23.35	22.1	42.3
172	**Tehri Garhwal**	**Tehri Garhwal**	**Dharkut (CG-33)**	76.63	76.4	50.83	40.6

5.1 DEPTH TO WATER LEVEL

5.1.1 January 2024

The depth to water level data was analysed for 163 Ground Water Monitoring Wells in Uttarakhand during January 2024 and is given in ***Table 5.*** Analysis of depth to water level data given in the table indicates that the deepest water level was 82.61 m bgl in Ladpur, Dehradun district whereas the shallowest water level was 0.05m bgl at Dallawala in Haridwar District. The shallowest depth to water level of 0–5 m bgl was recorded by 59 monitoring wells, which was 36.20 % of the totalnumber of wells. Water level in the range of 5-10 m bgl was also shown by 34 wells (20.86% of total number of wells), whereas deeper water level of 10–15 m bgl was recorded by 18 monitoring wells, which was 11.04% of the total number of wells. The deepest water level of >15 m bgl was shown by 52 monitoring wells, which was 31.90% of the total number of wells in Uttarakhand monitored in January 2024.

Table 5: District wise categorization of depth to water level data, January 2024

District	No. of stations analyzed	Depth to water level		Depth to water level (m bgl)							
		(m bgl)		0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	48	3.49	82.61	4	8.33	12	25.00	10	20.83	22	45.83
Haridwar	39	1.13	53.42	17	43.59	8	20.51	6	15.38	8	20.51
U. S. Nagar	46	0.05	15.96	36	78.26	9	19.57	0	0.00	1	2.17
Nainital	11	3.1	52.09	1	9.09	1	9.09	1	9.09	8	72.73
Champawat	4	4.99	38.72	1	25.00	1	25.00	1	25.00	1	25.00
Uttarkashi	9	10.05	37.06	0	0.00	3	33.33	0	0.00	6	66.67
Tehri Garhwal	5	31.27	76.63	0	0.00	0	0.00	0	0.00	5	100.00
Pauri Garhwal	1	47.83		0	0.00	0	0.00	0	0.00	1	100.00
Total	**163**	**0.05**	**82.61**	**59**	36.20	**34**	20.86	**18**	11.04	**52**	31.90

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for ***January 2024*** is shown in ***Fig. 5*** *(Kumaon Section), and Fig.**6** (Garhwal Section).*

A perusal of **Fig. 5 (Kumaon Section)** reveals that the major part of the Udham Singh Nagar district shows water level less than 5 m bgl. However shallow water level in the range of 5-10 m is covering major part of Jaspur, Kashipur, northern part of Khatima block and northern part of the Udham Singh Nagar district. Major part of Nainital district shows water level in the range of 15-30 m bgl. However deeper water level in the range of 30-50 m bgl occurs as patches rimming deepest water level of more than

50 m bgl in Ramnagar and Kotabag blocks of the Nainital district. Depth to water level in the Champawat district increases gradually from southern part (5-10 m bgl) to northern part (30-50 m bgl).

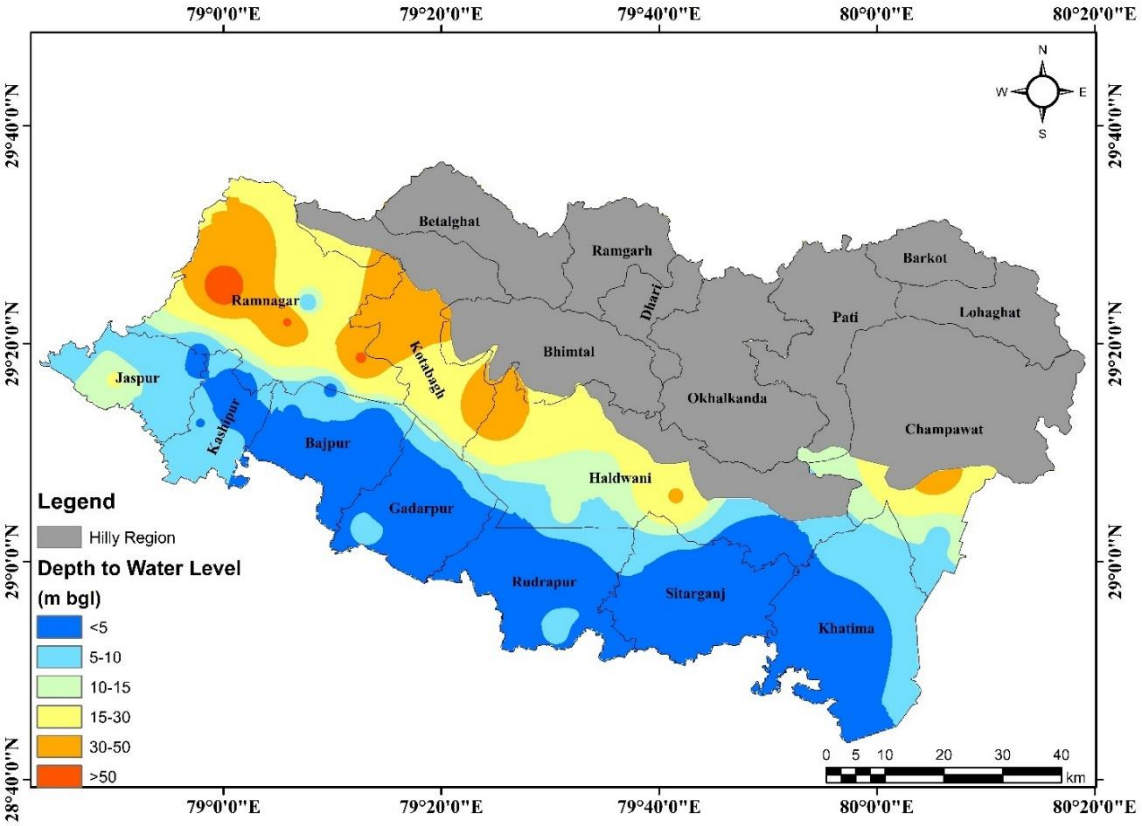


Fig.5: Depth to Water Level Map, Kumaon Region, Uttarakhand State January 2024

A perusal of **Fig. 6 (Garhwal Section)** reveals that the major part of the Haridwar district shows water level in the range of 5-10 m bgl. However shallowest water level of less than 5m bgl occur as small patches in the Khanpur, Laksar blocks of the Haridwar district. However, deeper water level in the range of 30-50 m bgl occurs as concentric ring rimming deepest water level of more than 50 m bgl in the eastern flank of Bahadrabad block of the Haridwar district. The major part of the Dehradun valley is showing water level in the range of 15-30 m bgl. However, the south-eastern part of the Doiwala block of the Dehradun district shows water level in the range of 10-15 m bgl. Deeper water level of 30-50 m bgl also occur as concentric rings rimming deepest water level of more than 50 m bgl in the southern part of Vikas Nagar block and northern part of Raipur and Sahaspur blocks of the district.

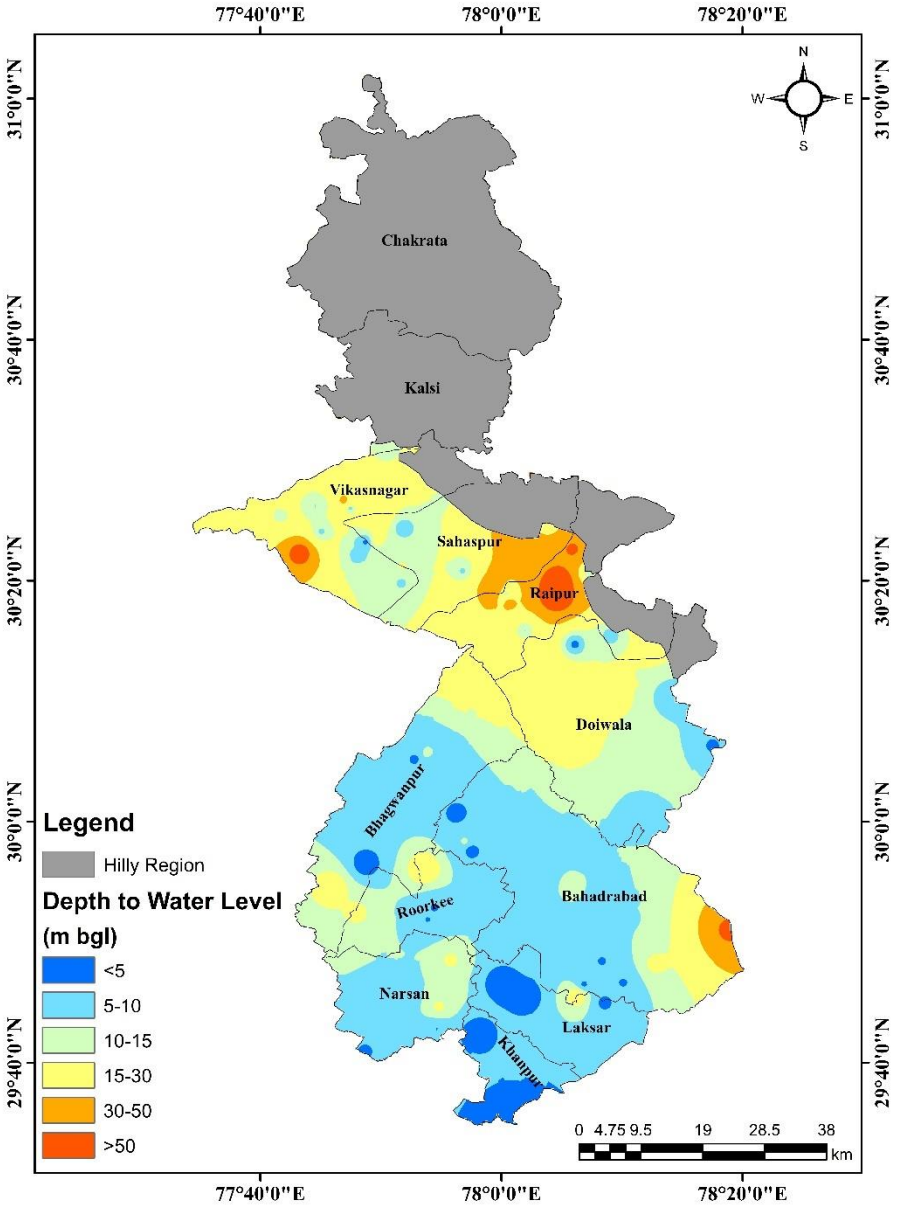


Fig.6: Depth to Water Level Map, Garhwal Region, Uttarakhand State January 2024

5.1.2 May 2023

The depth to water level data was analysed for 167 Ground Water Monitoring Wells in Uttarakhand during May 2023 and is given in ***Table 6.*** Analysis of depth to water level data given in the table indicates that the deepest water level was 97.43 m bgl at Trilokpur at Pauri Garhwal district whereas the shallowest water level was 0.7 m bgl at Kopa Singal in Udham Singh Nagar district. The depth to water level in the range of 0–5 m bgl was recorded in 26 ground water monitoring wells, which is 15.57% of the total number of wells. Water level in the range of 5–10 m bgl was shown by 48 monitoring wells (28.74% of total number), whereas deeper water level of 10–15 m bgl was recorded in 25 monitoring wells, which was 14.97% of the total number. The

deepest water level of >15 m bgl was shown by 68 monitoring wells, which is 40.72% of the total monitoring wells in Uttarakhand during May 2023.

Table 6: District wise categorization of depth to water level data, May 2023

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	49	5.95	89.93	0	0.00	9	18.37	12	24.49	28	57.14
Haridwar	42	0.88	62.13	8	19.05	16	38.10	7	16.67	11	26.19
U. S. Nagar	46	0.7	20.74	18	39.13	19	41.30	5	10.87	4	8.70
Nainital	11	6.43	69.76	0	0	2	18.18	0	0	9	81.82
Champawat	3	10.22	39.28	0	0	1	33.33	1	33.33	1	33.33
Uttarkashi	9	9.2	43.8	0	0	1	11.11	0	0	8	88.89
Tehri Garhwal	5	28.24	42.3	0	0	0	0.00	0	0	5	100.00
Pauri Garhwal	2	58.48	97.43	0	0	0	0	0	0	2	100
Total	**167**	**0.7**	**97.43**	**26**	15.57	**48**	28.74	**25**	14.97	**68**	40.72

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for ***May 2022*** is shown in ***Fig. 7*** *(Kumaon Section), and Fig.****8*** *(Garhwal Section).*

A perusal of **Fig. 7 (Kumaon Section)** reveals that the major part of the Udham Singh Nagar district shows water level in the range of 5-10 m bgl. However shallowest water level in the range of >5 m bgl is covering major part of Sitarganj, and Gadarpur block of the Udham Singh Nagar district. The deeper water level in the range of 15-30 is also observed mainly in the Jaspur and some part of the Kashipur block of the district. Major part of the Ramnagar and Kotabag blocks of the Nainital district shows water level in the range of 30-50 m bgl. However, Major part of the Halwani block of the Nainital district shows water level in the range of 15-30 m bgl. Depth to water level in the Champawat district increases gradually from southern part (10-15 m bgl) to northern part (30-50 m bgl).

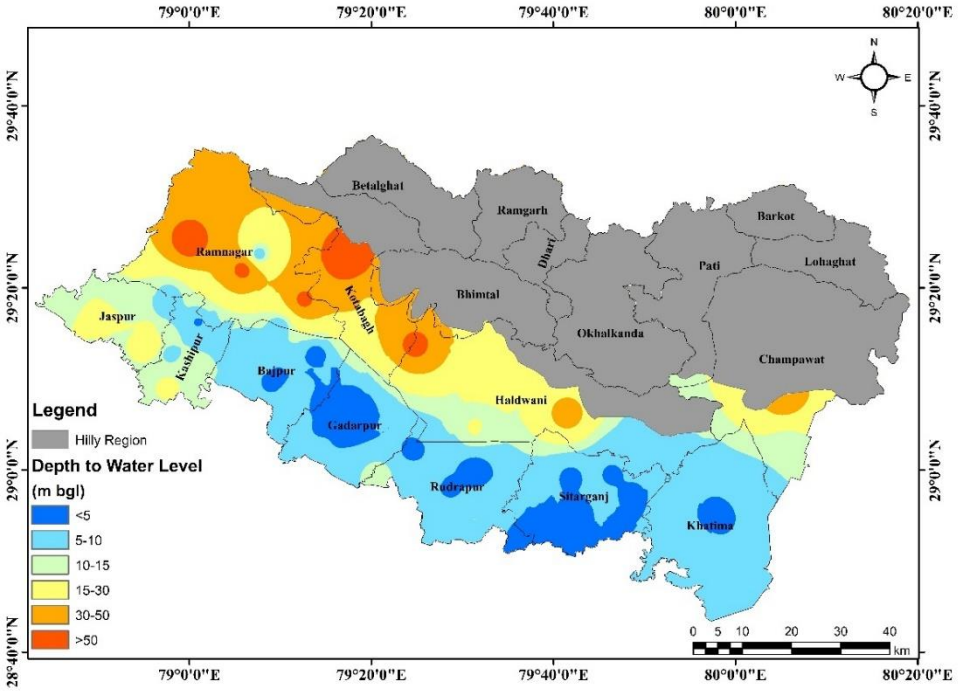


Fig.7: Depth to Water Level Map, Kumaon Region, Uttarakhand State, May 2023

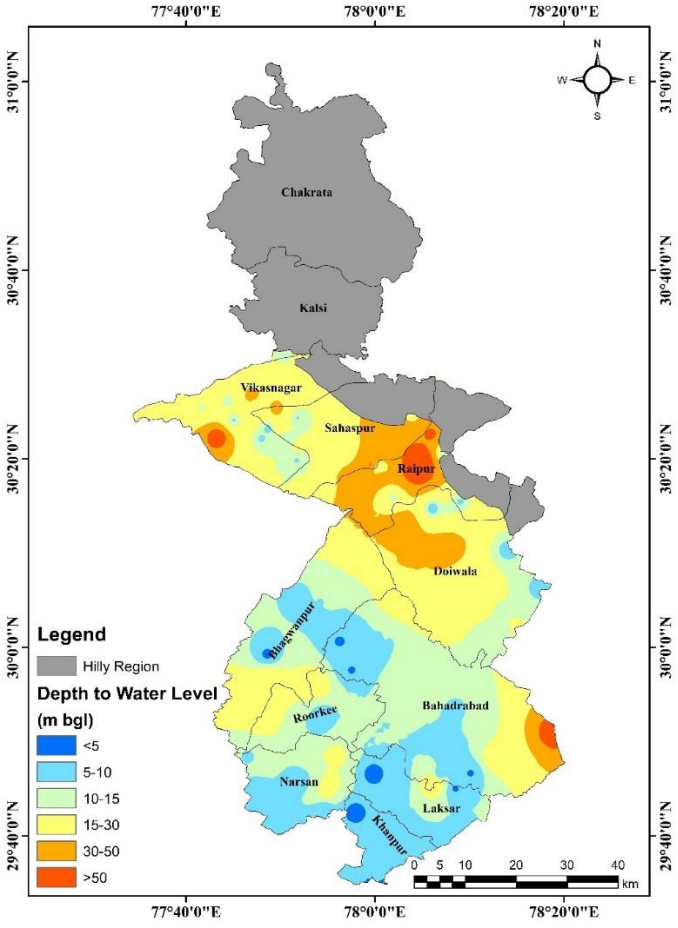


Fig.8: Depth to Water Level Map, Garhwal Region, Uttarakhand State, May 2023

A perusal of **Fig. 8 (Garhwal Section)** reveals that the major part of the southern and western part of the Haridwar district shows water level in the range of 5-10 m bgl. However deeper water level of 15-30 m bgl occur majorly in the Bhagwanpur and western part of the Roorkee blocks of the Haridwar district. However, deeper water level in the range of 30-50 m bgl occurs as concentric ring rimming deepest water level of more than 50 m bgl in the eastern flank of Bahadrabad block of the Haridwar district. The major part of the Dehradun valley is showing water level in the range of 15-30 m bgl. However, Major part of the Raipur block, some parts of Sahaspur block and Doiwala blocks of the Dehradun district shows water level in the range of 30-50 m bgl.

