

DISTRICT UDHAM SINGH NAGAR AT A GLANCE

S.No	Items	Statistics
1	GENERAL INFORMATION	
	(i) Geographical Area (Sq. km)	3055
	(ii) Number of Tehsils / Blocks	Tehsils-7 / Blocks-7
	(iii) Number of Villages	669
	(iv) Population (As on 2001 census)	12,35,614
	(v) Average Annual Rainfall (mm)	1296.85
2	GEOMORPHOLOGY	
	(i) Major Physiographic Units	Bhabar and Tarai
	(ii) Major Drainages	Sarada, Kosi, Gola and Phikka and their tributaries are Sawaldeo, Bour, Nandhour, Bhak, Kailash etc.
3	LAND USE (ha)	53256.0
	(i) Forest	84717
	(ii) Net Sown Area	149523
	(iii) Cultivable Area	150024
4	MAJOR SOIL TYPES	Udifluventic Ustochrepts, Typic Ustipsamments, Udic Ustochrepts, Udic Haplustolls, Typic Ustochrepts
5	AREA UNDER PRINCIPAL CROPS (ha)	
	(i) Paddy	108017
	(ii) Wheat	83029
	(iii) Sugarcane	38098
	(iv) Maize	704
	(v) Pulses	3771
6	IRRIGATION BY DIFFERENT SOURCES	
	(i) Dug wells (ha)	12099
	(ii) Tube wells/bore wells (Govt./Private) (ha)	10899/85602
	(iii) Tanks/Ponds (ha)	20
	(iv) Canals (ha)/length (km)	30224/924.3
	(v) Other sources (ha)	6582
	(vi) Net Irrigated area (ha)	145426
	(vii) Gross Irrigated area (ha)	232912
7	NUMBER OF GROUND WATER MONITORING WELLS OF CGWB	31
	(i) Number of Dug wells	18
	(ii) Number of Piezometers	Nil
	(iii) Number of Hand Pumps	13
	(iv) Number Observation wells	Nil
8	PREDOMINANT GEOLOGICAL FORMATION	Varanasi /Older Alluvium
9	HYDROGEOLOGY	

	(i) Major water bearing formations	Bhabar and Tarai (Varanasi /Older Alluvium)
	(ii) Pre-monsoon depth to water level range (Period: 2006)	2.09 to 7.08 m bgl
	(iii) Post-monsoon depth to water level range (Period: 2006)	1.73 to 6.89 m bgl
	(iv) Long term water level trend in 10 yrs (1997-2006)	
10	GROUNDWATER EXPLORATION BY CGWB (as on 31/03/2008)	
	(i) Number of wells drilled (EW, OW, PZ, SH, Total)	12 Exploratory Wells
	Depth Range (m)	74.98 to 88.39
	Discharge (lpm)	2683 to 3100
	Transmissivity (m ² /day)	7484 to 14140
11	GROUNDWATER QUALITY	Overall Groundwater quality is good for domestic and irrigation purpose.
	Presence of Chemical constituents more than permissible limit	All the parameters well within the permissible limits.
12	DYNAMIC GROUND WATER RESOURCES (2004) in MCM	
	(i) Annual Replenishable Groundwater Resources	665691.8 ha m
	(ii) Net Annual Ground Water Draft	49207.27 ha m
	(iii) Projected demand for domestic and industrial uses up to 2025	12798.0 ha m
	(iv) Stage of Groundwater Development	79.34% (Safe)
13	AWARENESS AND TRAINING ACTIVITY	--
	Mass Awareness Programmes Organized	Not yet organized
	Ground Water Management Training Programmes (GWMTP) Organized	Nearby town in Haldwani 2006 GWMTP was organized
14	EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING	
	Projects completed by CGWB (No & Amount Spent)	Nil
	Projects under technical guidance of CGWB (Numbers)	Nil
15	GROUNDWATER CONTROL AND REGULATION	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Blocks Notified	Nil
16	MAJOR GROUND WATER PROBLEMS AND ISSUES	There is no groundwater problem and issues in district Udham Singh Nagar.

DISTRICT GROUNDWATER BROCHURE

UDHAM SINGH NAGAR DISTRICT, UTTARAKHAND

1.0 INTRODUCTION

Udham Singh Nagar District is the food bowl of Uttarakhand State. Prior to its formation, it was part of District Nainital. It was separated out on the basis of physiographical conditions i.e. Tarai. It is also well known for the industries as the geographical location is conducive. Udham Singh Nagar district is famous for its agriculture and irrigation on synchronized patterns from the past as garner of popularity for its productivity in paddy crops in the whole Uttarakhand state, and it is rightly called “*Chawal ki Nagar*”, thus making it importance in bringing out the district groundwater brochure.

Udham Singh Nagar district falls in the Tarai region of Kumaon Division. The geographical area of the district is 3055 Km² and in aerially it ranks 9th in Uttarakhand state. It is located between latitude 28° 53' N and 29° 23' N and laterally extends between longitudes 78° 45' E and 80° 08' E. The district is bounded by Nainital and Champawat districts of Uttarakhand on the north, Moradabad, Rampur, Bareilly and Philibhit districts of Uttar Pradesh on the south, Bijnor district of Uttar Pradesh on west and Nepal on the east. The Sarada River forms the international boundary between India and Nepal. The study area falls in Survey of India Toposheet (Quadrangle Maps) Nos. 53K, O, P and 62D.

For the Administrative convenience, the district has been divided into 7 developmental blocks and 7 tehsils, viz. *Japsur, Kashipur, Bazpur, Gadarpur, Rudrapur, Sitargunj* and *Khatima* with the district's headquarters at Rudrapur, shown in **Fig.1**. District Udham Singh Nagar is reported with 669 inhabited villages, block wise villages are depicted in **Table 1**. Area wise Sitargunj block is the largest (325 km²), whereas Kashipur the smallest block (185 km²). Forest covers 5.0% area of the district. The total population of the district is 12,35,614 (Census: 2001), out of which male, female population is 6,49,484 and 5,86,130 respectively. It ranks third in the state in respect of the population. The population density is 405.45 persons/km². The overall literacy rate is 64.86%.

The officers of the Central Ground Water Board (CGWB) carried out Systematic Hydrogeological Surveys (SHS)/ Groundwater Management Studies (GWMS)/Reappraisal Hydrogeological Studies (RHS) and Hydrogeological investigations in Udham Singh Nagar district from time to time since 1959.