5.1.3 August 2023

During the month of August 2023, total of 170 Groundwater monitoring wells (including dug wells, hand pumps and piezometers) were monitored in Uttarakhand State in District Dehradun, Haridwar, Udham Singh Nagar, Pauri Garhwal, Nainital and Champawat. The depth to water level data has been classified and is given in **Table 7.** A perusal of the table indicates that deepest water level was 96.09 m bgl at Trilokpur in Pauri Garhwal district while the shallowest water level was 0.06 m bgl at Mahabir Nagar in Udham Singh Nagar District. The analysis of depth to water level data has also shown that shallowest water level of 0-5 m was recorded by 71 monitoring wells, which was 41.76% of the total number. Depth to water level in the range of 5-10 m was shown by 36 wells (21.18% of total number), the deeper water levels of 10-15 m was shown by 13 wells (7.65% of total) and the deepest water levels (>15 m) was recorded by 50 monitoring wells, which was 29.41% of the total number of wells in Uttarakhand monitored during August 2023.

Table 7: District wise categorization of the depth to water level data, August 2023

District	No. of stations analyzed	Depth to water level		Depth to water level (m bgl)							
		(m bgl)		0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	51	0.44	81.4	9	17.65	19	37.25	4	7.84	19	37.25
Haridwar	42	0.19	52.62	23	54.76	7	16.67	4	9.52	8	19.05
U. S. Nagar	46	0.06	17.58	36	78.26	7	15.22	2	4.348	1	2.17
Nainital	12	0.06	67.08	3	25	0	0	1	8.33	8	66.67
Champawat	3	5.52	26.31	0	0	2	66.67	0	0	1	33.33
Uttarkashi	9	8.3	29.14	0	0	1	11.11	2	22.22	6	66.67
Tehri Garhwal	5	22.1	50.83	0	0	0	0.00	0	0.00	5	100.00
Pauri Garhwal	2	47.21	96.09	0	0	0	0	0	0	2	100
Total	**170**	**0.06**	**96.09**	**71**	41.76	**36**	21.18	**13**	7.65	**50**	29.41

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for **August *2023*** is shown in ***Fig. 9*** *(Kumaon Section), and Fig.**10** (Garhwal Section).*

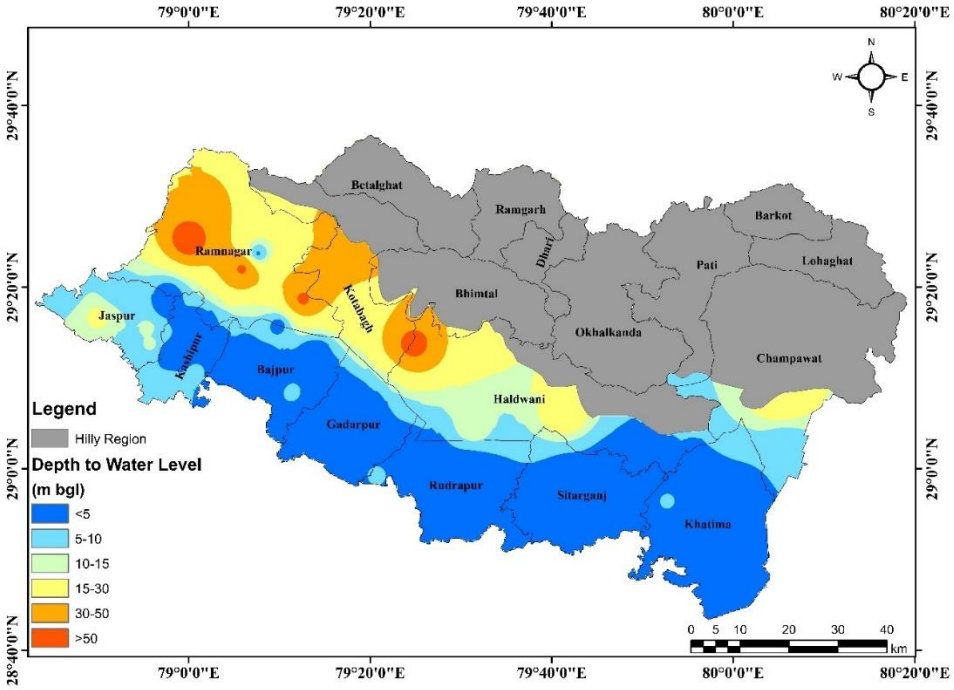


Fig.9: Depth to Water Level Map, Kumaon Region, Uttarakhand State, August 2023

A perusal of **Fig. 9 (Kumaon Section)** reveals that the major part of the Udham Singh Nagar district shows water level less than 5 m bgl. However shallow water level in the range of 5-10 m bgl is covering major part of Jaspur, Kashipur and northern part of the Udham Singh Nagar district. Major part of Nainital district shows water level in the range of 15-30 m bgl. However, deeper water level in the range 30-50 m bgl occurs as concentric layers rimming deepest water level of more than 50 m bgl in some part of the Nainital Valley. Depth to water level in the Champawat district increases gradually from southern part (5-10 m bgl) to northern part (15-30 m bgl).

A perusal of **Fig. 10 (Garhwal Section)** reveals that the major part of the Haridwar district shows water level in the range of 5-10 m bgl. Shallowest water level of >5 m bgl occurs mostly in Khanpur, Laksar and Bahadrabad blocks of the Haridwar district. However, deeper water level in the range of 30-50 m bgl occurs as concentric ring rimming deepest water level of more than 50 m bgl in the eastern flank of Bahadrabad block of the Haridwar district. The major part of the Dehradun valley is showing water level in the range of 15-30 m bgl. However, some part of the Raipur block, and Vikas Nagar blocks of the Dehradun district shows water level in the range of 30-50 m bgl.

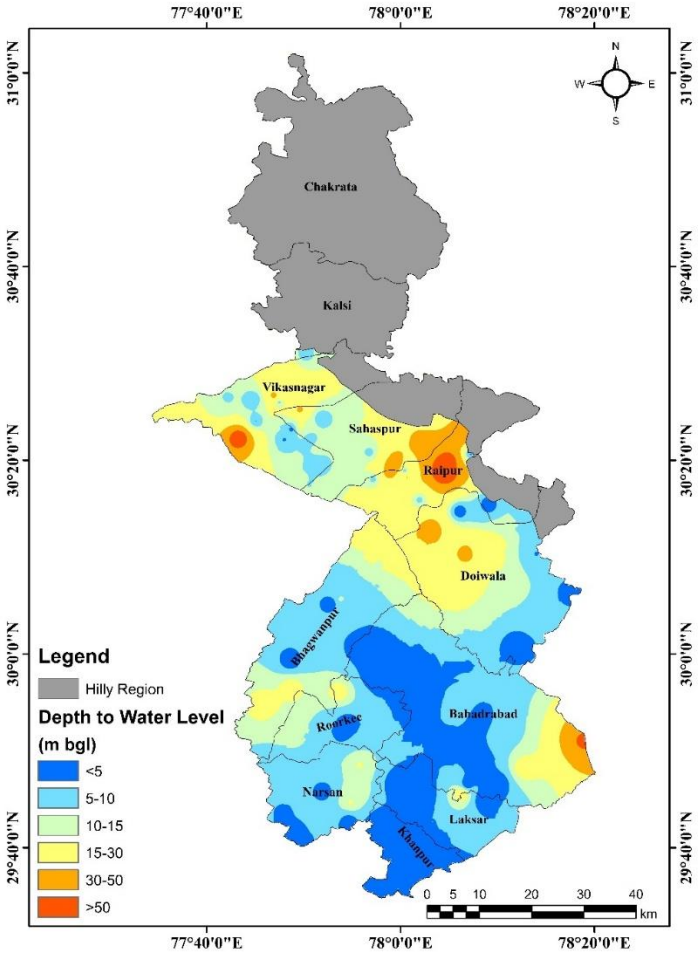


Fig.10: Depth to Water Level Map, Garhwal Region, Uttarakhand State, August 2023

5.1.4 November 2023

The depth to water level data is available for 174 Ground Water Monitoring Wells of Uttarakhand during November 2023. The data has been analysed and shown in ***Table 8***. During this period, the deepest water level of 97.14 m bgl was observed at Trilokpur (Pauri Garhwal district) while the shallowest water level of 0.17 m bgl was observed at Bhagwanpur in Haridwar district. The analysis of depth to water level data shows that out of 174 wells, 63 wells (39.207% of total number) have recorded shallowest water level in the depth range of 0–5 m whereas water level in the range of 5-10 m was recorded in 35 monitoring wells (20.11% of the total number). Deeper water level of 10–15 m was observed in 18 wells, which was 10.34% of the total number whereas the deepest water level of >15 m bgl was recorded in 58 wells (33.33 % of total wells) in Uttarakhand during November 2023.

Table 8: District wise categorization of depth to water level data, November 2023

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	57	1.67	78.85	6	10.53	15	26.32	9	15.79	27	47.37
Haridwar	41	0.17	51.1	19	46.34	9	21.95	6	14.63	7	17.07
U. S. Nagar	45	0.42	17.26	36	80.00	5	11.11	3	6.67	1	2.22
Nainital	12	3	64.58	2	16.67	2	16.67	0	0.00	8	66.67
Champawat	3	8.41	28.68	0	0.00	2	66.67	0	0.00	1	33.33
Uttarkashi	9	9.13	32.08	0	0.00	2	22.22	0	0.00	7	77.78
Pauri Garhwal	2	43.2	97.14	0	0.00	0	0.00	0	0.00	2	100.00
Tehri Garhwal	5	23.35	76.4	0	0.00	0	0.00	0	0.00	5	100.00
Total	**174**	**0.17**	**97.14**	**63**	36.21	**35**	20.11	**18**	10.34	**58**	33.33

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for November ***2023*** is shown in ***Fig. 11*** *(Kumaon Section), and Fig.**12** (Garhwal Section).*

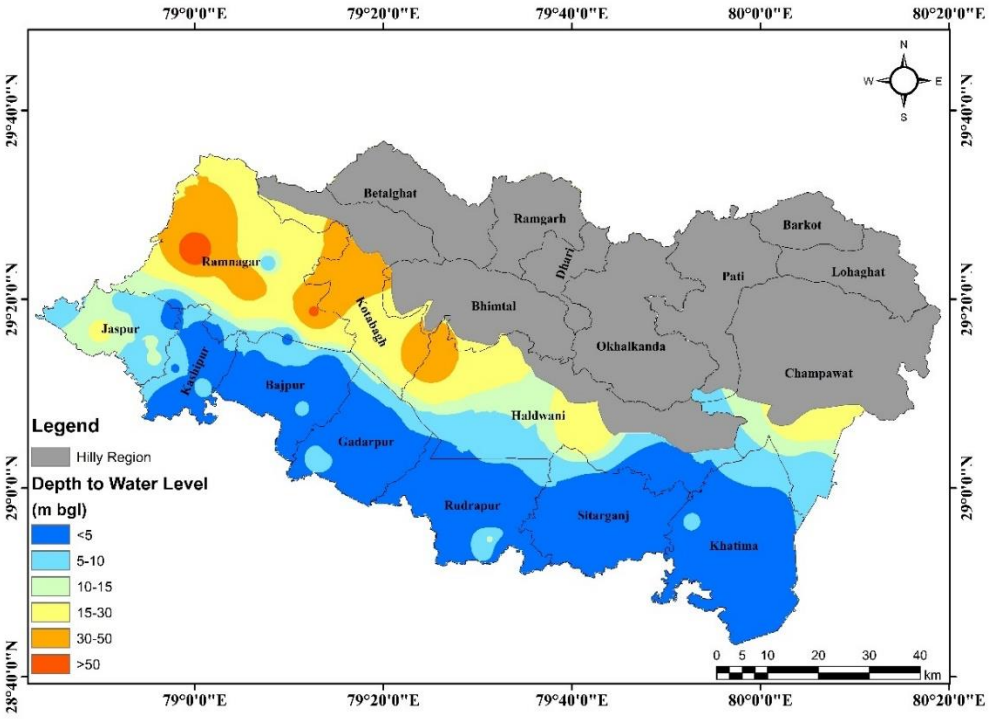


Fig.11: Depth to Water Level Map, Kumaon Region, Uttarakhand State, November 2023

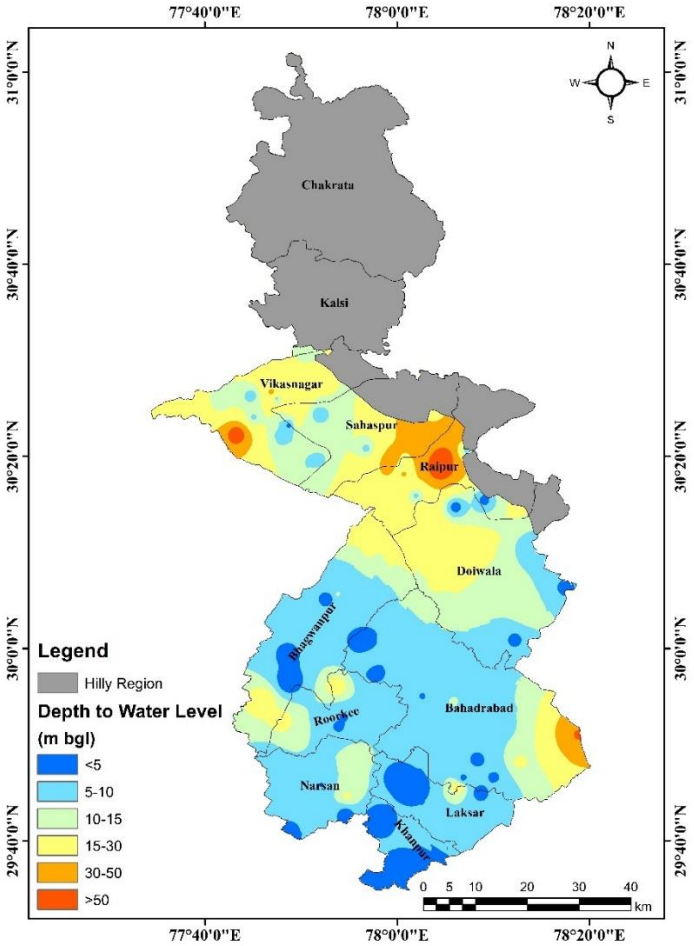


Fig.12: Depth to Water Level Map, Garhwal Region, Uttarakhand State, November 2023

A perusal of **Fig. 11 (Kumaon Section)** reveals that the major part of the Udham Singh Nagar district shows water level less than 5 m bgl. However, shallow water level in the range of 5-10 m bgl is covering major part of Jaspur, Kashipur and northern part of the Udham Singh Nagar district. Major part of Nainital district shows water level in the range of 15-30 m bgl. However, deeper water level in the range 30-50 m bgl occurs as concentric layers rimming deepest water level of more than 50 m bgl in some part of the Nainital Valley. Depth to water level in the Champawat district increases gradually from southern part (5-10 m bgl) to northern part (15-30 m bgl).