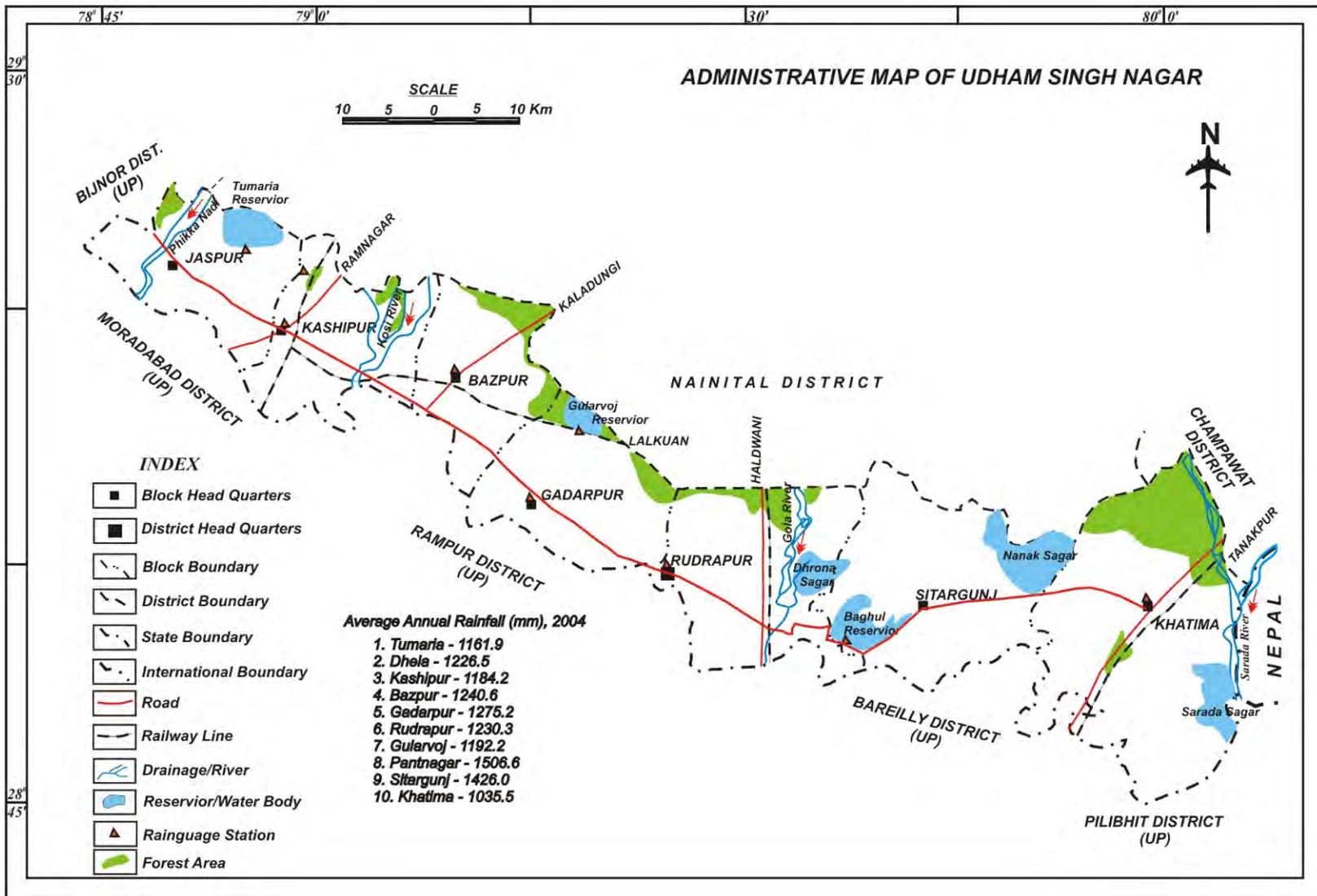


Fig. 1 Administrative map of district Udham Singh Nagar, Uttarakhand

DRAINAGE: District Udham Singh Nagar has a dense network of the drainage pattern. The rivers of the district belongs to the Ganges drainage system. Of these, Sarada, Kosi, Gola and Phikka river and their tributaries are Sawaldeh, Bour, Nandhour, Br 1 Kailash etc. drain the district, shown in **Fig. 2**. The unique feature of the area is debouching of major rivers into the plains from Lower Himalayas. The overall flow direction of these rivers generally north–south trend or northeast–southwest and flows to south till its confluences with the Ganga River. The major rivers are perennial, whereas their tributaries originating from sub-Himalayan zone are ephemeral and remain dry during the non-monsoon seasons. The overall drainage pattern in the study area sub dendritic to sub parallel.

Table 1. Details of the Developmental Blocks and tehsils, District Udham Singh Nagar

S. No	Name of the Block	Area (Km ²)	Name of Tehsil	Population Census2001	Villages		
					Inhabited	Uninhabited	Total
1	Jaspur	232	Jaspur	98279	100	5	105
2	Kashipur	185	Kashipur	86831	75	2	77
3	Bazpur	286	Bazpur	102143	113	3	116
4	Gadarpur	233	Gadarpur	104201	69	-	69
5	Rudrpur	307	Rudrpur	109730	90	-	90
6	Sitargunj	325	Sitargunj	146584	120	2	122
7	Khatima	324	Khatima	161291	89	1	90
	Forests	1103		23541			
	Urban	60		403014			
	Total	3055		1235614	656	13	669

(Source: District statistical Diary, 2005, district Udham Singh Nagar)

CROPPING PATTERN: Agriculture is the primary occupation of the people as it justifies the title of “Chawal ki Nagari”. About 64% of the total work force is engaged in farming the very fertile land (Tarai formation). Khariff and Rabi are two major cropping seasons. The main Khariff crops are rice, soyabean, Urd, Moong and till, and the Rabi crops are wheat, barley, Gram, Masoor, Mustard, Sunflower. It is observed in the study area that the rice crop is grown three times in a year. The total reported area in district is 279455 ha, out of which 84717 ha are occupied by the forests. Net sown area in the district is 149523 ha and gross sown area is 246481 ha. Area had sown more than once in the district is 96561 ha.

Area under *Rabi* and *Khariff* crops are 97973 ha and 139928 ha respectively. 8580 ha is reported under the *Zaid* crop. The sugarcane crop is also grown in very intensively as it is a cash crop.

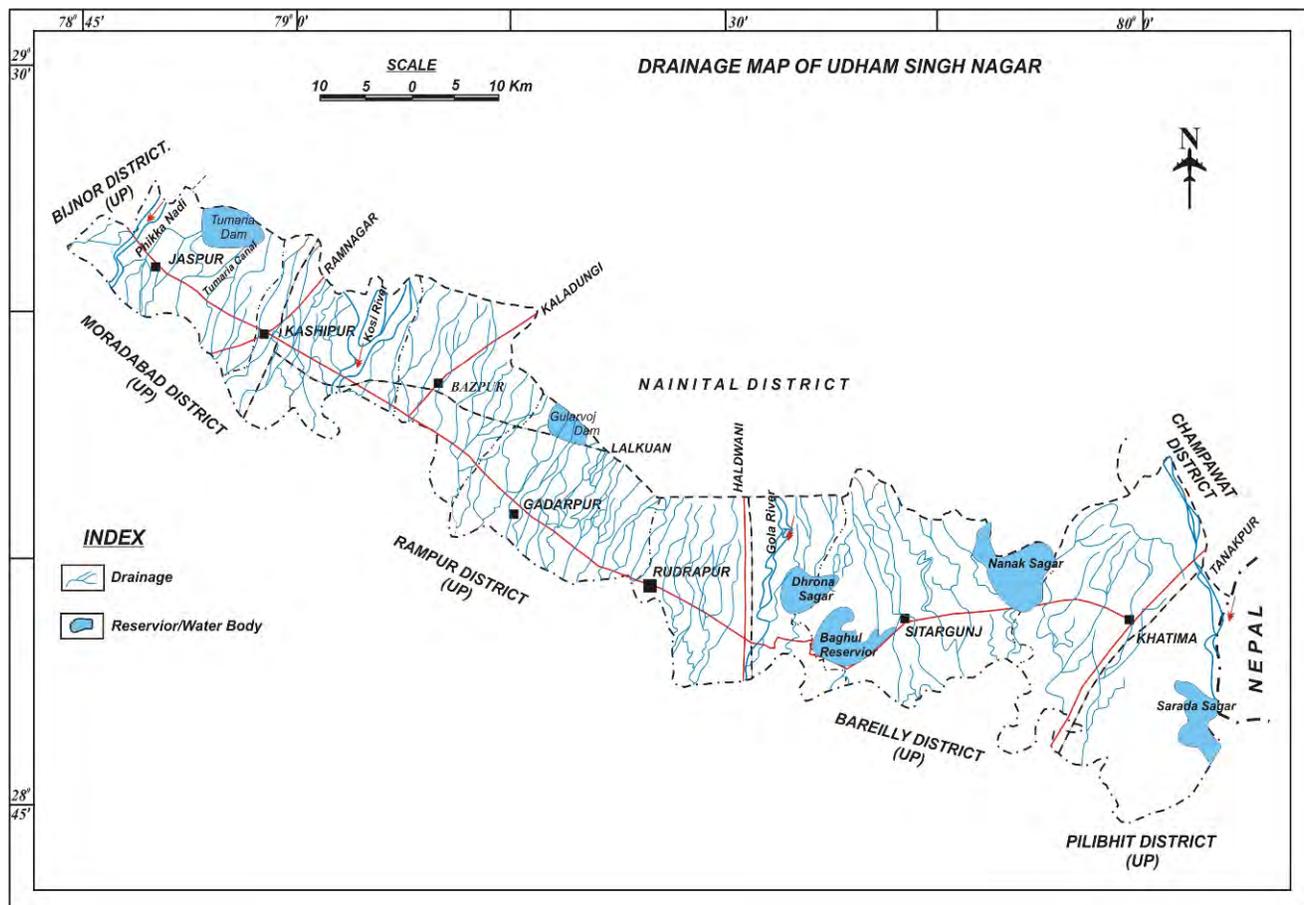


Fig. 2 Drainage map, District Udham Singh Nagar

IRRIGATION: The major rivers Kosi, Gola, and Sarada provide ample water to meet the irrigation demand, besides major reservoirs like Tumaria (Jaspur), Gularboj and Haripura (Gadarpur), Dron, Baghul and Nanak Sagar (Sitargunj) and Sarada Sagar (Khatima) in the study area. The prominent canals like Kosi, Gola and Sarada irrigate a large area of the Tarai belt and the other canals are Tumaria, Nathanpir. The branches of the major canals are the Gandli, Sukhi, Katna, Kailash, Kaman, Sanedi. The length of the canals in the study area is 924.3 km, which caters the needs of irrigation. Gadarpur block owns the maximum length of canals in the district, is of 205.65 km. Drip irrigation and sprinkler irrigations are in practice. The total irrigation potential created/utilized through minor irrigation schemes, through groundwater and surface water scheme is 144.140 and 72.851 mha, respectively.

There are 24703 shallow tubewells and 400 deep tube wells tapping multiple aquifers in the district.

2.0 CLIMATE AND RAINFALL

The climate varies from Sub-tropical and sub-humid with three distinct seasons i.e. summer, monsoon (rainy season) and winter. The rainy season starts from the month of middle June to September end, and followed by the winter season, which starts from the end of October and goes up to February. The winter rains are generally experienced in late December or early January, which brings down the temperature and that's how December and January are the coldest months in the district. The summer season starts from March and it goes up to June. The hottest months of the year are May and June. The maximum temperature in the district goes up to 42°C during the summers and the minimum temperature is between 1 and 4°C, further north of the district, the temperature comes down to 0.4°C in winter season.

Rainfall, spatially, is highly variable depending upon the altitude. The intensity of the rainfall increases from south to north and the amount of rainfall decreases in generally from west to east. About 90% of the rainfall received during the monsoon period, and the remaining 10% of the rainfall in non-monsoon period. The average annual rainfall is 1296.85 mm (Year; 2004). The annual rainfall according to the rainguage station and block-wise depicted in **Table 2** and pictorially shown in **Fig. 1**.

Table 2. Details of Ranifall (mm), District Udham Singh Nagar

S. No	Rainguage Station	Name of Block	Year	Rainfall (mm)
1	Tumaria	Jaspur	2004	1154
2	Kashipur	Kashipur	2004	2122
3	Dhela	Kashipur	2004	1137
4	Bazpur	Bazpur	2004	1317
5	Gadarpur	Gadarpur	2004	1121
6	Gularboj	Gadarpur	2004	1105
7	Rudrapur	Rudrapur	2004	1154
8	Pantnagar	Rudrapur	2003	2035.1
9	Sitargunj	Sitargunj	2004	1122
10	Khatima	Khatima	2004	1035.5

(Source: Irrigation Department, 2005, District Udham Singh Nagar)

3.0 GEOMORPHOLOGY AND SOIL TYPE

Udham Singh Nagar district may be broadly divided into two physiographic units from north to south viz., Bhabar and Tarai respectively. Since the area is located in the Himalayan foothills, a very thick column of alluvium is deposited, which further is classified into two distinct divisions:

(A) *The piedmont fan deposits known as Bhabar*

(B) *The Tarai Alluvium*

These zones spread in northeast – southwest direction all along the foothills of the Siwalik formation having a maximum width of less than 30 km. The general gradient towards south varies from 9 to 17 m/km. The slope gradually decreases towards south in the Tarai region and becomes almost flat close to the boundary between Tarai and Central Ganga plains, which exists few km south of the southern boundary of the study area. The geomorphology of an area plays a very significant role in the groundwater movement and occurrence, pictorially represented in **Fig. 3** and corresponding legend for groundwater prospects tabulated in **Table 3**.

The soil types are controlled by the topography and rock types. Based on the National bureau of soil Survey and Land Use Planning (ICAR) Nagpur, the soils of the district Udham Singh Nagar can be classified into Udifluventic Ustochrepts, Typic Ustipsamments, Udic Ustochrepts, Udic Haplustolls, Typic Ustochrepts as determined by their diagnostic properties. The Bhabar soils lay at the northern extremity of Khatima and Bazpur blocks, part of the alluvial fan deposits. Soils are shallow with sandy to loamy texture, poorly sorted, comprising mainly of gravel, sand, silt, clay with pebbles etc.

The Tarai soils run all along the northern extremity of the district, form continuous fringe with the Bhabar Zone. Bhabar formation is found in extreme northern parts of the Khatima and Bazpur blocks, boundary demarcated by the contact of Tarai and Bhabar. The Tarai belt is 8–25 km in width, and the general slope is <1% towards south. Soil is calcareous, moderately productive and suitable for extensive cultivation of high yielding variety of crops like rice and sugar cane. Soils typify marshy and swampy environment.

4.0 GROUNDWATER SCENARIO

4.1 GEOLOGY

Geology plays an important role in shaping the groundwater scenario of an area. So, it becomes imperative to know the geology of District Udham Singh Nagar. Piedmont alluvial deposits represent the geology of the study area. Broadly, it can be divided into two

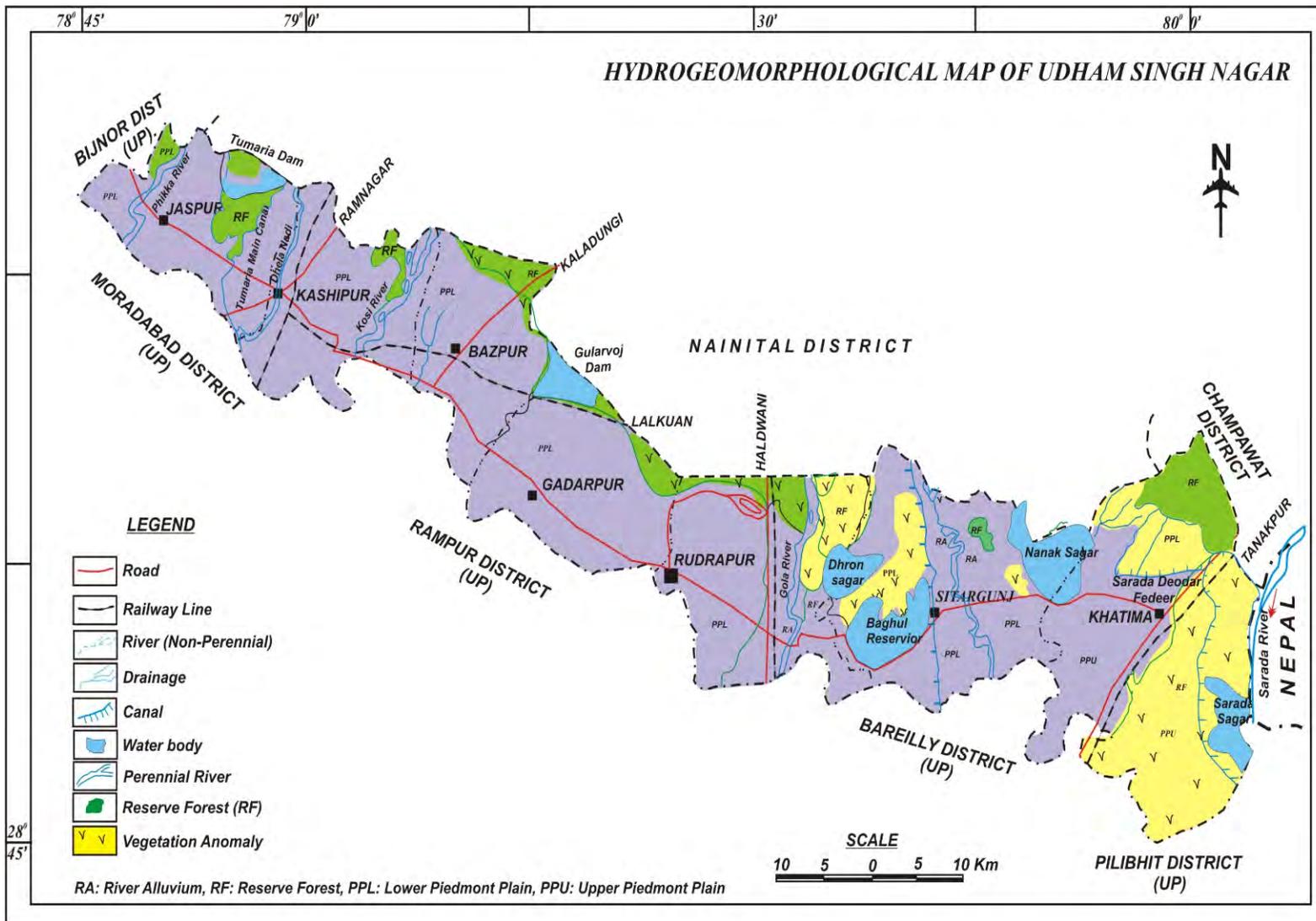


Fig. 3 Hydrogeomorphological Map of District Udhampur, Uttarakhand

formations viz. Bhabar and Tarai. These are characterized by distinct lithology, grain size distribution, variation of degree of sorting etc. a generalized geological succession, of the area, is as follows; Geological map of Udham Singh Nagar is shown in the **Fig. 4**.