A perusal of **Fig. 12 (Garhwal Section)** reveals that the major part of the Haridwar district shows water level in the range of 5-10 m bgl. Shallowest water level of >5 m bgl occurs mostly in Khanpur, and Bahadrabad blocks of the Haridwar district. However, deeper water level in the range of 30-50 m bgl occurs as concentric ring rimming deepest water level of more than 50 m bgl in the eastern flank of Bahadrabad block of the Haridwar district. The major part of the Dehradun valley is showing water level in the range of 15-30 m bgl. However, some part of the Raipur block, and Vikas Nagar blocks of the Dehradun district shows water level in the range of 30-50 m bgl.

5.2DISCHARGE OF SPRINGS

The discharge data of forty-one cold-water springs in Dehradun, Nainital, Uttarkashi and Almora districts for the months of January, May, August, and November 2022 is given in Table 9. A study of the table shows that spring discharge is lowest in pre-monsoon (May) whereas during post-monsoon (August), the discharge increased significantly. This indicates that rainfall is the principal contributing factor for variation in spring discharge.

A persual of ***Table 9*** indicates that discharge of the cold-water springs during the period May 2023-January 2024 varies from a minimum measurable discharge of 0.1 LPM at Golucheena (Almora) in January 2024 to a maximum of 606.06 LPM at Sipahi Dhara, Nainital district (August 2023). Discharge of springs varies within wide limits during the intervening period.

In Dehradun district, spring discharge varies between 3 LPM at Soda Sarauli in May 2023, and 30 LPM at Soda Sarauli in August 2023. In Nainital district, spring discharge varies from a minimum of 2 LPM at Kudaghat (May 2023) to a maximum of 606.06 LPM at Sipahidhara (August 2023). In Almora district, the spring discharge was found to be varying from a minimum of 0.1 LPM at Golucheena in January 2024 to a maximum of 92.31 LPM at Peepaldhar in November 2023. In Uttarkashi district, spring discharge was varying from 3.7 LPM at Nagal in May 2023 to a maximum of 450 LPM in Ganganani in August 2023.

Table 9: Discharge of Springs in May, August, November 2023 and January 2024 (in LPM)

S.No.	District	Location Details	Spring Discharge (in lpm)			
			Jan-24	Nov-23	Aug-23	May-23
1	Dehradun	Soda Saroli	7.32	20	30	3
2	Dehradun	Bhatta	3.73	4.74	6	3.75
3	Dehradun	Khandoli	15.03	16.08	6.25	16.2
4	Nainital	Amritpur (Ranibagh)	12	30	92.31	4.96
5	Nainital	Salari	12.5	24	5.77	4.4
6	Nainital	Dogaon	37.5	9.38	46.11	14.39
7	Nainital	Sipahi Dhara	380.5	461.54	606.06	46.75
8	Nainital	Garampani	16.67	22.22	35.16	23.05
9	Nainital	Jyolikot	15	26.09	56.55	11.08
10	Nainital	Kudaghat (Kuda Pahar)	8.57	8.57	36.88	2
11	Almora	Patali Talla	2.18	10.08	13.02	10.66
12	Almora	Patali Malla	26.75	79.8	3.93	9.84
13	Almora	Baniya Diggi	3.38	6.86	4.4	0.53

14	Almora	Goluchheena	0.1	0.5	1.23	0.37
15	Almora	Katarmal	16.67	21.43	11.59	16.67
16	Almora	Dharanaula	6	6.67	7.03	6.8
17	Almora	Palna	1.91	3.36	1.97	1.45
18	Almora	Bhagtola	0.8	3.75	2.83	1.71
19	Almora	Jholi	9.38	10.34	10	10.08
20	Almora	Itola	3.24	3.24	4.38	1.56
21	Almora	Chanoda	1.3	1.94	1.83	0.92
22	Almora	Paitsaal	4.29	13.64	11.59	2.17
23	Almora	Guruda-I	13.64	14.46	3.24	1.26
24	Almora	Chhani Bartola	8.69	18.46	14.89	4.75
25	Almora	Dhansari	26.67	54.55	74.53	3.39
26	Almora	Deepakot	12	11.54	13.83	8.53
27	Almora	Dhalnagaon	8.82	11.43	23.5	4.59
28	Almora	Simalkhet	5	11.88	40.03	1.87
29	Almora	Peepal Dhar	79.15	92.31	72.46	7.56
30	Almora	Ramghat	3.64	16.44	33.87	6.83
31	Almora	Naula	NA	NA	1.87	1.27
32	Almora	Mehragaon (Someshwar)	1.94	8.35	82.36	2.63
33	Almora	Lodh	2.4	5.45	6.63	2.08
34	Almora	Bhoolgaon SP	16.22	60	1.53	23.67
35	Almora	Dudholi	9.09	17.14	21.88	4.82
36	Almora	Deghat	0.2	0.5	2.06	NA
37	Champawat	Chalthi	5.78	NA	NA	NA
38	Champawat	Swala	32.6	NA	NA	NA
39	Champawat	Majhera	23.17	NA	NA	NA
40	Champawat	Bangaon	3.18	NA	NA	NA
41	Champawat	Basaan	11.87	NA	NA	NA
42	Champawat	Ghat	1.4	NA	NA	NA
43	Uttarkashi	Dharasu	11.56	8.92	10.45	3.75
44	Uttarkashi	Nagal	11.11	7.57	33.57	3.7
45	Uttarkashi	Ratodi Sar	12.24	10.91	10	6.6
46	Uttarkashi	Ganganani	231.58	270.02	450	9.6
47	Tehri Garhwal	Tachhala	26.08	40	NA	NA
48	Tehri Garhwal	Jakhani	6.38	12.91	NA	NA
49	Tehri Garhwal	Dholapani	30.29	59.05	NA	NA
50	Tehri Garhwal	Jakhnyali	1.05	NA	NA	NA
51	Tehri Garhwal	Pilkhi	2.06	NA	NA	NA
52	Tehri Garhwal	Gojiyana	4.47	NA	NA	NA
53	Tehri Garhwal	Holta	95.71	NA	NA	NA
54	Bageshwar	Shimar	21.43	24	NA	NA
55	Bageshwar	Bamrari	54.55	34.29	NA	NA
56	Bageshwar	Kamedi	4.62	4.9	NA	NA

57	Bageshwar	Kukura khad	9.38	7.5	NA	NA
58	Bageshwar	Sainj	21.43	27.27	NA	NA
59	Bageshwar	Gadhia Gaon 1	NA	10	NA	NA
60	Bageshwar	Khark tamta	11.76	22.22	NA	NA
61	Bageshwar	Napoliya	2.91	3.64	NA	NA
62	Bageshwar	Amsarkote	80	80	NA	NA
63	Bageshwar	Gair ki Dhara	54.54	NA	NA	NA
64	Chamoli	Mayapur	27.27	17.96	NA	NA
65	Chamoli	BanjBagd	7.79	9.79	NA	NA
66	Chamoli	Karanprayag	7.14	3.33	NA	NA
67	Chamoli	Kameda	11.76	NA	NA	NA
68	Chamoli	Drongiri	17.14	NA	NA	NA
69	Chamoli	Nauganga	13.04	NA	NA	NA
70	Chamoli	Sunil	9.23	NA	NA	NA
71	Chamoli	Singdhar Gopaldhar	66.25	NA	NA	NA
72	Chamoli	Singhdhar	11.35	NA	NA	NA
73	Chamoli	Gorang	30	NA	NA	NA
74	Rudraprayag	Tilwara	4.61	NA	NA	NA
75	Rudraprayag	Siyalsu	23.57	NA	NA	NA
76	Rudraprayag	IndraNagar	20.27	NA	NA	NA
77	Rudraprayag	Gorti	5.45	NA	NA	NA
78	Rudraprayag	Amroti	20.71	NA	NA	NA
79	Pithoragarh	Panda	16.24	NA	NA	NA
80	Pithoragarh	Pithoragarh	9.85	NA	NA	NA
81	Pithoragarh	Hudkanna	47.18	NA	NA	NA
82	Pithoragarh	Timta	9.79	NA	NA	NA

NA: Not Available

5.3LONG TERM (DECADAL) DEPTH TO WATER LEVEL

The available long-term data of ground water levels in some of the Ground Water Monitoring Wells of the state was analysed to have an idea of the decadal (long-term) water level data and decadal versus current depth to water level fluctuations. The average value of depth to water level for selected Ground Water Monitoring Wells (based on availability of long-term water level data) was calculated for the past ten years (January, May, August and November for the period from 2012 to 2021). The average depth to water level data available for Ground Water Monitoring Wells is given in Table 10.

Table 10: Long-term (Decadal) Depth to Water Level Data, Uttarakhand State (in m bgl)

Sl No.	Location Details	Avg January	Avg May	Avg August	Avg November
		2014-2023	2013-2022		
Dehradun District					
1	**Khandgaon**	9.01	10.88	5.71	6.49
2	**Khadiri (Khadak Maf)**	14.15	15.54	11.80	14.91
3	**Rishikesh**	5.49	8.34	4.56	6.17
4	**Lal Tappar**	14.21	18.34	14.43	14.15
5	**Bhaniawala**	28.36	34.51	21.93	24.98
6	**Dudhli* new**	36.11	40.74	35.91	30.28
7	**Kotimachak**	19.72	21.28	11.34	16.55
8	**Chandmari**	29.92	35.09	28.54	27.65
9	**Duggiawala**	3.70	5.03	3.56	4.46
10	**Mathrowala**	10.10	12.13	8.69	9.19
11	**Kuanwala**	6.01	10.10	0.81	2.78
12	**Gularghagti**	11.40	13.35	8.82	10.53
13	**Maldeota**	11.57	13.48	4.86	8.10
14	**Nanurkhera**	61.88	70.72	64.02	60.30
15	**Tarla Nagal**	73.02	75.51	66.28	67.03
16	**Tarla Nagal**	73.02	75.51	49.61	54.18
17	**Purukulgaon**	25.75	27.17	17.87	23.11
18	**Niranjanpur**	32.51	36.60	36.63	32.15
19	**CGWB Office**	NA	58.84	58.28	55.27
20	**Harbanswala**	49.17	53.05	50.98	46.16
21	**Kanwali**	13.08	15.03	8.98	11.69
22	**Bhopalpani (Badawali)**	6.94	9.85	2.25	2.34
23	**Ladpur**	73.84	77.16	81.04	80.32
24	**Singhniwala**	8.93	9.34	7.20	8.61
25	**Baronwala**	19.69	17.47	16.97	18.80
26	**Ramgarh**	NA	NA	4.98	5.89
27	**Jhajra**	9.82	13.09	6.89	7.93
28	**Jhajra**	9.82	13.09	7.32	7.50
29	**Nanda ki Chowki**	10.63	14.74	8.42	8.52
30	**Nanda ki Chowki**	10.63	14.74	11.74	11.13

31	**Selakui**	9.35	16.27	6.56	8.61
32	**Selakui**	9.35	16.27	11.76	13.08
33	**Sabhawala**	8.87	9.06	5.92	7.29
34	**Rampura**	10.92	11.08	7.87	10.02
35	**Shankarpur**	21.49	23.02	18.81	20.81
36	**Redapur**	6.45	8.90	6.61	5.68
37	**Redapur**	6.45	8.90	4.05	NA
38	**Sahaspur**	6.88	9.04	5.25	6.95
39	**Chhorba**	30.60	35.56	33.39	31.94
40	**Telpura**	34.76	39.65	37.50	35.84
41	**Badripur**	8.95	9.32	7.11	8.69
42	**Judli**	13.10	13.46	11.32	12.80
43	**Herbertpur**	9.96	10.10	6.44	8.50
44	**Vikas Nagar**	26.87	26.93	22.24	24.83
45	**Dharmawala**	NA	NA	3.60	NA
46	**Dakpatthar**	25.57	27.09	22.06	25.31
47	**Barothiwala**	4.37	4.23	2.66	26.60
48	**Dhakrani**	17.54	16.21	10.49	15.44
49	**Timli**	61.34	65.78	56.49	61.84
50	**Baluwala**	36.14	36.19	35.51	35.08
51	**Luxmipur**	28.44	28.36	26.07	27.22
52	**Haripur**	11.19	11.06	7.67	9.88
53	**Jamuna Pull**	NA	15.10	9.35	12.50
Haridwar District					
54	**Shahidwala Grant**	10.83	11.15	10.73	10.11
55	**Sahidwala Grant**	10.45	11.99	10.25	10.03
56	**Budhwa Shahid**	3.57	4.91	3.11	3.03
57	**Bugawala**	6.21	7.73	6.44	6.18
58	**Bahabalpur**	2.81	3.26	2.02	2.49
59	**Bhagwanpur**	17.54	19.55	19.78	17.25
60	**Chudiala**	20.03	21.95	20.54	19.23
61	**Iqbalpur**	14.10	16.06	14.14	15.35
62	**Jaswawala**	3.80	4.60	3.27	3.51
63	**Kota Muradnagar**	9.62	10.54	8.31	9.37
64	**Bandarjud**	NA	11.10	8.63	8.88
65	**Rathora**	4.95	5.01	4.26	4.16
66	**Bahadrabad**	11.92	10.47	12.73	11.81
67	**Sarai**	12.99	13.09	11.28	11.92
68	**Dhanpura**	6.69	8.79	5.66	8.96
69	**Shahpur Shitlakhera**	4.12	5.67	3.31	3.70
70	**Laldhang**	57.04	65.39	61.67	56.21
71	**Bhogpur**	3.47	4.09	1.84	2.74
72	**Dalupuri**	25.67	28.33	27.02	24.75

73	**Panjaheri**	7.32	7.67	4.63	6.17
74	**Rasiyabad Choraha**	4.11	3.58	2.44	1.78
75	**Shyampur**	10.09	10.31	8.71	9.32
76	**Jassodharpur**	3.55	3.28	4.62	3.34
77	**Bhoopatwala**	9.25	10.73	8.01	3.89
78	**Imlikhera**	14.96	16.36	15.64	16.16
79	**Roorkee**	6.15	7.78	6.25	6.32
80	**Sikhar**	16.37	18.46	17.27	16.29
81	**Khera Jat**	5.65	6.68	5.61	5.60
82	**Nizampur**	NA	10.93	10.35	10.35
83	**Malakpur Mazra**	5.76	7.06	6.40	4.33
84	**Jhabreda**	9.09	9.71	8.55	9.50
85	**Landhaura**	18.03	18.75	17.70	17.20
86	**Lakhnauta**	6.83	6.49	5.33	5.96
87	**Gurukul Narsen**	6.09	6.18	4.20	5.08
88	**Libhrahedi**	6.44	8.03	5.60	6.07
89	**Mudlana**	17.66	16.93	17.61	17.50
90	**Hussainpur**	1.76	3.66	1.33	2.05
91	**Laksar**	3.03	4.17	2.21	2.90
92	**Bhikkampur**	3.32	3.89	2.09	2.29
93	**Govardhanpur**	2.16	3.88	1.78	2.31
94	**Dallawala**	1.75	1.93	0.89	1.37
95	**Khanpur**	2.47	4.06	2.00	2.77
Nainital District					
96	**Khaat Baans**	29.23	29.31	27.32	30.13
97	**Lalkuan**	9.47	13.60	12.11	10.41
98	**Lamachaur**	44.57	48.41	50.61	42.13
99	**Kaladungi**	29.03	30.07	27.54	27.38
100	**Kathgodam**	18.80	19.07	15.19	16.89
101	**Belparao**	57.75	NA	56.34	56.29
102	**Maldhan Colony**	3.10	5.11	3.55	4.18
103	**Dhela**	NA	69.53	68.72	71.79
104	**Ram Nagar**	7.18	7.89	6.72	8.83
105	**Garjiya**	NA	NA	3.28	4.18
106	**Dohniya**	59.71	63.67	57.72	55.87
107	**Chilkiya**	53.92	56.02	48.70	51.57
Udham Singh Nagar District					
108	**Kanchanpur (Majhola)**	4.34	5.20	4.29	3.71
109	**Khatima**	2.14	3.01	1.38	1.79
110	**Sarasariya**	3.95	6.55	5.21	3.79
111	**Chakarpur**	5.72	6.50	4.54	4.29
112	**Barianjaniya**	3.93	5.56	3.02	3.24
113	**Sitarganj**	1.53	3.20	1.21	1.25