Table 4. Geological details of district Udham Singh Nagar, Uttarakhand

Age	Morphotectonic Unit	Divisions	Lithology
<i>Recent to Quaternary</i>	<i>Piedmont</i>	<i>Bhabar</i>	<i>Boulder sand and clay</i>
	<i>Alluvial plain</i>	<i>Tarai</i>	<i>Sand, clay and slit.</i>

(i) BHABAR FORMATION:

Bhabar formation is essentially constituted of alluvial deposits lying on the sloping plains in the Himalayan foothills. It is primarily constituted of unconsolidated sediments like sand, gravel, boulder and clays. The grain size varies from material of sand grade (2 mm) through

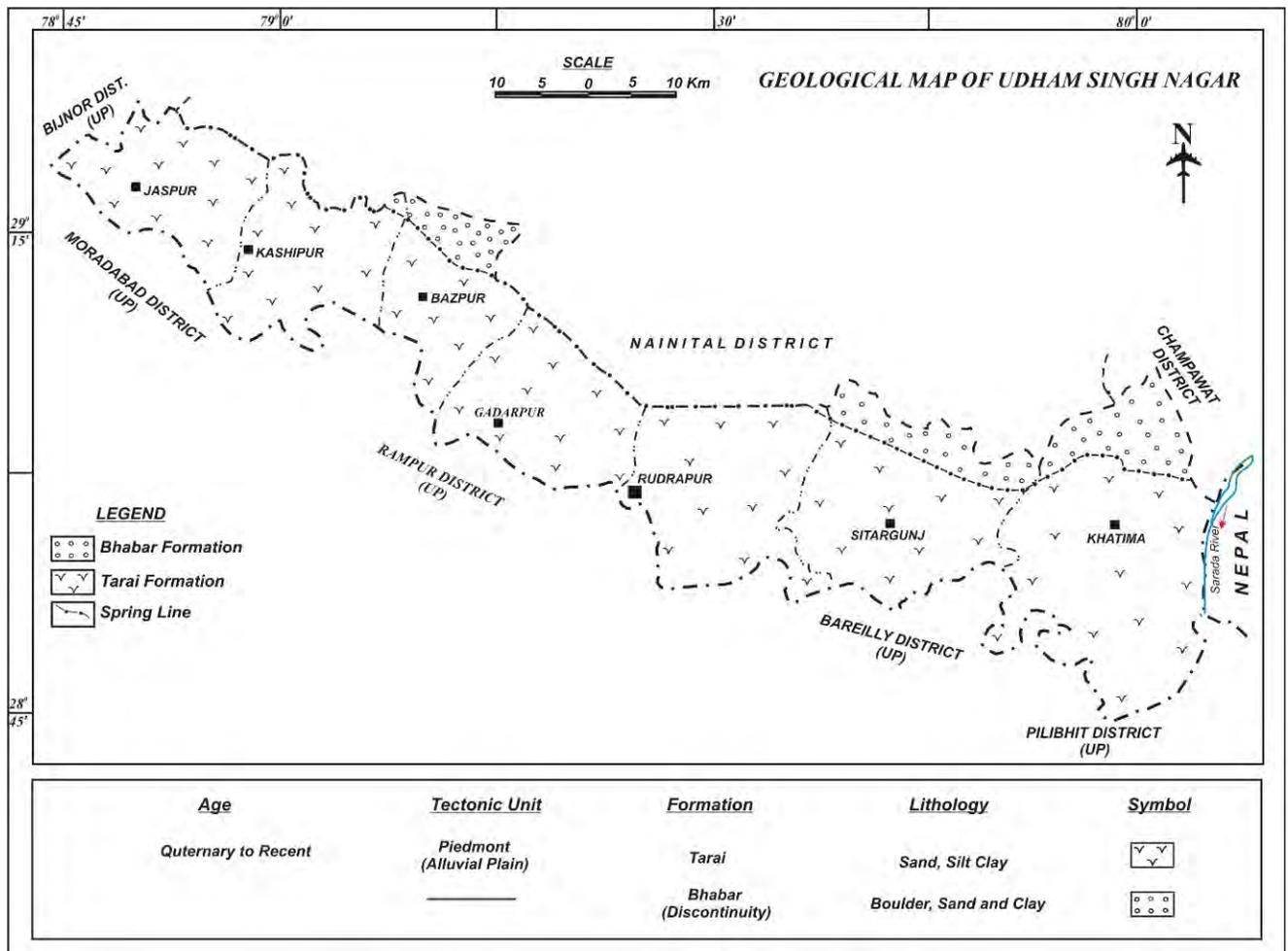


Fig. 4 Geological map of District Udham Singh Nagar

granules, pebbles, cobbles to boulders size i.e. >256 mm, sometimes the boulders have dimensions in feet. The clays are generally brown in color and clay bed sequences tend to pinch and for the same reason have short lateral continuity. The Bhabar formation is exposed immediately south of the Siwaliks of the Himalayan foothills, observed at northern parts of the Bazpur, Siatargunj and Khatima blocks. The exact trend and disposition of Bhabar formation depends largely upon the disposition of the Siwaliks. The extreme northern portion of the Bhabar zone is marked by the contact with Siwalik Ranges, whereas the southern limit is defined by the contact between Bhabar and Tarai, which forms the spring line or marshy conditions. The width of the bhabar formation is quite variable, the maximum being 21 kms.

(ii) TARAİ FORMATION:

The Tarai formation is exposed immediately south of the Bhabar formation, and the name itself being derived from marshy conditions. Tarai formation consists of clays, sandy clays, fine to medium sand and occasional gravels. In this formation there is a dominance of clayey successions over sandy horizons. The granular zones mostly occur as lenses and have inter-tonguing relationships with clastic and non-clastic units. The northern limits of the zone is demarcated by the spring line, i.e. the contact between Bhabar and Tarai, whereas the southern limit of this zone is taken to be the region where auto flow conditions cease to exist in the tube wells. The Tarai sediments representing the finer portion of the channel bed load and the load in suspension and solution, which are brought by the streams and evenly sorted out by the river action. Tarai formation is better sorted as compared to the Bhabar.

4.2 HYDROGEOLOGY

Generally the groundwater flows from north to south in the study area. Based on the behavior and occurrence of groundwater, the district can be broadly categorized into two broad hydrogeomorphic units namely (1) Bhabar and (2) Tarai, which have significantly different Hydrogeological attributes. These are briefly described hereunder and the Hydrogeological map of Udham Singh Nagar district is shown in **Fig.5**.

(i) BHABAR ZONE: Bhabar is highly porous and permeable alluvial tract lying in an elongated form along the Siwalik foothills. It has northwest-southeast elongation and forms

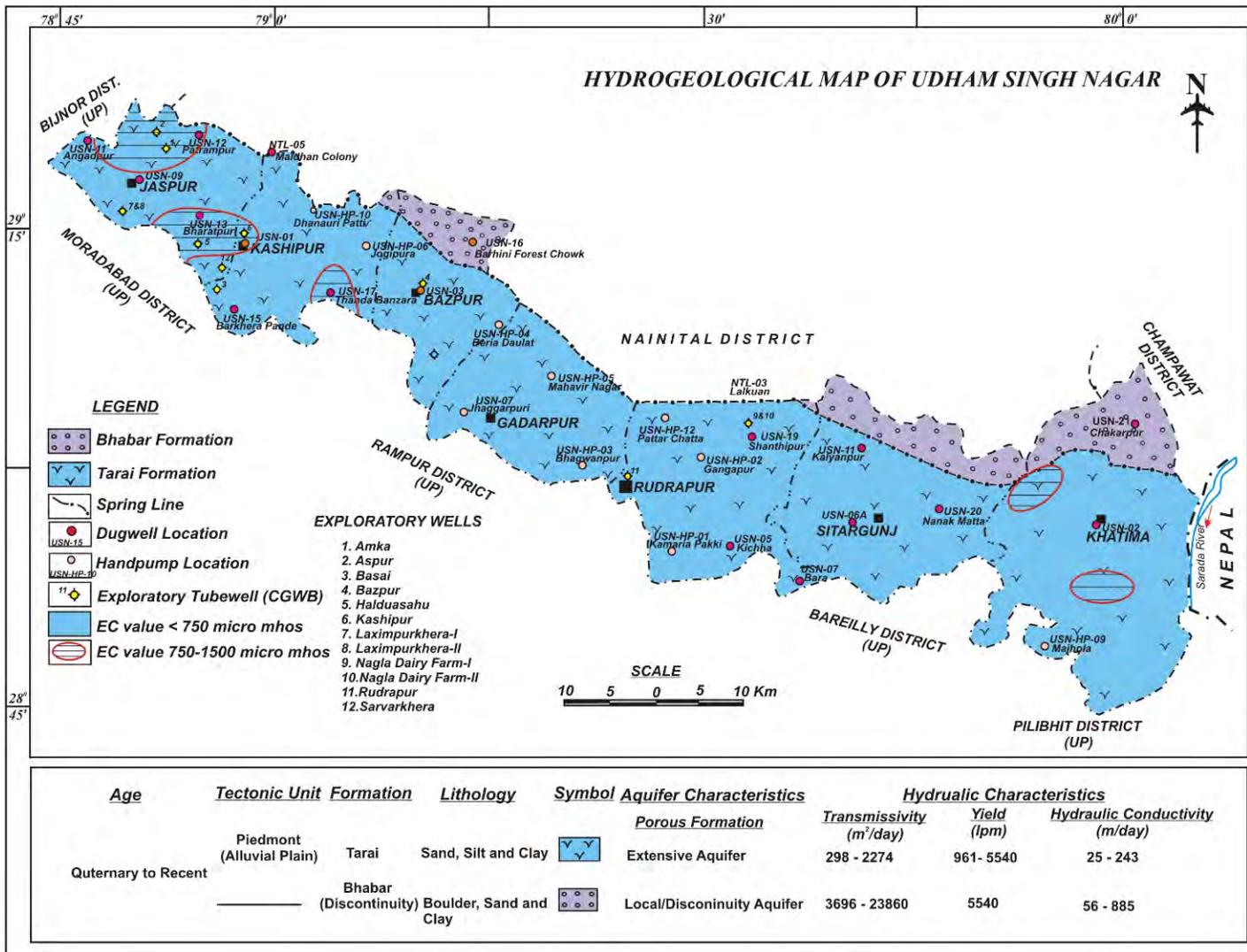


Fig.5 Hydrogeological Map of District Udham Singh Nagar, Uttarakhand

a highly potential hydrogeologic unit. Bhabars are poorly sorted, unconsolidated sediments viz., boulders, cobbles, pebbles, and granules, coarse to fine sand, silt and clay. The Bhabar merges gradually with the Tarai occurring in the south. The contact between these two hydrogeomorphic units is characterized by the change in slope and groundwater effluents, which form the spring line. These channels debouch the sediments at the downhill, over the foothills of the sub-Himalayan zone.