114	**Nanak Mata**	2.92	4.52	2.10	2.63
115	**Kalyanpur**	2.28	3.47	1.71	2.21
116	**Tukri**	2.83	4.37	3.13	2.58
117	**Begur Mod**	3.36	4.25	3.27	3.15
118	**Bidora**	2.81	4.54	4.37	2.28
119	**Dhyanpur**	1.70	4.14	2.27	1.21
120	**Bara**	2.01	2.18	1.14	2.01
121	**Kichha**	7.44	8.73	7.70	7.80
122	**Kamaria Pakki**	4.79	7.61	6.06	4.57
123	**Gangapur**	2.66	3.88	2.71	2.59
124	**Shantipuri**	1.65	1.99	1.06	1.74
125	**Patthar Chatta**	2.30	3.38	2.41	2.50
126	**Rudrapur**	2.58	3.67	2.82	2.84
127	**Kanakpur**	2.36	3.97	3.98	2.43
128	**Rajpura**	2.53	4.09	3.20	2.43
129	**Pipaliya**	3.13	6.87	5.76	3.60
130	**Jhagarpuri**	3.17	3.31	2.20	3.69
131	**Mahabir Nagar**	1.94	3.14	1.25	1.85
132	**Kopa Signal**	0.50	0.83	1.11	0.85
133	**Beria Daulat**	3.03	3.26	2.33	2.64
134	**Bhagwanpur**	3.79	10.31	8.52	3.40
135	**Pattharpui**	3.20	3.80	2.57	3.24
136	**Lalpuri**	1.84	2.73	1.97	1.76
137	**Bazpur**	1.66	2.69	0.86	1.28
138	**Jharkhandi**	1.57	2.32	1.66	1.38
139	**Jogipura**	3.49	5.95	4.16	3.71
140	**Banna Khera**	3.62	5.08	3.79	3.73
141	**Pritpur**	3.60	6.50	4.56	3.26
142	**Badaripur**	4.09	6.68	5.46	NA
143	**Barkhare Pande**	5.78	11.32	7.56	4.03
144	**Sultanpur Patti**	2.86	4.79	3.34	2.63
145	**Kashipur**	4.95	7.18	5.22	5.22
146	**Bharatpur**	7.82	11.38	11.16	7.81
147	**Dhanauri Patti**	2.46	4.49	2.88	2.94
148	**Durgapur**	3.19	5.56	3.77	2.90
149	**Shand Khera**	5.27	9.26	6.84	5.24
150	**Jaspur**	13.88	16.01	14.03	12.33
151	**Patrampur**	7.43	10.92	10.49	7.72
152	**Angadpur**	6.93	12.22	9.06	8.63
153	**Missarwala**	7.26	14.47	12.07	8.43
Champawat District					
154	**Tanakpur**	10.46	NA	8.39	9.34
155	**Bastia**	33.49	35.80	25.15	25.29

156	**Bichai**	9.81	11.74	8.80	9.70
Pauri Garhwal District					
157	**Kaudia (Kotdwar)**	53.29	57.56	55.88	52.56
158	**Trilokpur**	NA	86.54	86.43	74.32
Uttarkashi District					
159	**Chinyalisaur**	28.34	33.05	23.95	16.88
160	**Devidhar**	11.43	10.90	8.66	9.86
161	**Uttarkashi**	17.60	17.45	15.20	16.05
162	**Barkot**	16.54	16.25	15.21	16.66
163	**Sharukhet**	39.83	39.84	37.83	39.81
164	**Ganeshpur**	17.36	16.56	14.13	16.17
165	**Maneri**	23.90	21.98	20.99	25.86
166	**Charethi**	25.57	20.43	19.83	21.66
167	**Dunda**	33.52	31.92	22.53	6.73

5.4 WATER LEVEL FLUCTUATION

The changes in ground water level in response to recharge and ground water withdrawal are important aspects for study of the overall hydrogeological scenario of an area. The water level fluctuation is calculated in each case under the following three categories.

- Changes in water level during each period of observation with respect to average water level for the last ten years for that period.
- Changes in water level during each season/period with respect to observed data of pre-monsoon water level during the same year.
- Changes in water level during each season/period with respect to water levels observed in previous year of the same period.

Tables and maps, which show the long-term (decadal), yearly and seasonal water level fluctuations, were prepared for the monitoring wells of Dehradun, Haridwar, Udham Singh Nagar, Nainital and Champawat district. The analysis of water level fluctuation data and conclusion drawn from it are discussed below.

5.4.1 DECADAL (LONG-TERM) WATER LEVEL FLUCTUATION

5.4.1.1 Water Level Fluctuation (January 2014-2023 versus January 2024)

Decadal (long-term) water level data for 160 ground water monitoring wells is analysed and is given in ***Table 11***.

A perusal of the table indicates that out of 160 monitoring wells, 58 wells (36.25% of the total number) had shown the minimum decadal rise in the range 0-2 m, 14 wells (8.75% of the total number) of monitoring wells had shown a higher rise in the range 2-4 m while 12 wells (7.5% of total) had shown the highest decadal rise of >4 m. The minimum decadal decline in the rangeof 0-2 m is shown by 58 wells (36.25% of total) while 11 wells (6.88%) had shown higher decadal rise of 2-4 m. 7 monitoring well (4.38%) has recorded the highest decadal decline (>4 m) in Uttarakhand State.

The decadal water level fluctuation map for average (January 2014 -2023) versus January 2024 is shown in ***Fig.13****(Kumaon Section), and* ***Fig.14*** *(Garhwal section).*

A perusal of **Fig. 13** (Kumaon Region) reveals that minimum decadal rise of 0-2 m is observed in major part of the Udham Singh Nagar district, Haldwani block of Nainital district and Champawat district. Champawat district is representing mainly rising decadal water level trend from south to north of the district. Minimum decadal rise of 0-2 m is observed in major part of the Bajpur block, some parts of Gadarpur, Kashipur and Jaspur blocks of the Udham Singh Nagar district and north-western part of Ramnagar block and central part of Kotabag block of Nainital district. Higher decadal rise of 2-4 m observed as rimming the highest decadal rise of >4 m in the northern part of the Kotabag-Ramnagar blocks of the Nainital district.

A perusal of **Fig. 14** (Garhwal Region) reveals that minimum decadal rise of 0-2 m is observed in major part of the Haridwar district and Dehradun Valley. However higher decadal rise of 2-4 m is observed in the Bahadrabad and Southern part of Bhagwanpur blocks of Haridwar district and in major part of Doiwala block and some part of Raipur block of the Dehradun district. Minimum decadal decline of 0-2 m is observed in Eastern part of Bahadrabad and Laksar blocks, southern part of Laksar block, major portion of Bhagwanpur block of Haridwar district and southern part of Vikas Nagar and Sahaspur blocks and northern part of Raipur and Doiwala block of Dehradun district. Highest decadal decline of >4 m is observed mainly in the eastern part of Bahadrabad block of the Haridwar district.

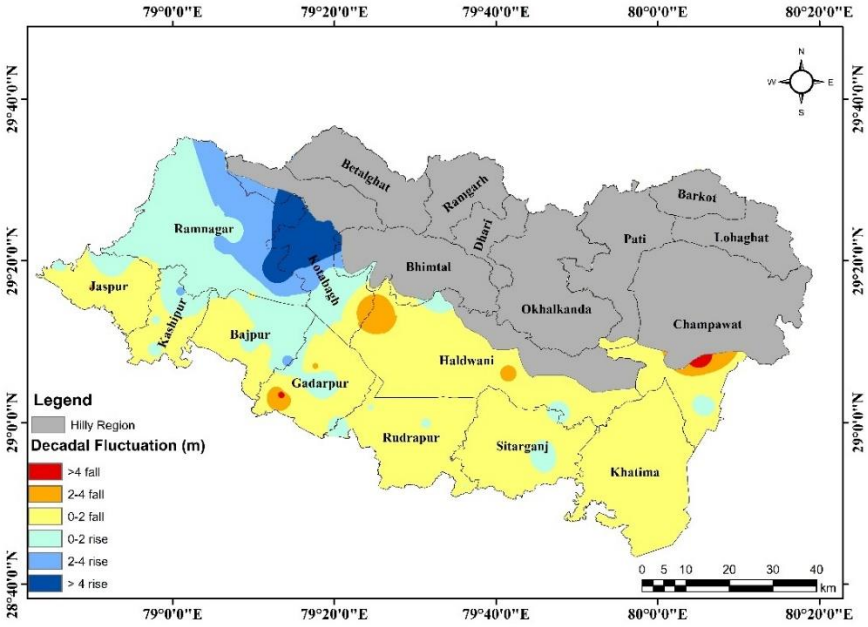


Fig.13: Decadal Water Level Fluctuation (Jan 2014-2023 Vs Jan 2024), Kumaon Region

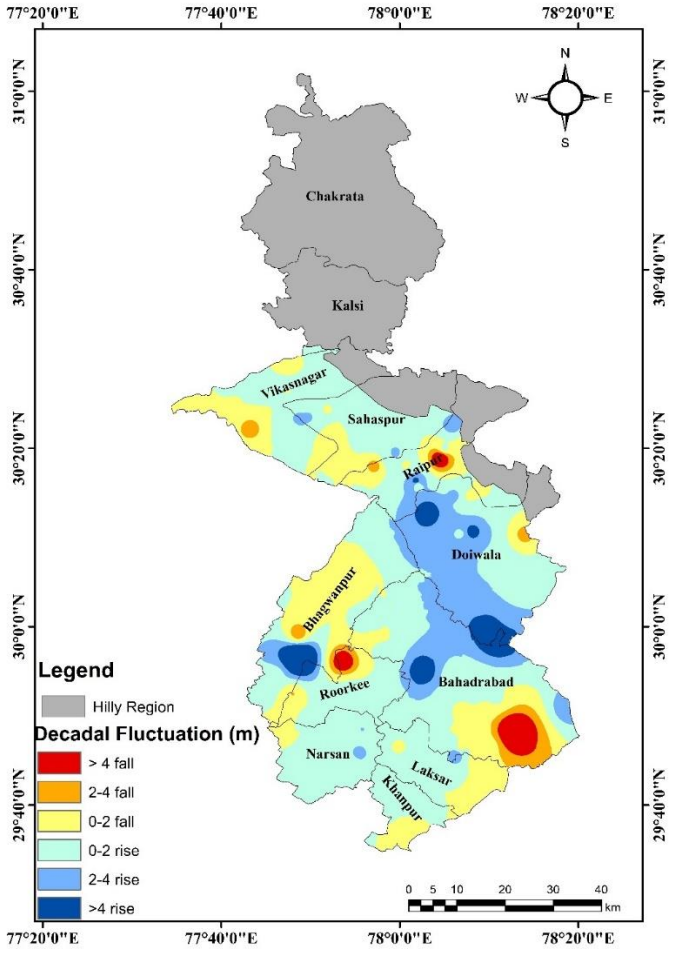


Fig.14: Decadal Water Level Fluctuation (Jan 2014-2023 Vs Jan 2024), Garhwal Region

Table 11. Decadal Water Level Fluctuation (January 2014-January 2023 versus January 2024)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	49	0.20	6.42	0.05	8.77	22	44.90	7	14.29	3	6.12	13	26.53	3	6.12	1	2.04
Haridwar	40	0.3	15.99	0.01	12.23	15	37.50	4	10.00	3	7.50	14	35.00	2	5.00	2	5.00
Udham Singh Nagar	46	0.007	3.03	0.09	4.94	15	32.61	2	4.35	0	0.00	25	54.35	3	6.52	1	2.17
Nainital	11	0.00	11.57	1.93	3.96	5	45.45	1	9.09	2	18.18	2	18.18	1	9.09	0	0.00
Champawat	4	0.44		0.02	5.23	1	25.00	0	0.00	0	0.00	1	25.0	0	0.00	2	50.00
Pauri Garhwal	1	5.46		0.00		0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
Uttarkashi	9	5.1	16.65	0.33	7.31	0	0.00	0	0.00	3	33.33	3	33.33	2	22.22	1	11.11
Total	**160**					**58**	36.25	**14**	8.75	**12**	7.50	**58**	36.25	**11**	6.88	**7**	4.38

5.4.1.2 Water Level Fluctuation (May 2013-2022 versus May 2023)

The analysis of decadal depth to water level data for **163** ground water monitoring wells is given in ***Table 12***. A perusal of the table indicates that the minimum long-term rise in the range of 0-2 m is observed in 49 monitoring wells (30.06 % of the total number) whereas higher rise in the range of 2-4 m is observed in 6 wells (3.68 % of total). The 2 nos. of well (1.23%) recorded the decadal rise in water level (>4 m). The lowest long-term decline in the range of 0-2 m is recorded in 63 wells, which is 38.65% of the total number. Higher long-term decline in the range of 2-4 m is recorded in 24 wells, which is 14.72% and the highest decline of >4 m is recorded in 19 wells, which is 11.66% of the total number.

The decadal water level fluctuation map for average (May 2013-2022) versus May 2023 is shown in ***Fig.15****(Kumaon Section), and* ***Fig.16*** *(Garhwal section).*

A perusal of **Fig. 15** (Kumaon Region) reveals that minimum decadal decline of 0-2 m is observed in major part of the Udham Singh Nagar, Nainital and Champawat district. Higher decadal decline of 2-4 m is observed rimming the highest decadal decline of >4 m in Kashipur, Jaspur, Rudrapur blocks of Udham Singh Nagar district and Haldwani and Kotabag blocks of Nainital district. Minimum decadal rise of 0-2 m is observed in the Ramnagar block of the Nainital district and southern part of the Champawat district.

A perusal of **Fig. 16** (Garhwal Region) reveals that minimum decadal decline of 0-2 m is observed in major part of Haridwar and Dehradun district. Higher Decadal decline of 2-4 m is observed as rimming highest decadal decline of >4 m in the eastern flank of Bahadrabad block, some parts of Bhagwanpur-Roorkee blocks of Haridwar district and in some parts of Vikas Nagar, Raipur and Doiwala blocks of Dehradun district. Minimum decadal rise of 0-2 m is observed mainly in the Narsan, Laksar and Khanpur blocks of Haridwar district and in some northern part of Raipur and Doiwala blocks of Dehradun district.