The sediments are deposited in the form of triangular alluvial fans and cones, by the braided streams. The alluvial cones join together to form an extensive piedmont plain. This Bhabar zone is highly productive. This zone is characterized by high degree of permeability and porosity, allowing major part of the precipitation to infiltrate, within a very short span of time, leading to the formation of excellent groundwater reservoirs. The aquifers in these zones are mostly unconfined. However, there are perched conditions also present in the study area. The Bhabar zone acts as a recharge front for the Tarai belt. Depth to water level progressively decreases towards south and water finally emerges at the surface as a spring line.

Bhabar is the main intake area close to the Himalayan foothills. Generally the water table is as deep as 75 m bgl; the water table also shows higher seasonal fluctuation.

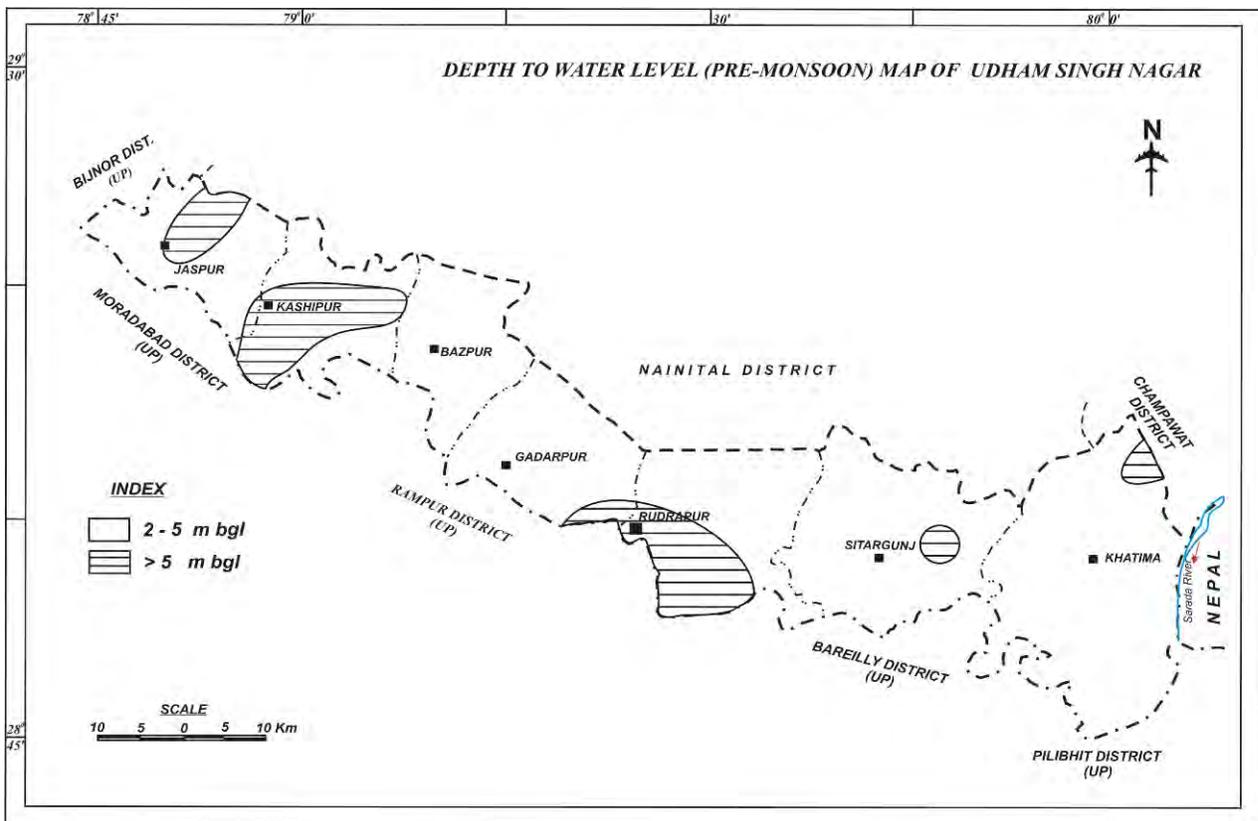


Fig. 6 Depth to water level Map (Pre-monsoon, 2006), District Udham Singh Nagar

The groundwater body appears to be sustained and recharged by (1) direct infiltration from precipitation on the land surface, and (2) infiltration from turbulent streams flowing across the belt. Considerable amount of water is also discharged by perennial springs at the southern limit of Bhabar during in monsoon seasons. The formation is favorable to percolate the water laterally from the Bhabar to Tarai and the Older Alluvium further south. The hydraulic gradient is approximately 2.97 m/km. The pre monsoon and post monsoon depth to water level ranges from 2.01(Barhini) to 5.58 (Chakarpur) m bgl, and 1.73 (Barhini) to 5.20 (Chakarpur) m bgl, respectively. Seasonal fluctuation varies from 0.28 to 0.38 m. The depth to water level of pre monsoon, post monsoon and seasonal fluctuation maps are prepared and shown in **Fig. 6**, **Fig. 7**, and **Fig. 8**, respectively. The yield of the tube well is observed up to 5540 lpm. The transmissivity values range from 3696 to 23860 m²/day. The hydraulic conductivity, as deciphered from pumping tests, range from 56 to 825 m/day.

(ii) **TARAI ZONE:** Tarai formation lies south of the Bhabar, which comprises predominantly of clays and silts with horizons of well-sorted granular material such as sand,

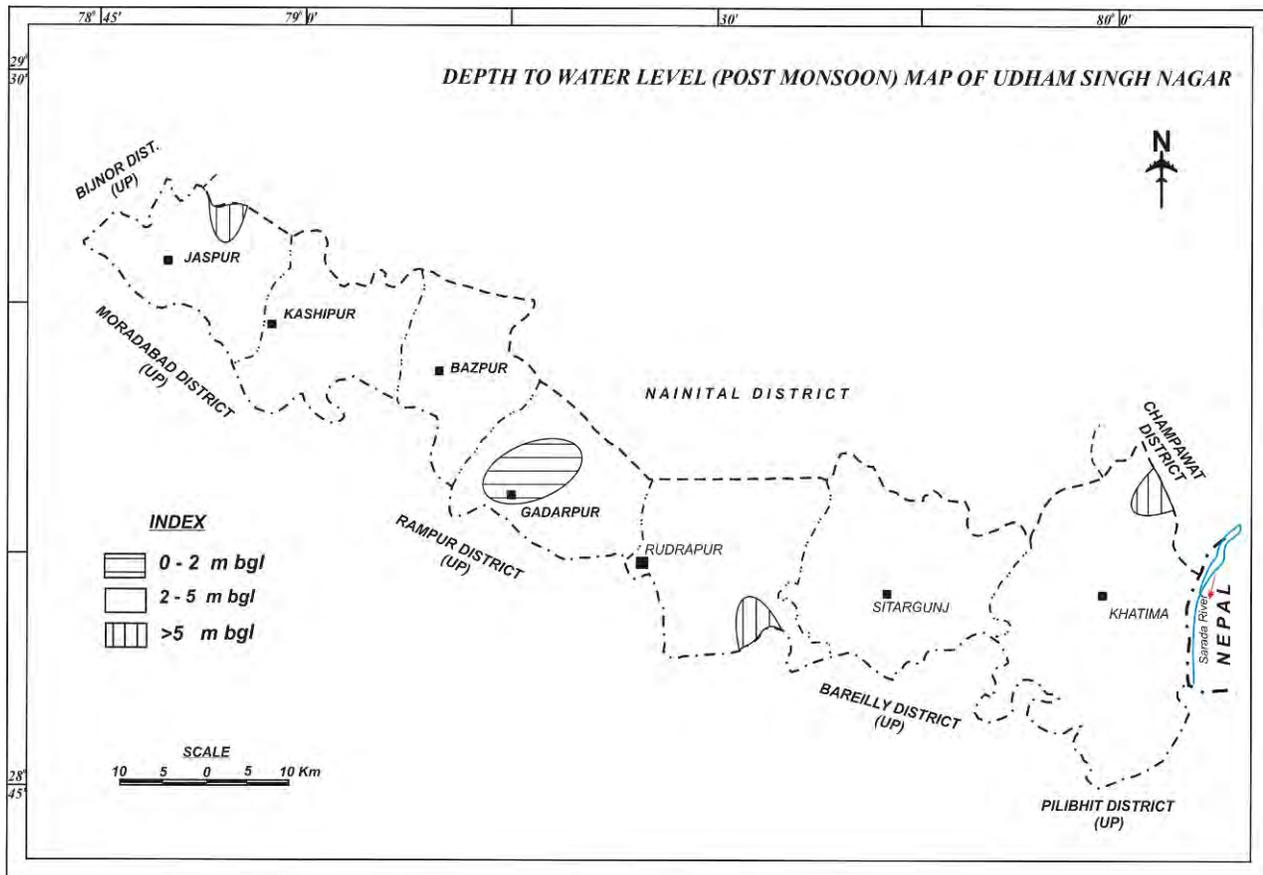


Fig. 7 Depth to water level Map (Post-monsoon, 2006), District Udham Singh Nagar

gravel occasionally boulders and cobbles and pebble beds. The boundary between the Bhabar and the Tarai is defined by a spring line, which is characterized by auto-flow (free-flowing) conditions. There are plenty of moist and waterlogged areas around the spring line particularly during monsoon season. The sand and gravel associated with the finer fractions are the major aquifers in this zone.

Groundwater in shallow aquifer is tapped through dug-wells; the groundwater occurs under unconfined/phreatic conditions. The groundwater in deep aquifers is, under confined and artesian conditions. The deeper aquifers (> 50 m) being generally confined conditions with higher artesian heads, and the tightly cased tubewells constructed in them result in flowing wells. The unconfined shallow groundwater of the Tarai may be recharged by (1) the direct infiltration from rainfall on the land surface, (2) the infiltration from the streams when flooded, (3) return seepage from irrigation (4) lateral percolation from adjacent Bhabar zone. On the contrary, the confined groundwater is probable recharged by downward percolation and lateral flow from Bhabar belt. Bhabar is, therefore, the intake area for Tarai as well.

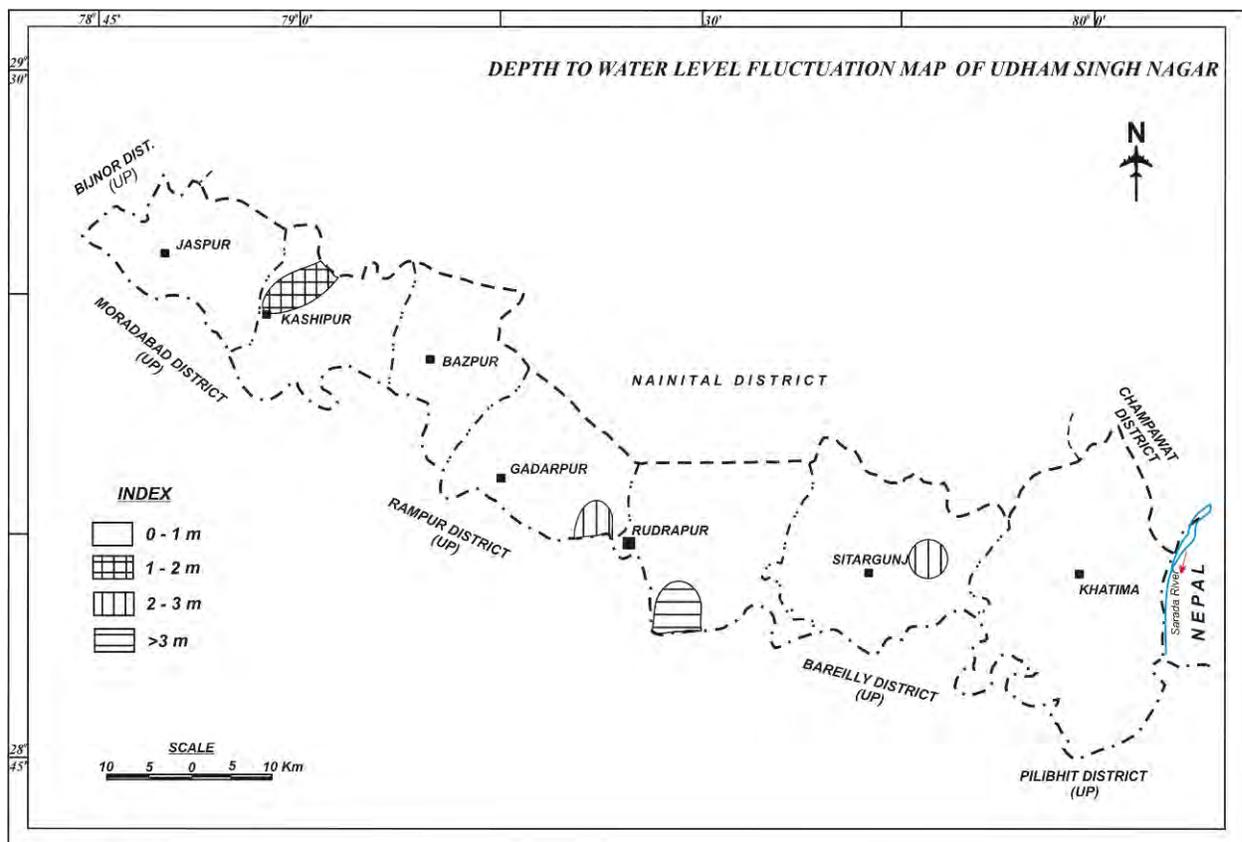


Fig. 8 Fluctuation Map (Period, 2006), District Udhamsingh Nagar

The groundwater in Tarai zone occurs both in unconfined and confined conditions. In the unconfined aquifer, the depth to water level in pre monsoon and post monsoon varies

from 2.09 to 7.08 m bgl and from 1.99 to 6.89 m bgl, respectively. The seasonal fluctuation varies from 0.09 to 3.56 m. The general slope of water table is from north to south. The detailed hydrogeological map along with locations of exploratory tube wells are shown in **Fig. 5**. The tube wells tapping deeper confined aquifers with auto-flow conditions yield 25.0 to 55.0 lps of freshwater for a draw down of 2.0 to 8.0 m. In case of tubewells tapping confined aquifers with non flowing conditions the yield varies between 10 and 40 lps for a draw down of 4.0 to 9.0 m. The exploratory wells of CGWB tapping confined aquifer, drilled depth ranges from 74.98 to 88.39 m, yield ranges from 2683 to 3100 lpm, transmissivity values range from 1180 to 2500 m²/day, and the hydraulic conductivity ranges from 25 to 243 m/day. The hydraulic gradient ranges between 1.35 to 4.0 m/km. the coefficient of permeability ranges between 17 and 108 m/day.

(iii) GROUNDWATER CONDITIONS IN AUTO FLOW ZONES:

Artesian conditions are restricted to the Tarai zone. In a well, penetrating through an aquifer, the water level will rise above the bottom of the confining bed. If the water level rises above the top of the upper confining layer, above the ground surface, free flowing /auto flow conditions result. In this zone confining conditions result due to intercalation of permeable materials like sand and gravel with impervious clay horizons. The difference in elevation of Bhabar and Tarai, together with the regional slope of the strata, appears to build the artesian head in the aquifers. Permeability of the Tarai aquifers is less than that of Bhabar, thereby playing a vital role in developing the pressure, as it impedes ground water flow. The discharge of the tubewells is dependent of aquifer properties, and local ground conditions. There are more than 2000 artesian wells existing in Kashipur, Bazpur, Gadarpur, Rudrapur and Sitargunj blocks. Central Ground Water Board has constructed artesian wells at Basai, Kashipur, Bazpur, Nagla and Rudrapur (**Fig. 5**). The drilled depth ranging from 84.4 to 433.0 m bgl, with free flowing head upto 8.69 m above ground level. The yield of these wells upto 3400 lpm, with the drawdown 5.39 to 10.69 m. The Transmissivity values range from 825 to 12274 m²/day, and the hydraulic conductivity ranges from 16.17 to 106.6 m/day.

It is observed that the pressure head of the artesian aquifers drastically reduced over the two decades and some of the shallower depth wells lost its artesian conditions. The causes of reduction in discharge of artesian wells may be attributed i. Over exploitation of groundwater due to industrialization ii. Reduction in recharge area due to developmental activities in Bhabar zone iii. Over exploitation of confined artesian aquifer iv. Interlinking of

confined and unconfined aquifers due to increased number of tube wells, v. choking of wells and vi. Continuous free flow of artesian water as there is no efforts to arrest the auto-flow.