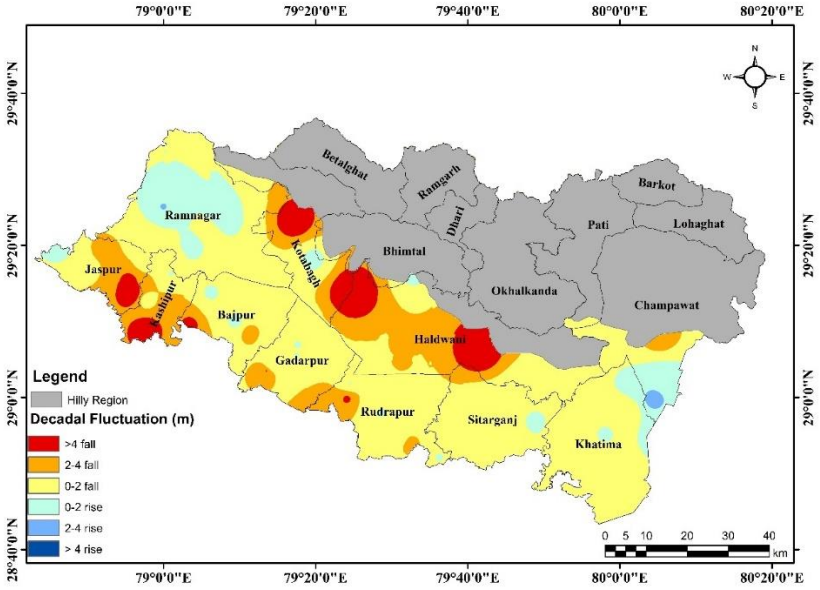


Fig.15: Decadal Water Level Fluctuation (May 2013-2022 Vs May 2023), Kumaon Region

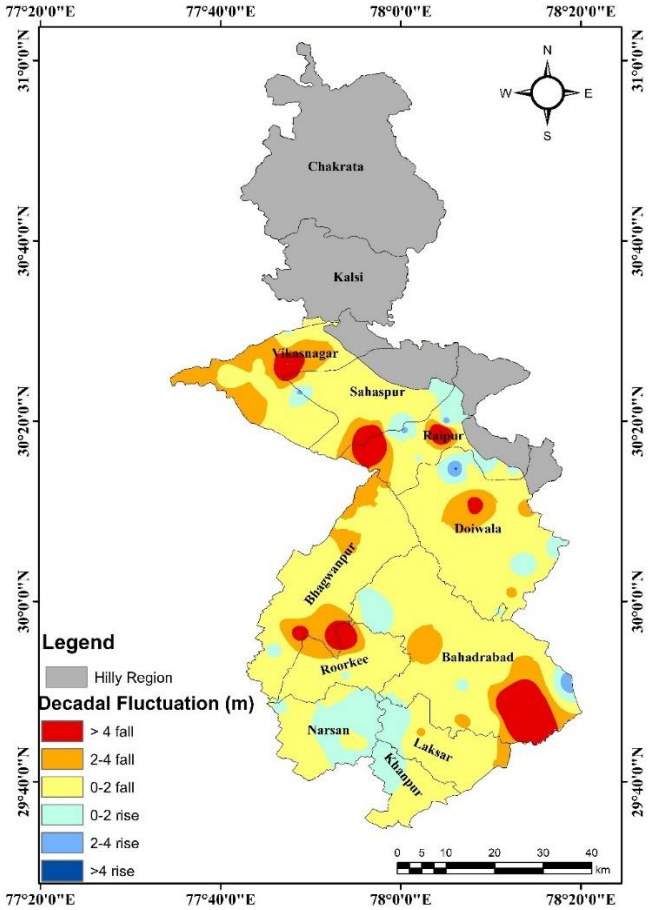


Fig.16: Decadal Water Level Fluctuation (May 2013-2022 Vs May 2023), Garhwal Region

Table 12. Decadal Water Level Fluctuation (May 2013 –May 2022 versus May 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	50	0.11	4.15	0.04	19.03	16	32.00	3	6	1	2.00	16	32.00	10	20.00	4	8.00
Haridwar	42	0.12	3.26	0.05	17.36	16	38.10	1	2.38	0	0.00	17	40.48	5	11.90	3	7.14
Udham Singh Nagar	46	0.06	1.03	0.11	6.27	11	23.91	0	0.00	0	0.00	24	52.17	5	10.87	6	13.04
Nainital	11	0.38	2.08	1.11	8.40	4	36.36	1	9.09	0	0.00	2	18.18	1	9.09	3	27.27
Champawat	3	1.44	2.79	0	3.54	1	33.33	1	33.33	0	0.00	0	0.0	1	33.33	0	0.00
Pauri Garhwal	2	0.00	0.00	0.92	10.89	0	0.00	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
Uttarkashi	9	1.35	8.22	1.7	14.74	1	11.11	0	0.00	1	11.11	3	33.33	2	22.22	2	22.22
Total	**163**					**49**	30.06	**6**	3.68	**2**	1.23	**63**	38.65	**24**	14.72	**19**	11.66

5.4.1.3 Water Level Fluctuation (August 2013-2022 versus August 2023)

Long-term water level data for 167 monitoring wells is analysed and is shown in ***Table 13***.A perusal of **Table 13** indicates that the minimum long-term rise in the range of 0-2 m is observed in 73 monitoring wells 43.71 % of the total number), whereas higher rise in the range of 2-4 m is observed in 33 wells (19.76 % of total) and the highest rise of >4 m is observed in 17 monitoring wells(10.18% of total). The lowest long-term decline of water level in the range of 0-2 m is recorded in 28 monitoring wells, which is 16.77 % of the total number. Higher long-term decline in the range of 2-4 m is recorded by 9 wells (5.39 % of total) whereas the highest decline of >4 m is observed in 7 monitoring wells, which is 4.19% of the total number of wells.

The decadal water level fluctuation map for average (August 2013-2022) versus August 2023 is shown in ***Fig.17****(Kumaon Section), and Fig.****18*** *(Garhwal section).*

A perusal of **Fig. 17** (Kumaon Region) reveals that minimum decadal rise of 0-2 m is observed in major part of Udham Singh Nagar & Champawat district and Ramnagar, Kotabag blocks of Nainital district. Higher decadal rise of 2-4 m is observed in Kashipur, Jaspur, southern Rudrapur blocks of Udham Singh Nagar district, and in eastern flank of Ramnagar and northern part of Kotabag blocks of Nainital district. Highest decadal rise of >4 m is being observed mainly in the northern part of Kotabag block of Nainital district. However, major part of Haldwani block of Nainital district is showing minimum decadal decline of 0-2 m. Higher decadal decline of 2-4 m is observed as concentric ring rimming highest decadal decline of >4 m in the western flank of Haldwani block of the Nainital district.

A perusal of **Fig. 18** (Garhwal Region) reveals that minimum decadal rise of 0-2 m is observed mainly in the Bhagwanpur, Khanpur, Southern part of Narsan blocks of Haridwar district and North-western part of Sahaspur, eastern & northern part of Vikas Nagar blocks of Dehradun district. Higher decadal rise of 2-4 m is observed mainly in the Roorkee block, Bahadrabad block, Northern portion of Narsan blocks of Haridwar district and southern part of Doiwala block, Sahaspur and Raipur blocks of Dehradun district. However, decadal decline of 0-2 m is observed mainly in the Doiwala & Vikas Nagar blocks of Dehradun district and Bahadrabad & Bhagwanpur blocks of the Haridwar district.

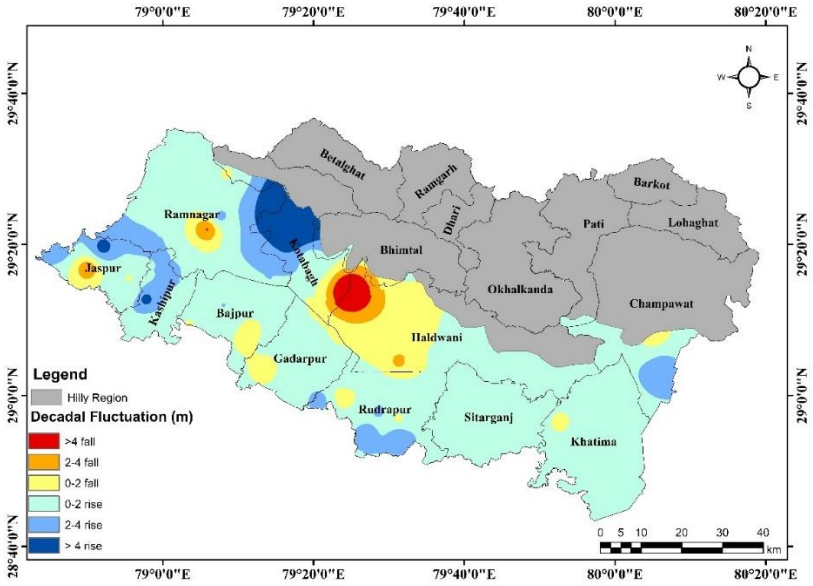


Fig.17: Decadal Water Level Fluctuation (August 2013-2022 Vs August 2023), Kumaon Region

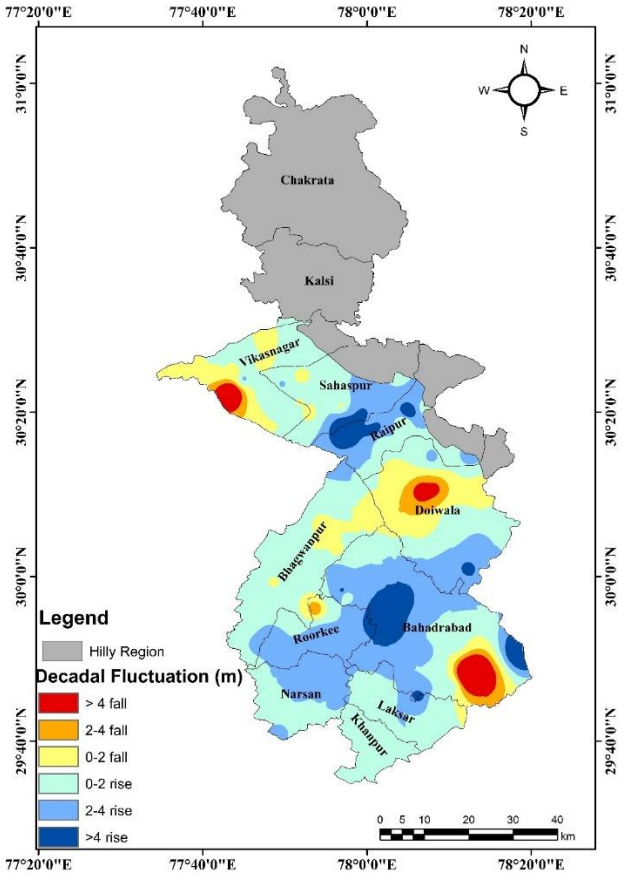


Fig.18: Decadal Water Level Fluctuation (August 2013-2022 Vs August 2023), Garhwal Region

Table 13. Decadal Water Level Fluctuation (August 2013 –August 2022 versus August 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	53	0.09	8.53	0.10	12.47	21	39.62	8	15.09	7	13.21	12	22.64	2	3.77	3	5.66
Haridwar	42	0.03	9.91	0.12	17.21	19	45.24	12	28.57	4	9.52	5	11.90	1	2.38	1	2.38
Udham Singh Nagar	46	0.03	4.87	0.12	3.55	27	58.70	8	17.39	2	4.35	8	17.39	1	2.17	0	0.00
Nainital	12	0.08	18.26	0.15	7.83	4	33.33	3	25.00	1	8.33	1	8.33	2	16.67	1	8.33
Champawat	3	2.47	3.28	0	1.16	0	0.00	2	66.67	0	0.00	0	0.0	1	33.33	0	0.00
Pauri Garhwal	2	0.00	8.87	0.00	9.66	0	0.00	0	0.00	1	50.00	0	0.00	0	0.00	1	50.00
Uttarkashi	9	0.36	12.94	0.5	6.61	2	22.22	0	0.00	2	22.22	2	22.22	2	22.22	1	11.11
Total	**167**					**73**	43.71	**33**	19.76	**17**	10.18	**28**	16.77	**9**	5.39	**7**	4.19

5.4.1.4 Water Level Fluctuation (November 2013-2022 versus November 2023)

Long-term water level data for 158 monitoring wells is analysed and is shown in ***Table14***. The table indicates that 60 monitoring wells out of 158 (37.97 % of total) had shown decadal rise of 0-2 m, 22 monitoring wells (13.92 % of total) had shown rise of 2-4 m and 13 wells (8.23 % of total) has shown the highest decadal rise of >4 m. As far as decadal decline in water level is concerned, 47 wells out of 158 (29.75 % of total) had recorded decadal decline in the range of 0- 2 m, 10 monitoring wells (6.33% of total) had shown higher decadal decline of 2-4 m, and total 6 wells out of 158 (around 3.80%) of wells have shown decadal decline of >4 m in Uttarakhand in the post-monsoon period.

The decadal water level fluctuation map for average (November 2013-2022) versus November 2023 is shown in ***Fig.19****(Kumaon Section), and* ***Fig.20*** *(Garhwal section).*

A perusal of **Fig. 19** (Kumaon Region) reveals that minimum decadal decline of 0-2 m is observed in major part of Udham Singh Nagar and Champawat district, western and eastern most flank of Haldwani block of Nainital district. However higher decadal decline of 2-4 m is observed as concentric rings rimming highest decadal decline of >4 m in the Jaspur block of Udham Singh Nagar district and western portion of Haldwani block of Nainital district. Minimum decadal rise of 0.2 m observed mainly in Kashipur, Rudrapur, eastern Khatima blocks of Udham Singh Nagar district and in the Ramnagar & Haldwani blocks of Nainital district. Southern portion of the Champawat district is also showing minimum decadal rise of 0-2 m. Highest decadal rise of >4 m is observed mainly in the Kotabag and western Ramnagar blocks of Nainital district.

A perusal of **Fig. 20** (Garhwal Region) reveals that minimum decadal rise of 0-2 m is observed in more than 60% of the Garhwal Region. Higher decadal rise of 2-4 m is mainly observed rimming the highest decadal rise of >4 m in the Bahadrabad & Bhagwanpur blocks of Haridwar district and Raipur, western Doiwala & eastern Sahaspur blocks of Nainital district. However, decadal decline is mainly observed in the eastern side of the Haridwar district.

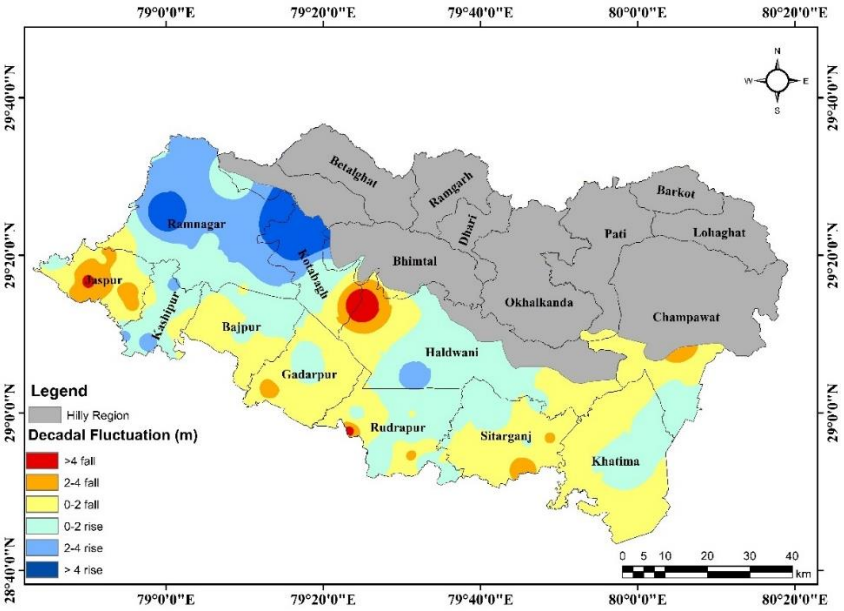


Fig.19: Decadal Water Level Fluctuation (Nov 2013-2022 Vs Nov 2023), Kumaon Region

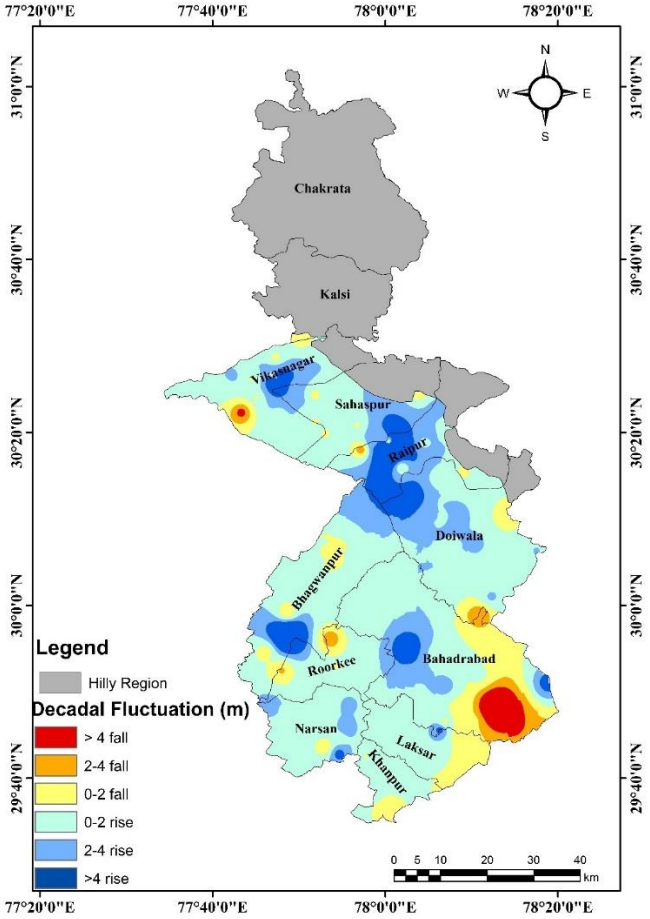


Fig.20: Decadal Water Level Fluctuation (Nov 2013-2022 Vs Nov 2023), Garhwal Region

Table 14. Decadal Water Level Fluctuation (November 2013 - November 2022 versus November 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	49	0.03	6.17	0.05	13.55	16	32.65	13	26.53	2	4.08	16	32.65	1	2.04	1	2.04
Haridwar	38	0.04	17.08	0.08	14.28	16	42.11	4	10.53	4	10.53	11	28.95	2	5.26	1	2.63
Udham Singh Nagar	45	0.007	3.03	0.03	4.93	19	42.22	2	4.44	0	0.00	18	40.00	5	11.11	1	2.22
Nainital	12	0.42	13.89	0.00	6.75	6	50.00	3	25.00	2	16.67	0	0.00	0	0.00	1	8.33
Champawat	3	1.29		0.21	3.39	1	33.33	0	0.00	0	0.00	1	33.3	1	33.33	0	0.00
Pauri Garhwal	2	9.35		22.82		0	0.00	0	0.00	1	50.00	0	0.00	0	0.00	1	50.00
Uttarkashi	9	0.007	10.18	0.24	16.25	2	22.22	0	0.00	4	44.44	1	11.11	1	11.11	1	11.11
Total	**158**					**60**	37.97	**22**	13.92	**13**	8.23	**47**	29.75	**10**	6.33	**6**	3.80

5.4.2 ANNUAL WATER LEVEL FLUCTUATION

5.4.2.1 Water Level Fluctuation (January 2023 versus January 2024)

The analysis of water level data of 158 ground water monitoring wells for the period January 2023versus January 2024 is given in ***Table 15.***

A perusal of the table also reveals that out of 158 monitoring wells, 53 wells (33.54%) have recorded the minimum annual rise in the range 0-2 m whereas 18 wells (11.39 % of total wells) had shown higher rise in the range 2-4 m. 10 nos. of monitoring well (6.33 % of the total)had recorded the highest annual water level rise of greater than 4 metres. Lowest annual decline of 0-2 m is recorded by 61 monitoring wells (38.61 % of total) while 10 wells (6.33%) had recorded higher decline in the range of 2-4 m while only 7 wells (4.43% of the total) had recorded the highest annual water level decline of greater than 4 metres.

The annual water level fluctuation map during the period January 2023 versus January 2024 has been shown in ***Fig.21****(Kumaon Section), and Fig.****22*** *(Garhwal section).*

Visual interpretation of **Fig. 21** has shown that the minimum annual decline of 0-2 m is mostly observed in the Udham Singh Nagar district, Champawat district and Ramnagar & Haldwani blocks of Nainital district. Higher annual decline of 2-4 m is observed as rimming the highest annual decline of >4 m in Haldwani & Kotabag blocks of Nainital district and Jaspur block of Udham Singh Nagar district. Annual rise is observed as small patches in Ramnagar block of Nainital district and western flank of Jaspur block of Udham Singh Nagar district.

Visual interpretation of **Fig. 22** has shown that the minimum annual rise of 0-2 m is majorly observed in Haridwar district and Vikas Nagar & Raipur blocks of Dehradun district. Higher annual rise of 2-4 m is observed mainly in southern part of Bhagwanpur block, eastern and northern part of Bahadrabad block of Haridwar district and more than 60% area of Doiwala block of Dehradun district. Highest annual rise of >4 m is observed as small patches in Bhagwanpur & Bahadrabad block of Haridwar district and Doiwala block of Dehradun district. Minimum annual decline of 0-2 m is mainly observed in Sahaspur block of Dehradun district.

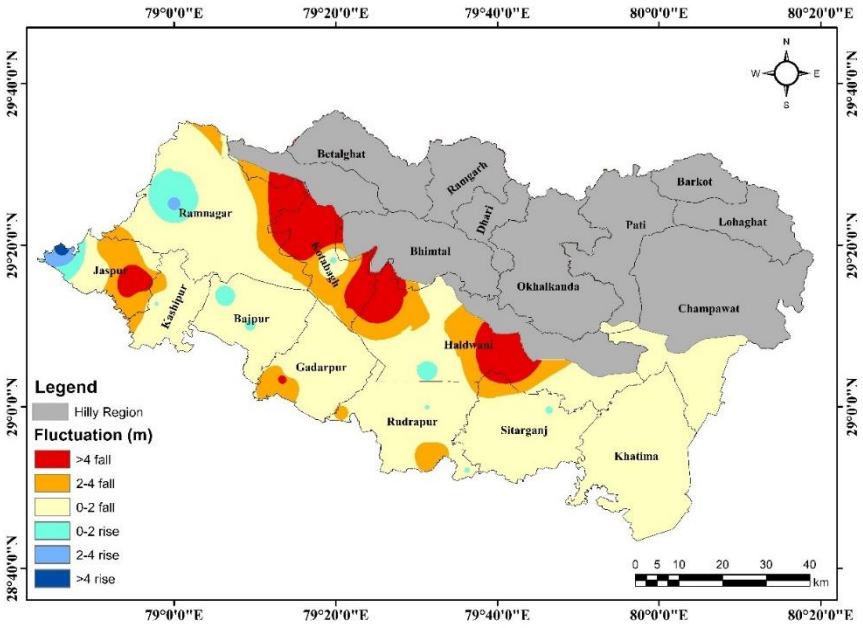


Fig.21: Annual Water Level Fluctuation (Jan23 Vs Jan24), Kumaon Region

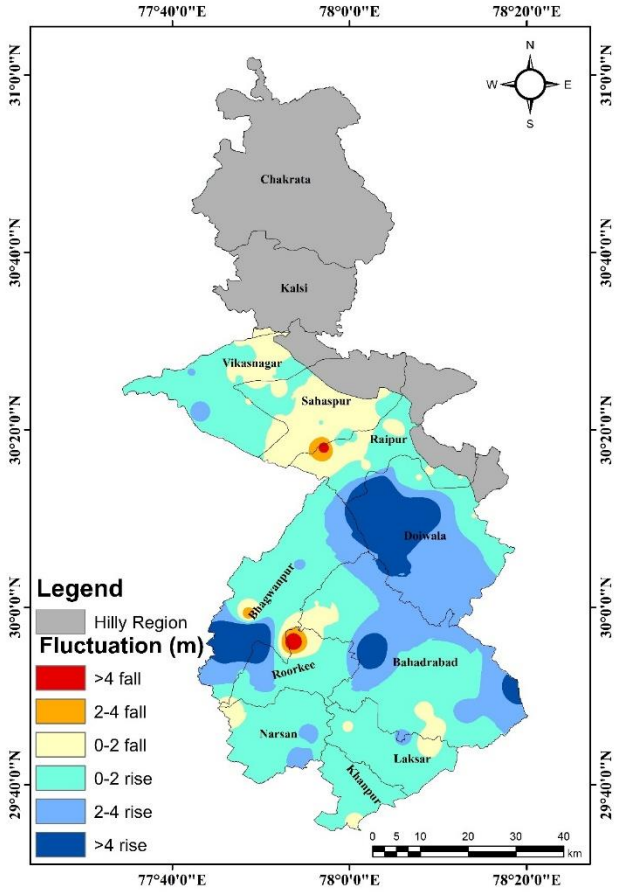


Fig.22: Annual Water Level Fluctuation (Jan23 Vs Jan24), Garhwal Region

Table 15: Annual Water Level Fluctuation (January 2023 versus January 2024)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	48	0.02	14.58	0.03	5.29	18	37.50	7	14.58	3	6.25	18	37.50	1	2.08	1	2.08
Haridwar	39	0.01	6.66	0.01	20.06	20	51.28	5	12.82	4	10.26	8	20.51	1	2.56	1	2.56
Udham Singh Nagar	46	0	2.40	0.05	3.33	11	23.91	1	2.17	0	0.00	28	60.87	6	13.04	0	0.00
Nainital	11	0.26	16.29	0.54	6.17	3	27.27	1	9.09	2	18.18	3	27.27	2	18.18	1	9.09
Champawat	4	0		0.73	12.52	0	0.00	0	0.00	0	0	3	75	0	0.00	1	25.00
Pauri Garhwal	2	3.54		6.63		0	0	1	50.00	0	0	0	0	0	0	1	50
Uttarkashi	8	1.28	7.61	0.42	8.1	1	12.5	3	37.50	1	12.5	1	12.5	0	0	2	25
Total	**158**					**53**	33.54	**18**	11.39	**10**	6.33	**61**	38.61	**10**	6.33	**7**	4.43

5.4.2.2 Water Level Fluctuation (May 2022 versus May 2023*)*

The analysis of data for 162 Ground Water Monitoring Wells for May 2022 versus May 2023 is given in ***Table 16.***

A perusal of ***Table 16*** reveals that out of 162 monitoring wells 44 (27.16% of total) has shown minimum rise in the range 0-2 m whereas higher rise of 2-4 m is shown by 7 monitoring wells (4.32% of the total) and the highest rise of >4 m is recorded by 4 monitoring wells (2.47%) for calculating the annual fluctuation in ground water level for the pre-monsoon period. The minimum decadal decline in the range of 0-2 m is shown by 82 out of 162 monitoring wells (50.62% of the total number) had recorded annual decline in the range of 0-2 m. Higher annual decline of 2-4 m is recorded by 9 monitoring wells (5.56% of total) whereas the highest declineof >4 m is recorded by 14 monitoring wells (8.64 % of the total number).

The annual water level fluctuation map during the period May 2022 versus May 2023 has been shown in ***Fig.23****(Kumaon Section), and Fig.****24*** *(Garhwal section).*

Visual interpretation of **Fig. 23** has shown that the minimum annual decline of 0-2 m is mostly observed in the Udham Singh Nagar district, Champawat district and Ramnagar & Haldwani blocks of Nainital district. Higher annual decline of 2-4 m is observed as rimming the highest annual decline of >4 m in Haldwani & Kotabag blocks of Nainital district and Jaspur block of Udham Singh Nagar district. Annual rise is observed as small patches in Ramnagar block of Nainital district and western flank of Jaspur block of Udham Singh Nagar district.

Visual interpretation of **Fig. 24** has shown that the minimum annual decline of 0-2 m is observed in the major part of the Garhwal section. Higher annual decline of 2-4 m is observed as rimming the highest annual decline of > 4 m in eastern flank of Bahadrabad block, in southern part of Bhagwanpur block of Haridwar district and southern part of Sahaspur-Raipur block, Central part of Doiwala block of Dehradun district. Annual rise of 0-2 m is observed mainly in Khanpur, Laksar, Narsan & Roorkee blocks of Haridwar district and in small parts of Raipur and Doiwala blocks of Dehradun district.

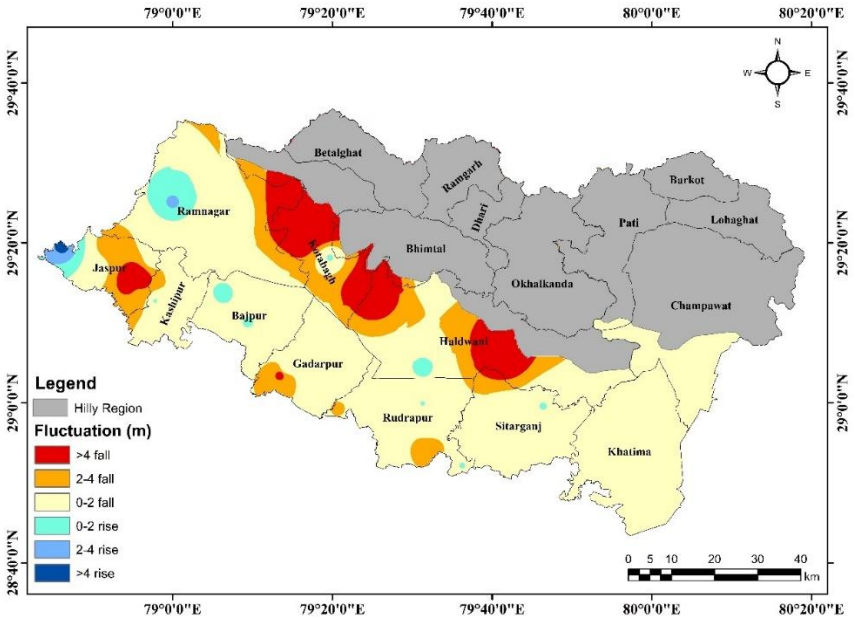


Fig.23: Annual Water Level Fluctuation (May2022 Vs May2023), Kumaon Region

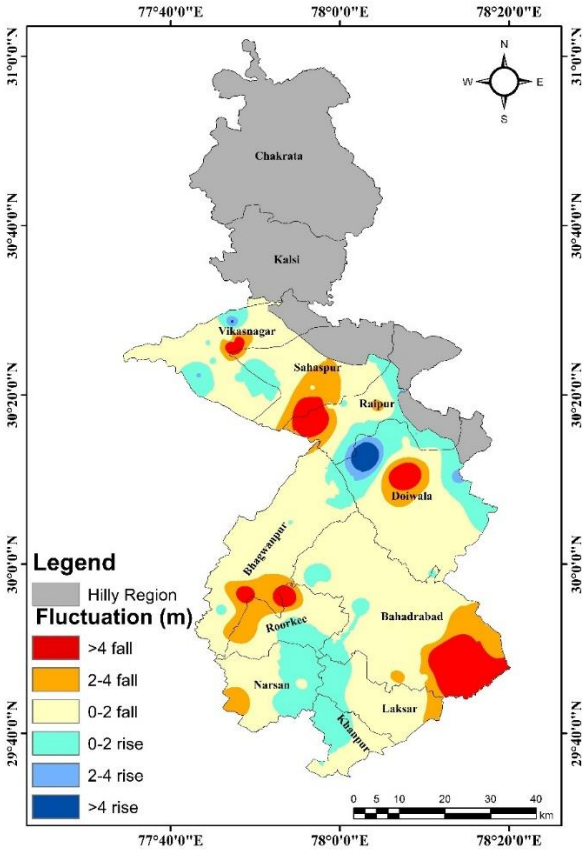


Fig.24: Annual Water Level Fluctuation (May2022 Vs May2023), Garhwal Region

Table 16. Annual Water Level Fluctuation (May 2022 versus May 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	50	0	11.30	0.03	18.65	19	38.00	6	12.00	3	6.00	16	32.00	2	4.00	4	8.00
Haridwar	42	0.04	1.47	0.01	17.39	15	35.71	0	0.00	0	0	20	47.62	2	4.76	3	7.14
Udham Singh Nagar	46	0.01	4.63	0.03	11.21	7	15.22	0	0.00	1	2.17	31	67.39	5	10.87	2	4.35
Nainital	11	0.15	2.37	0.12	21.31	2	18.18	1	9.09	0	0.00	5	45.45	0	0.00	3	27.27
Champawat	2	0		0.06	0.07	0	0.00	0	0.00	0	0	2	100	0	0.00	0	0.00
Pauri Garhwal	2	0.00	0	5.41	21.26	0	0	0	0.00	0	0	0	0	0	0	2	100
Uttarkashi	9	0	0.27	0.44	1.3	1	11.11	0	0.00	0	0	8	88.89	0	0	0	0
Total	**162**					**44**	27.16	**7**	4.32	**4**	2.47	**82**	50.62	**9**	5.56	**14**	8.64

5.4.2.3 Water Level Fluctuation (August 2022 versus August 2023)

The analysis of annual water level fluctuation data for 160 Ground Water Monitoring Wells for the periods August 2022 and August 2023 is given in ***Table 17.***

Analysis of the fluctuation data has indicated that out of 160 monitoring wells, 60 wells (37.50% of total) had shown an annual rise in the range 0-2 m while higher rise of 2-4m is observed in 41 monitoring well (25.63% of total). The highest rise in the range >4 m is recorded by 34 monitoring wells, which is 21.25% of the total number of wells. It is also seen that 13 wells out of 160, 8.13% of total) had recorded annual decline in the range of 0-2 m. Higher annual decline of 2-4 m is shown by 5 monitoring wells (3.13% of total) while the highest decline of >4 m is shown by 7 monitoring wells, which is 4.38% of the total number of wells.