(iv) GROUNDWATER MONITORING WELLS (GMMW):

Central Ground Water Board has established 28 nos. groundwater monitoring wells to monitor the groundwater regime periodically and to study the hydrogeological behavior of the aquifers in district Udham Singh Nagar, which are shown in **Fig. 5**. The basin wise groundwater monitoring wells are given in **Table 5**.

Table 5. Details of block wise groundwater monitoring wells, District Udham Singh Nagar

S. No	Name of the Block	GMMW	Type of structure	Basin	Geology
1	Jaspur	1. Jaspur 2. Angadpur 3. Patrampur 4. Bharatpur	DW DW DW DW	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium
2	Kashipur	1. Kashipur 2. Barkhera Pande 3. Dhanauri Patti 4. Jogipura 5. Thanda Banzara	DW DW HP HP DW	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium
3	Bazpur	1. Bazpur 2. Banna Khera 3. Barhini FC 4. Beria Daulat	DW DW DW HP	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium
4	Gadarpur	1. Mahavir Nagar 2. Jhaggarpuri 3. Bhagwanpur	HP HP HP	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium
5	Rudrapur	1. Pattar Chatta 2. Gangapur 3. Kamaria Pakki 4. Shanthipur 5. Kichha 6. Bara	HP HP HP DW DW DW	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium
6	Sitargunj	1. Sitargunj 2. Kalyanpur 3. Nanak Matta	HP DW DW	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium
7	Kahtima	1. Khatima 2. Chakarpur 3. Majhola	DW DW HP	Ganga Basin Ramganga Sub-basin	Terrace and Channel Alluvium

4.3 GROUNDWATER RESOURCES

Groundwater resource estimation has been carried out for district Udham Singh Nagar. As a part of the Reappraisal Hydrogeological Studies (RHS) in the study area, an attempt has been made to evaluate the available groundwater resources in the district based on the norms laid down in GEC-1997 (Groundwater Resource Estimation Committee) as well as the adhoc norms of the State Groundwater Department (Erstwhile Uttar Pradesh). Resources have been calculated block wise based on the Water Table Fluctuation (WTF) and Rainfall Infiltration Method (RIF). The overall stage of groundwater development in the district is 79.67%, and it is mentioned in the **Table 6**. The summarized results of the resource potential details of each block are depicted in the **Table 7**. The graphical representation of stage of groundwater development (groundwater availability, groundwater draft and balance) had shown block wise in the **Figure .9** given hereunder.

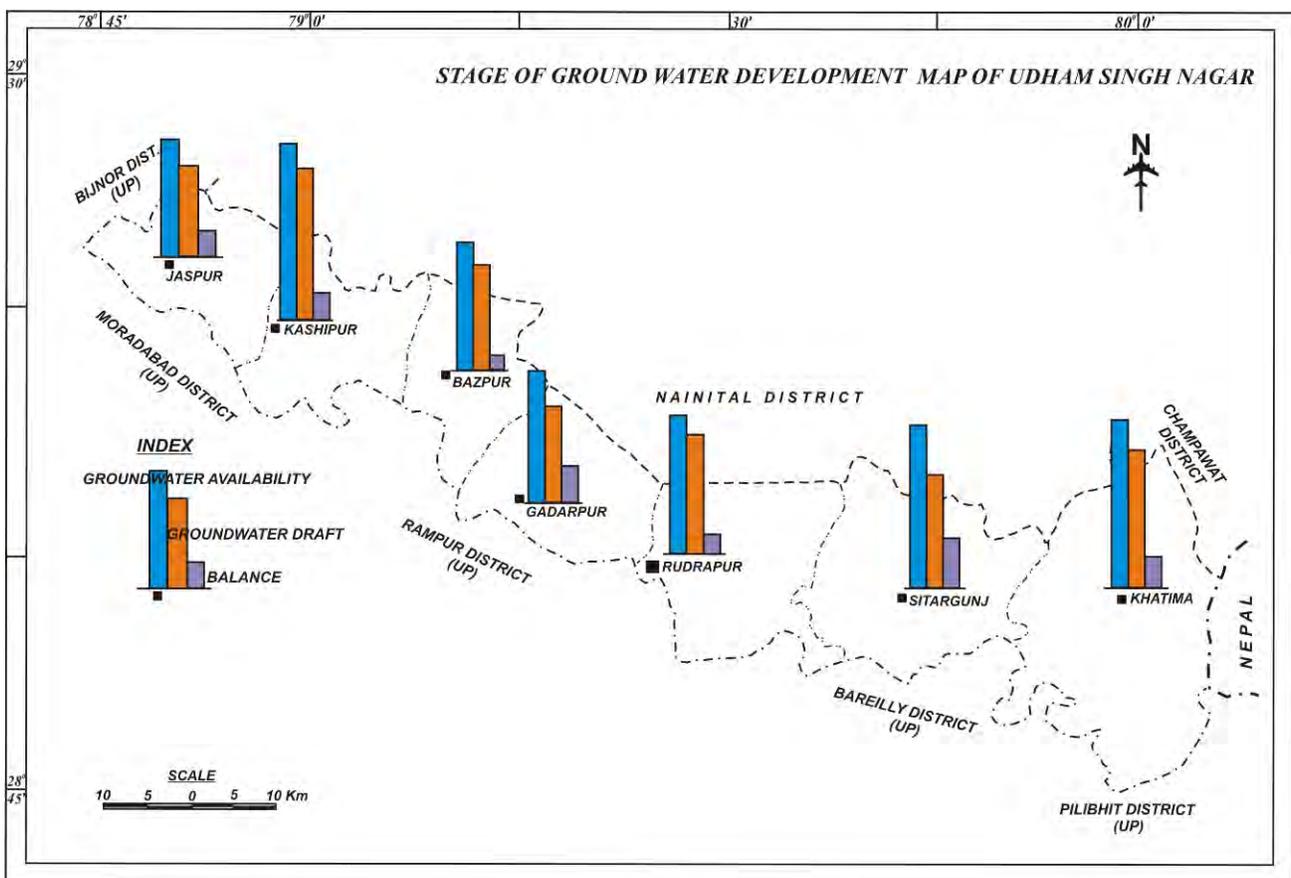


Fig. 9 Bar diagram of Stage of groundwater development, district Udham Singh Nagar

Table 6. Groundwater Resources Potential (in Ha m), District Udham Singh Nagar

S. No	District	Total annual GW Recharge	Net GW Availability	Annual draft for all uses	Net GW Availability for future irrigation	Stage of Development (%)	Remarks
1	Udham Singh Nagar	665691.8	62005.8	49207.27	12798	79.67	For plain area

Table 7. Block-wise Groundwater Resources Potential District, Udham Singh Nagar, Uttarakhand as on 01/04/2004

S. No	Block	GW Availability	GW Draft	Level of Development (%)	Categorization
1	Jaspur	8868.06	6836.73	77.09	Semi-Critical
2	Kashipur	7331.68	6179.41	84.28	Semi-Critical
3	Bazpur	8151.94	6905.15	84.70	Semi-Critical
4	Gadarpur	7226.31	5256.68	72.74	Semi-Critical
5	Rudrapur	7880.80	6838.26	86.77	Semi-Critical
6	Sitargunj	10960.79	7629.64	69.60	Safe
7	Khatima	11586.26	9561.40	82.52	Semi-Critical

Rudrapur block (86.77%) has shown the highest groundwater development, and the lowest groundwater development is shown by the Sitargunj block (69.60%). As per the norms of GEC-1997, all the blocks are under semi-critical situation except Sitargunj block with safe distinction.

4.4 GROUND WATER QUALITY

To assess the chemical quality of groundwater in the study area, 63 numbers of water samples collected from various structures like dug wells, hand pumps, tube wells etc. and got them analyzed for EC, pH, Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Nitrate, Copper, Lead, Zinc, Iron, Chromium and Manganese. The ranges of different chemical parameter, in District Udham Singh Nagar, are tabulated in **Table 8**.