The annual water level fluctuation map during the period August 2022 versus August 2023 is shown in ***Fig.25****(Kumaon Section), and* ***Fig.26*** *(Garhwal section).*

Visual interpretation of **Fig. 25** has shown that the minimum annual rise of 0-2 m is observed in Khatima, Sitarganj, Gadarpur, Bajpur blocks of Udham Singh Nagar district and Haldwani & Kotabag blocks of Nainital district. However, higher annual rise of 2-4 m is observed in Rudrapur, Bajpur & eastern Gadarpur blocks of Udham Singh Nagar district and Ramnagar & central part of Haldwani blocks of Nainital district. Highest annual rise of >4 m is observed mainly in the Jaspur, Kashipur, southern Rudrapur blocks of Udham Singh Nagar district and western part of Ramnagar & some part of Haldwani block of Nainital district.

Visual interpretation of **Fig. 26** has shown that the higher annual rise of 2-4 m is observed majorly in the Haridwar district and Doiwala block of Dehradun district. Minimum annual rise of 0-2 m is observed mainly in Vikas Nagar, Sahaspur & some parts of Doiwala blocks of Dehradun district. Annual decline is also being observed as small patches in the eastern Bahadrabad block of Haridwar district and northern Vikas Nagar block of Dehradun Valley.

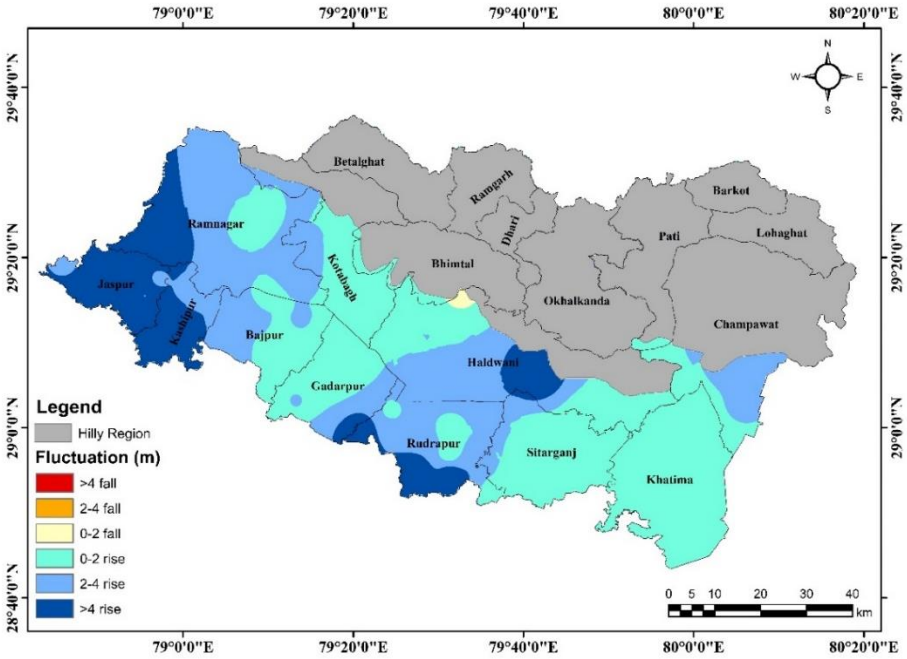


Fig.25: Annual Water Level Fluctuation (August2022 Vs August2023), Kumaon Region

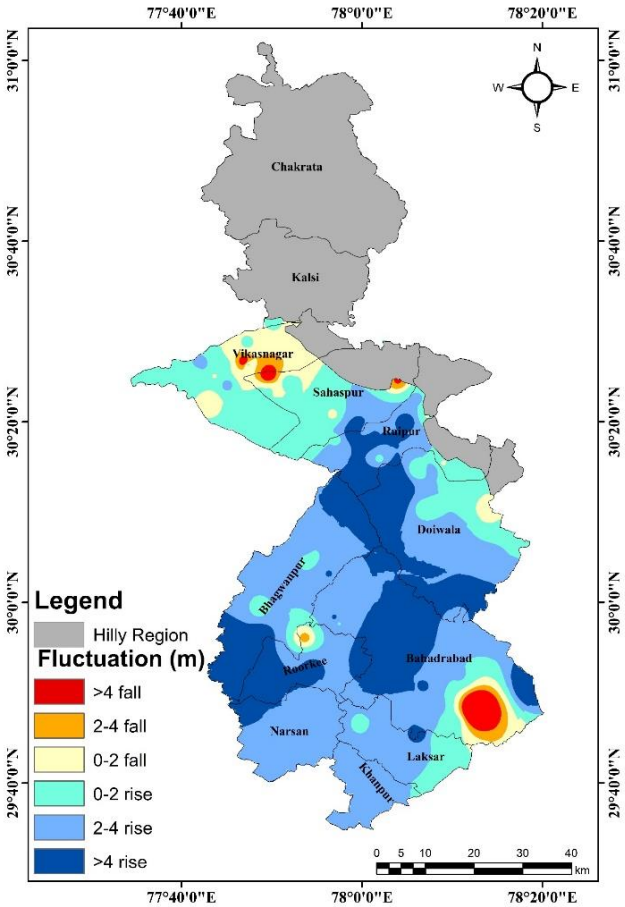


Fig.26: Annual Water Level Fluctuation (August2022 Vs August2023), Garhwal Region

Table 17. Annual Water Level Fluctuation (August 2022 versus August 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	53	0.09	20.61	0.02	8.40	26	49.06	6	11.32	8	15.09	8	15.09	2	3.77	3	5.66
Haridwar	42	0.10	10.62	2.74	16.52	8	19.05	19	45.24	13	30.95	0	0.00	1	2.38	1	2.38
Udham Singh Nagar	44	0.11	9.91	0.00		24	54.55	11	25.00	9	20.45	0	0.00	0	0.00	0	0.00
Nainital	7	0.99	8.57	0.58		2	28.57	2	28.57	2	28.57	1	14.29	0	0.00	0	0.00
Champawat	3	2.00	3.06	0.00		0	0.00	3	100.00	0	0.00	0	0.0	0	0.00	0	0.00
Pauri Garhwal	2	0.00		2.19	21.31	0	0.00	0	0.00	0	0.00	0	0.00	1	50.00	1	50.00
Uttarkashi	9	5.00	9.09	0.19	10.48	0	0.00	0	0.00	2	22.22	4	44.44	1	11.11	2	22.22
Total	**160**					**60**	37.50	**41**	25.63	**34**	21.25	**13**	8.13	**5**	3.13	**7**	4.38

5.4.2.4 Water Level Fluctuation (November 2022 versus November 2023)

The analysis of annual water level fluctuation data for 156 Ground Water Monitoring Wells in Uttarakhand is available.

A study of the water level fluctuation data has revealed that 46 monitoring wells out of 156 wells (29.49% of the total number) has recorded a rise in the range of 0-2 m. 16 monitoring well (10.26% of the total) had shown the higher rise of 2-4 m during this period. Highest declineof >4 m was observed in 12 monitoring wells (7.69% of the total). The 60 nos. of monitoring well (38.46% of the total) had recorded an annual decline in the range of 0-2 m during the post monsoon period. 13 wells (8.33% of total number) had shown higher decline of water level in the range of 2-4 m, while highest decline of >4m was observed in 09 numbers of well (5.77% of the total).

The annual water level fluctuation map during the period November 2022 versus November 2023 is shown in ***Fig.27****(Kumaon Section), and* ***Fig.28*** *(Garhwal section).*

Visual interpretation of **Fig. 27** has shown that the minimum annual decline of 0-2 m is observed in most of the areas of the Udham Singh Nagar and Champawat districts and some parts of the Nainital District. However, higher annual decline of 2-4 m is observed as small concentric layers rimming highest annual decline of >4 m in Jaspur block of Udham Singh Nagar district and Haldwani block of Nainital district.

Visual interpretation of **Fig. 28** has shown that the minimum annual rise of 0-2 m is observed majorly in the Haridwar district and Doiwala & Vikas Nagar blocks of Dehradun district. Higher annual rise of 2-4 m is observed mainly Bhagwanpur, Roorkee, Narsan & some parts of Bahadrabad block of Haridwar district and Doiwala & Sahaspur blocks of Dehradun district. However, minimum annual decline of 0-2 m is also observed in eastern part of Bahadrabad block of Haridwar district and northern part of Vikas Nagar, Sahaspur & parts of Doiwala block of Dehradun district. Highest annual decline of >4 m is also observed in some parts of Doiwala block of Dehradun district.

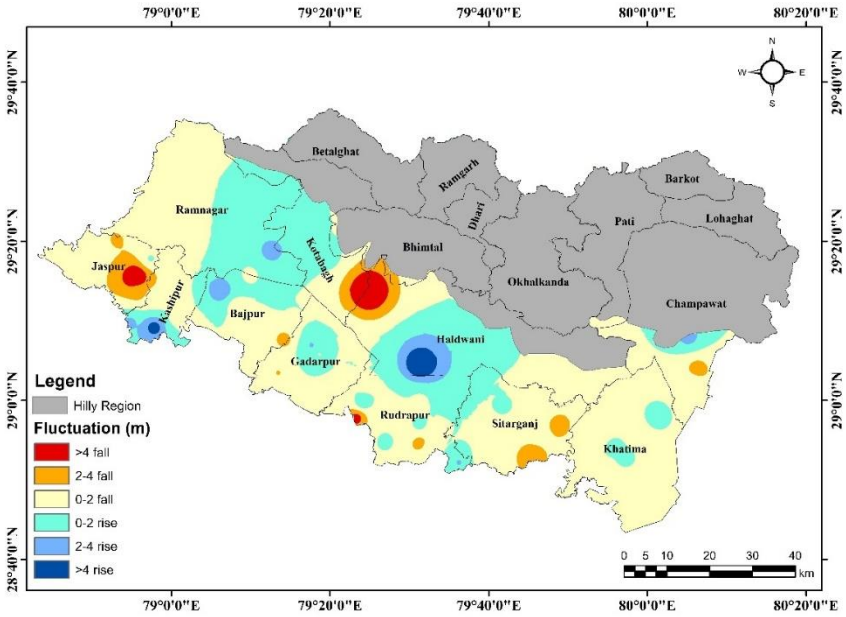


Fig.27: Annual Water Level Fluctuation (Nov2022 Vs Nov2023), Kumaon Region

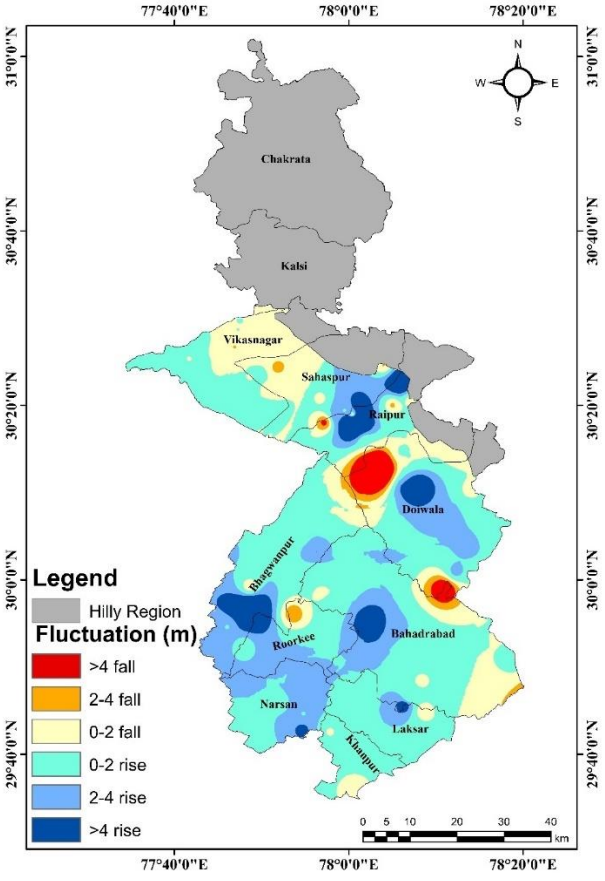


Fig.28: Annual Water Level Fluctuation (Nov2022 Vs Nov2023), Garhwal Region

Table 18. Annual Water Level Fluctuation (November 2022Versus November 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	47	0.02	12.1	0.08	19.01	14	29.79	5	10.6383	3	6.38	19	40.43	4	8.51	2	4.26
Haridwar	36	0.2	7.64	0.22	7.74	19	52.78	5	13.89	4	11.11	6	16.67	1	2.78	1	2.78
Udham Singh Nagar	51	0.17	5.07	0.03	8.18	9	17.65	4	7.84	1	1.96	28	54.90	7	26.00	2	3.92
Nainital	8	0.26	6.98	0.36	7.14	3	37.50	1	12.50	1	12.50	2	25.00	0	0.00	1	12.50
Champawat	3	2.58		1.43	2.65	0	0.00	1	33.33	0	0.00	1	33.33	1	33.33	0	0.00
Pauri Garhwal	2	6.66		30.38		0	0.00	0	0.00	1	50.00	0	0.00	0	0.00	1	50.00
Uttarkashi	9	0.65	8.41	0.07	31.38	1	11.11	0	0.00	2	22.22	4	44.44	0	0.00	2	22.22
Total	**156**					**46**	29.49	**16**	10.26	**12**	7.69	**60**	38.46	**13**	8.33	**9**	5.77

5.4.3 SEASONAL WATER LEVEL FLUCTUATION

5.4.3.1 Water Level Fluctuation (May 2023 versus January 2024)

The seasonal water level fluctuation for the period May 2023 versus January 2024 is available for 161 monitoring wells in Uttarakhand State. The water level fluctuation data is given in ***Table 19.***

A perusal of **Table 19** also reveals that that the lowest seasonal rise of 0-2 m was shown by 98 monitoring wells (60.87% of total) whereas higher rise of 2-4 m was shown by 29 wells (18.01% of total). The highest seasonal rise of >4 m was shown by 17 wells, which was 10.56% of the total wells. Seasonal decline in the range of 0-2 m was shown by 13 monitoring wells (8.07 % of total) while higher decline of 2-4 m was recorded by only 3 monitoring well (1.86% of total). The highest seasonal rise of >4 m was shown by only 01 well, which was 0.62% of the total wells for which the data is available in Uttarakhand State during the period May 2023 versus January 2024.

The seasonal water level fluctuation map during the period May 2023 versus January 2024 is shown in ***Fig.29****(Kumaon Section),and* ***Fig.30*** *(Garhwal section).*

Visual interpretation of **Fig. 29** has shown that the lowest seasonal rise of 0-2 m and 2-4 m is observed in major parts of the Kumaon Section of Uttarakhand State. Kumaon section is representing mainly seasonal rising water level trend when compared with water level data of May 2023 with January 2024.

Visual interpretation of **Fig. 30** has shown that the lowest seasonal rise of 0-2 m and 2-4 m is observed in major parts of the Garhwal Section of Uttarakhand State. Kumaon section is representing mainly seasonal rising water level trend when compared with water level data of May 2023 with January 2024.