Table 8. Variations of different chemical parameter, District Udham Singh Nagar

Parameter	Dug wells/Hand Pumps
Electrical Conductivity (EC)	262 – 1300 μ mohos
pH	7.8 - 8.3
Calcium (Ca)	8 – 40 mg/l
Magnesium (Mg)	10 – 58 mg/l
Sodium (Na)	1.4 – 46 mg/l
Potassium (K)	0.4 – 68 mg/l
Bicarbonate (HCO_3)	18 – 262 mg/l
Chloride (Cl)	7 – 270 mg/l
Nitrate(NO_3)	0.5 – 63 mg/l
Fluoride (F)	0.1 – 0.4 mg/l
Total Hardness as CaCO_3	120 – 300 mg/l
Copper (Cu)	0.02 – 0.03 mg/l
Lead (Pb)	0.01 – 0.03 mg/l
Zinc (Zn)	0.03 – 1.09 mg/l
Iron (Fe)	0.12 – 3.00 mg/l
Chromium (Cr)	0.02 – 0.13 mg/l
Manganese (Mn)	0.10 – 3.20 mg/l

5.0 GROUNDWATER MANAGEMENT STRATEGY

Groundwater in Udham Singh Nagar district has been extensively developed through tubewells. Proper management is required to minimize the over withdrawal of priceless groundwater in the district. The artesian aquifers are required to be protected by putting sluice valves on the wells, which arrests the free flow of water. Most of the shallow artesian aquifer got dried because of the over development of the groundwater in the area. It is observed from the groundwater management studies, the shallow tube wells less than 60 feet are giving very low discharge during summers, for which deeper aquifers are to be tapped for further future groundwater development. Rainwater Harvesting and Artificial Recharge are to be practiced on a larger scale in the Bhabar areas, which is recharging zone for Tarai area, thus maintaining discharge/pressure head of the artesian wells.

5.1 STATUS OF GROUNDWATER DEVELOPMENT

Groundwater in Udham Singh Nagar district has been extensively developed through tubewells. Central Ground Water Board has constructed twelve exploratory wells (**Table 9**), out of them five wells are exhibiting auto-flowing conditions, viz, Basai, Kashipur, Bazpur, Nagla and Rudrapur, The discharge of these wells ranges between 961 and 2300 lpm. State Government (Jal Nigam, Irrigation Department etc) and local populace have drilled maximum tubewells in the alluvial portions with depth ranging from 60 to 150 m bgl. The discharge of these tubewells ranges from 1200 to 2500 lpm.

5.2 WATER CONSERVATION AND ARTIFICIAL RECHARGE

Proper groundwater management is required to minimize the over withdrawal of priceless groundwater in the district. Rainwater Harvesting and Artificial Recharge are to be practiced on a larger scale in the Bhabar areas. The Bhabar zone along the foothills of Siwalik consists of boulders, gravels, sand and clay, which exhibit high porosity and permeability enabling it to form a good recharge zone through direct infiltration of precipitation. The Groundwater Management Studies reveals that the overall groundwater flows in north–south direction. The high altitude areas of Siwalik and Bhabar areas may be used for the construction of check dams by tapping the lower order streams, so that groundwater is recharged in the plain areas (Tarai Zone), which enables/restores the life of some artesian wells. The areas where maximum agricultural activities and industrial withdrawal are taking places may be selected for rainwater harvesting and groundwater recharge through abandoned dugwells or dried bore wells.

6.0 GROUND WATER RELATED ISSUES AND PROBLEMS

Hydrogeological investigations reveal that the depth to water level is shallow in Udham Singh Nagar district since last two decades and there is no change in the long term water level trend. The shallow aquifer gets contaminated and gives foul smell as many industries discharges their untreated effluents directly to near by water bodies, which affects the quality of drinking water. Groundwater pollution studies are to be taken up in project mode to bring out clearer picture in realistic manner. However, in hand pumps the quality problem is mainly because of the color (yellowish brown) and bitter taste, indicating that

the water has very high iron content. Putting an iron filter unit with the outlet of the hand pump can solve the problem.

7.0 AWARENESS & TRAINING ACTIVITY

There is no mass awareness and ground water management training activities have been conducted in the district. However, one Groundwater Management Training on “Rainwater Harvesting and Artificial Recharge to Groundwater” has been conducted in nearby town, Haldwani, Nainital district by Central Ground Water Board, Uttaranchal Region, Dehradun. The delegates participated from both the districts Udham Singh Nagar and Nainital. The Industrialist working in the area were advised and requested to save groundwater from various sources of pollution and to adopt Rainwater Harvesting and Artificial Recharge to sustain groundwater resources. The Gram Pradhans, Village Development Officers and NGOs were especially invited so that they could increase the awareness among villagers on important issues like sustainable development of the fast depleting groundwater resource by adopting methods on conservation of groundwater. In order to create awareness in masses, exhibition on different techniques of Rainwater Harvesting in rural and urban areas were exhibited. During the Training Programme, Sh. A. M. Khan, the then Regional Director gave a talk on water conservation and management. Dr. R. P. Singh, Scientist ‘D’, delivered lecture on various techniques of Rainwater Harvesting in rural and urban areas and discussed about the significance of such activities, in context of hilly region. Dr. S. K. Srivastava, Scientist ‘B’ (Chemist) elaborated on the quality of water for drinking and irrigational uses and discussed in detail about pollution hazards of groundwater.

8.0 AREA NOTIFIED BY CGWA

There is no block under over exploited category in district Udham Singh Nagar and hence no notified area by Central Ground Water Authority.

9.0 RECOMMENDATIONS

1. The groundwater is developed mainly through tube wells, hand pumps and dug wells. The overall groundwater scenario in the district is safe to semi-critical. However, the situation is slowly deteriorating due to over exploitation of groundwater

due to rapid urbanization, industrialization besides rapid deforestation. There is an urgent need for intensive monitoring of groundwater scenario in the district.

2. Deforestation must be avoided in Bhabar areas, which is recharge zone for groundwater.
3. In the district, paddy is grown intensively, leading to over exploitation of groundwater. The local farmers should be encouraged to adopt cultivating of other less water consuming crops along with paddy.
4. Due to artesian conditions in 1/3rd area of the district, water is being wasted as there is no mechanism to regulate the free flow of groundwater. There should be proper mechanism to stop such wastage, which facilitate to protect the diminishing pressure heads of the artesian wells.
5. Unmetered domestic water is being supplied in the district, which leads to wastage of water. There should be metered domestic water supply so as to encourage water conservation.
6. Some of the major towns/cities are situated close to perennial rivers like Sarada, Gola, Kosi and Phikka. A battery of shallow tube wells may be constructed along these rives to augment domestic water supply and irrigation. This will help to reduce stress on groundwater.
7. The district receives moderate to high rainfall and most of it goes waste as runoff. There is an urgent need to harvest the rainwater by utilizing it for artificial recharge. On farm rainwater conservation will not only help to reduce depletion of groundwater but will also help to preserve the soil nutrients.
8. Abandoned dug wells can be used for recharging the groundwater instead of filling with garbage.
9. Mass Awareness and Rainwater Harvesting Training programmes should be taken up with the participation of local people for creating awareness.
10. Detailed pollution studies are required in the vicinity of the industrial areas like Kashipur, Rudrapur and Sitargunj blocks to asses the quality of groundwater.
11. In the district, hand pumps and dug wells are being monitored as groundwater monitoring wells, which easily get disturbed by anthropogenic activities, so loosing the valuable water level data. To mitigate this problem, purpose built Piezometers should be constructed, so that long term water level data can be obtained.

Table 3. Hydrogeomorphological aspects and details of geomorphic units, District Udham Singh Nagar, Uttarakhand

Map Symbol	Geomorphic Unit	Lithostratigraphy	Structure	Description	Groundwater Prospects
	Fluvial boulder bed	Boulder, gravel, sand	--	Deposited partly as valley fills and constitutes boulder, cobble, pebble, gravel, sand and silt	Excellent
PPU/ PPL	Piedmont Plain (Upper/Lower) (PPU/PPL)	Rock Debris and Alluvium	--	Piedmont plain in the area is found as gently sloping plain formed of the foot hill zones by the coalescence of several alluvial fans consisting of fine to coarse alluvium brought by Kosi and Gola rivers and several other streams such as Sawaldeo Nadi, Bour Nadi, Nandhour Nadi etc, debouching from the hills to the plains. Upper/Lower piedmont plains are marked based on slope variation and extension of deposition. Lower piedmont plain contain more silt and clay and is covered with vegetation (Bhabar)	Moderate to Good
AF	Alluvial Fan (AF)	Alluvium		Streams deposits whose surface approximates segment of a cone that radiates down slope from where the stream leaves a mountainous region. Such alluvial fans are observed along Gola river and in between Bour Nadi and Bhak Nadi.	Good
RA	Ravines (RA)	Alluvium (AI)		Ravenous lands are identified as small, narrow, deep depressions smaller than gorge. The gullies are covered by surface run-off and are marked by eroded land surfaces along Kailash Nadi and Gola river.	Poor
T	Terrace	Alluvium (AI)		Occurs by the sides of Kosi river and its upper reaches and are almost flat terraces. These terraces are separated by steep wall like escarpments and are characterized by thick vegetation.	Moderate to Good
V V	<u>Landforms</u> Vegetation Anomaly	--	--	Thick dense vegetation indicates the presence of loose material and good quantity of water.	Moderate to Good
	Meander scar			Abandoned meanders in the lower piedmont plain areas are often filled in by alluvial deposits and covered with vegetation.	Good to excellent
	Water logged area			Water logged areas are identified at places where the water table is at or near land surface.	Good for shallow aquifers

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