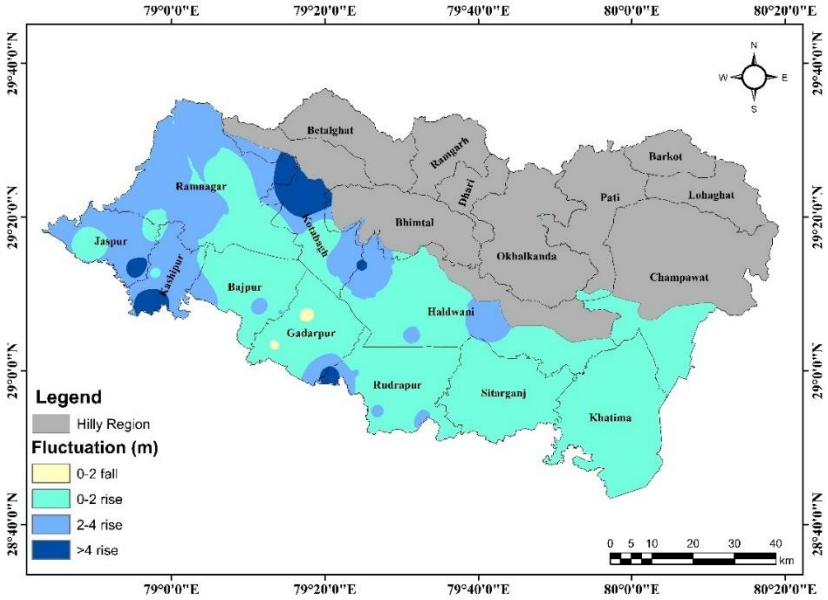


Fig.29: Seasonal Water Level Fluctuation (May23 Vs Jan24), Kumaon Region

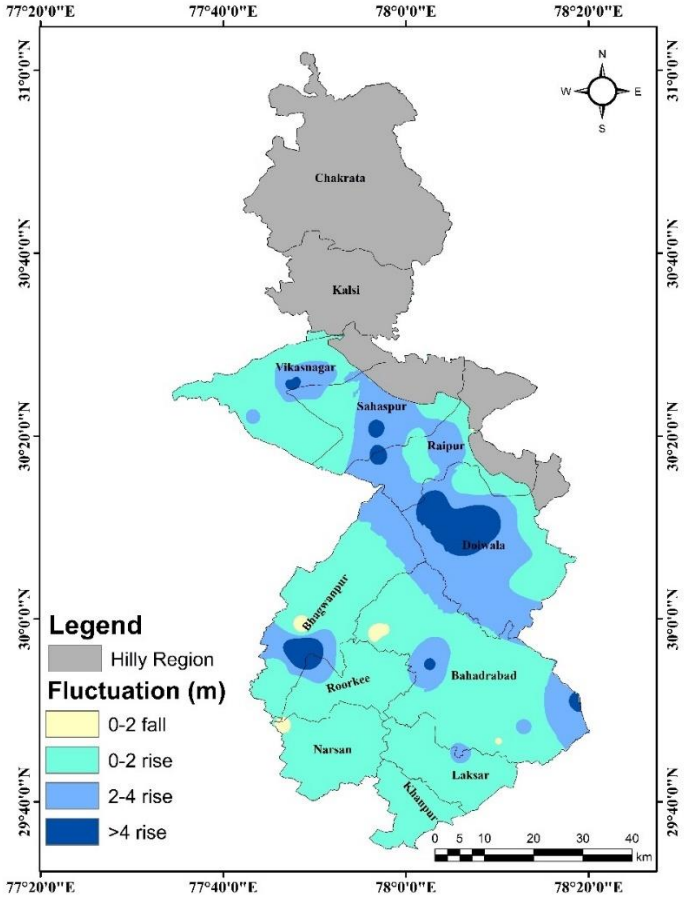


Fig.30: Seasonal Water Level Fluctuation (May23 Vs Jan24), Garhwal Region

Table 19. Seasonal Water Level Fluctuation (May 2023 Versus January 2024)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	48	0	9.55	0.08	0.11	29	60.42	11	22.92	6	12.50	2	4.17	0	0.00	0	0.00
Haridwar	39	0.14	11.52	0.13	1.27	29	74.36	2	5.13	3	7.69	5	1.00	0	0.00	0	0.00
Udham Singh Nagar	46	0.04	5.74	0.32	1.15	30	65.22	11	23.91	3	6.52	2	4.35	0	0.00	0	0.00
Nainital	11	0	10.83	0		5	45.45	4	36.36	2	18.18	0	0.00	0	0.00	0	0.00
Tehri Garhwal	5	5.52		1.29	18.02	0	0.00	0	0.00	1	20.00	1	20.00	2	40.00	1	20.00
Champawat	3	0.31	0.46	0		3	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	9	0.36	4.54	1.24	2.35	2	22.22	1	11.11	2	22.22	3	33.33	1	11.11	0	0.00
Total	**161**					**98**	60.87	**29**	18.01	**17**	10.56	**13**	8.07	**3**	1.86	**1**	0.62

5.4.3.2 Water Level Fluctuation (May 2023 versus August 2023)

The seasonal fluctuation of water level during the period May 2023 versus August 2023 for168 ground water monitoring wells in Uttarakhand State is given in ***Table 20.***

The perusal of Table 20 reveals that rise in the range of 0-2 m was shown by 82 monitoring wells, which was 48.81% of the total number of wells. Higher rise in the range 2-4 m was shown by 55 wells (32.74% of total) while the highest rise of >4 m was shown by 26 wells (15.48% of total). The lowest seasonal decline of 0-2 m was recorded by 02 monitoring wells (1.19% of total). while highest decline of >4 m was shown by 1 monitoring wells, which was only 0.60 % of the total number of wells during the period May versus August 2023.

The seasonal water level fluctuation map during the period May 2023 versus August 2023 is shown in ***Fig.31****(Kumaon Section), and* ***Fig.32*** *(Garhwal section).*

Visual interpretation of **Fig. 31** has shown that the lowest seasonal rise of 0-2 m and 2-4 m is observed in major parts of the Kumaon Section of Uttarakhand State. Kumaon section is representing mainly seasonal rising water level trend when compared with water level data of May 2023 with August 2023.

Visual interpretation of **Fig. 32** has shown that the lowest seasonal rise of 0-2 m and 2-4 m is observed in major parts of the Garhwal Section of Uttarakhand State. Kumaon section is representing mainly seasonal rising water level trend when compared with water level data of May 2023 with August 2023.

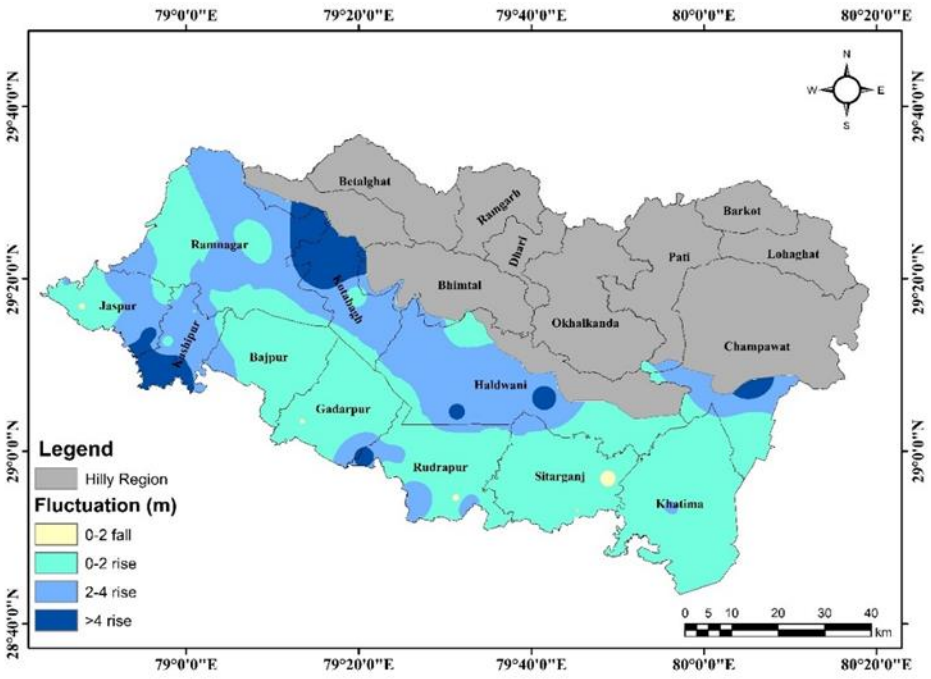


Fig.31: Seasonal Water Level Fluctuation (May23 Vs Aug23), Kumaon Region

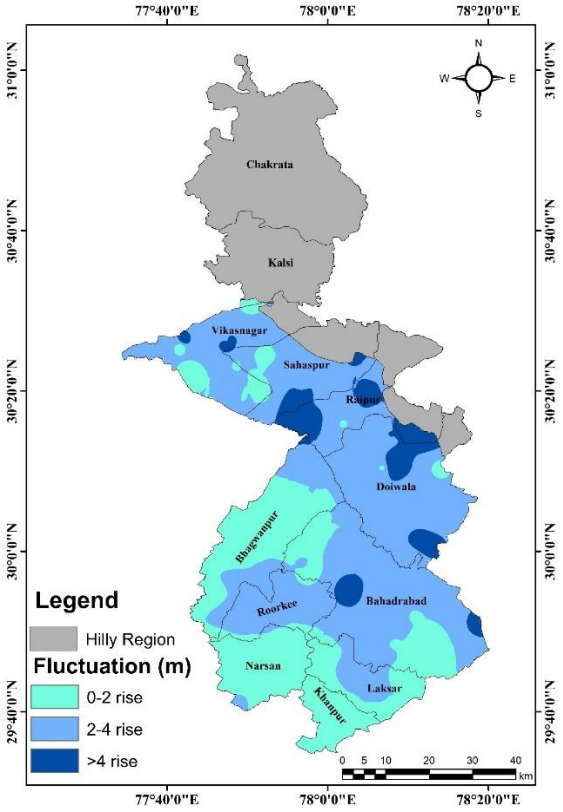


Fig.32: Seasonal Water Level Fluctuation (May23 Vs Aug24), Garhwal Region

Table 20. Seasonal Water Level Fluctuation (May 2023 Versus August 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	50	0.22	12.63	0.00		14	28.00	21	42	15	30.00	0	0.00	0	0.00	0	0.00
Haridwar	42	0.01	5.69	0.00		25	59.52	15	35.71	2	4.76	0	0.00	0	0.00	0	0.00
Udham Singh Nagar	46	0.32	5.04	0	0.15	29	63.04	13	28.26	3	6.52	1	2.17	0	0.00	0	0.00
Nainital	11	0	15.17	0.81		6	54.55	2	18.18	2	18.18	1	9.09	0	0.00	0	0.00
Pauri Garhwal	2	0.67	5.6	0		1	50.00	0	0.00	1	50.00	0	0.00	0	0.00	0	0.00
Tehri Garhwal	5	0.79	10.1	5.11		1	20.00	0	0.00	1	20.00	0	0.00	0	0.00	1	0.00
Champawat	3	0	6.52	0		2	66.67	0	0.00	1	33.33	0	0.00	0	0.00	0	0.00
Uttarkashi	9	0.45	7.77	0		4	44.44	4	44.44	1	11.11	0	0.00	0	0.00	0	0.00
Total	**168**					**82**	48.81	**55**	32.74	**26**	15.48	**2**	1.19	**0**	0.00	**1**	0.60

5.4.3.3 Water Level Fluctuation (May 2023 versus November 2023)

The water level fluctuation data of May 2022 was compared with that of November 2023 for 169 ground water monitoring wells in Uttarakhand and the result is given in ***Table 21.***

A perusal of the fluctuation data shows that seasonal rise of 0-2 m was shown by 97 monitoring wells out of 169 (57.40%), that in the range of 2-4 m by 32 monitoring wells (18.93% of total) and that in the range of >4 m by 28 wells (16.57% of total) in Uttarakhand State. Seasonal decline in the range 0-2 m was recorded by 11 monitoring wells (6.51% of total). Highest seasonal decline in the range of >4 m had been recorded by 1 monitoring well only (0.59% of total).

The seasonal water level fluctuation map during the period May 2023 versus November 2023 is shown in ***Fig.33****(Kumaon Section), and* ***Fig.34*** *(Garhwal section).*

Visual interpretation of **Fig. 33** has shown that the lowest seasonal rise of 0-2 m and 2-4 m is observed in major parts of the Kumaon Section of Uttarakhand State. Kumaon section is representing mainly seasonal rising water level trend when compared with water level data of May 2023 with November 2023.

Visual interpretation of **Fig. 34** has shown that the lowest seasonal rise of 0-2 m and 2-4 m is observed in major parts of the Garhwal Section of Uttarakhand State. Kumaon section is representing mainly seasonal rising water level trend when compared with water level data of May 2023 with November 2023.

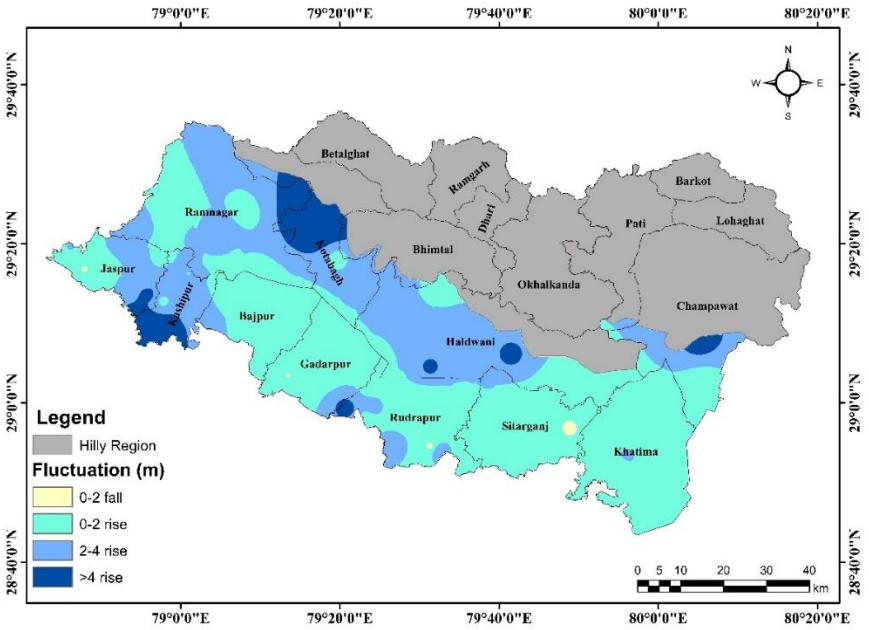


Fig.33: Seasonal Water Level Fluctuation (May23 Vs Nov23), Kumaon Region

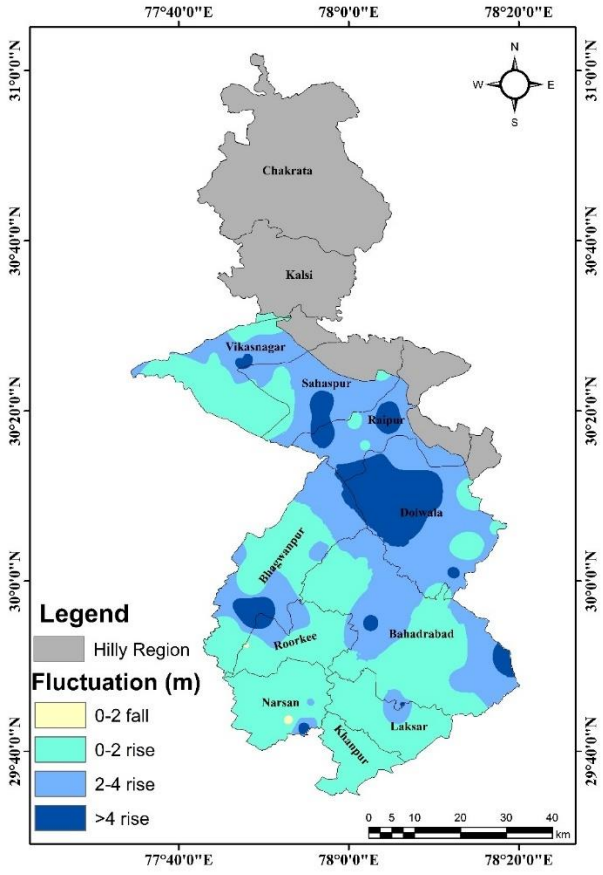


Fig.34: Seasonal Water Level Fluctuation (May23 Vs Nov23), Garhwal Region

Table 21. Seasonal Water Level Fluctuation (May 2023 Versus November 2023)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	48	0.16	9.32	0.07	0.25	20	41.67	15	31.25	11	22.92	2	4.17	0	0.00	0	0.00
Haridwar	42	0.02	12.21	0.01	0.72	29	69.05	5	11.90	5	11.90	3	1.00	0	0.00	0	0.00
Udham Singh Nagar	52	0.01	7.9	0.02	0.53	34	65.38	9	17.31	4	7.69	5	9.62	0	0.00	0	0.00
Nainital	10	0.63	13.91	0		5	50.00	2	20.00	3	30.00	0	0.00	0	0.00	0	0.00
Champawat	2	0.94	5.33	0		1	50.00	0	0.00	1	50.00	0	0.00	0	0.00	0	0.00
Tehri Garhwal	4	0.56	9.48	1.28	7.9	1	25.00	0	0.00	1	25.00	1	25.00	0	0.00	1	25.00
Pauri Garhwal	2	0.14	7.64	0		1	50.00	0	0.00	1	50.00	0	0.00	0	0.00	0	0.00
Uttarkashi	9	0.03	6.02	0		6	66.67	1	11.11	2	22.22	0	0.00	0	0.00	0	0.00
Total	**169**					**97**	57.40	**32**	18.93	**28**	16.57	**11**	6.51	**0**	0.00	**1**	0.59