GROUND WATER BROCHURE, DISTRICT UTTARAKASHI

DISTRICT AT A GLANCE

S.No	Items	Statistics
1	**GENERAL INFORMATION**	
	i) Geographical area (Sq km)	8016
	ii) Administrative Divisions (As on 2001-02) Number of Tehsil/Blocks: Number of Panchayat /Villages	4/6 670
	iii) Population (As on 2001 Census)	2,95,013
	iv) Average Annual Rainfall (mm)	1706
2	**GEOMORPHOLOGY**	
	Major physiographic units:	Lesser, Central and Higher Himalaya.
	Major Drainages:	Bhagirathi, Yamuna & Tons
3	**LAND USE (Sq. km)**	
	a) Forest area (sq. km.)	6957
	b) Net area sown (sq. km.)	290.19
	c) Cultivable area (sq. km.)	-
4	**MAJOR SOIL TYPES**	Lithic/typic cryorthents, lithic/typic udorthents &dystric eutrochrepts
5	**AREA UNDER PRINCIPAL CROPS**	Wheat 33.07%, Rice 28.14%, Manduwa 15.37%
6	**IRRIGATION BY DIFFERENT SOURCES** (Areas and Numbers of Structures)	
	Dugwells:	Nil
	Tube wells/ Borewells:	Nil
	Tanks/ponds:	Nil
	Canals:	232.45 km
	Other sources:	6 lift schemes
	Net irrigated area:	487.74 sq. km.
	Gross irrigated area:	-
7	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB**	
	No of Dug wells:	Nil
	No of Piezometers:	Nil
8	**PREDOMINANT GEOLOGICAL FORMATIONS**	Alluvium, Garhwal Group and Jaunsar Group
9	**HYDROGEOLOGY**	
	➢ Major water bearing formation	Quartzites and phyllites of Garhwal Group
	➢ Pre-monsoon Depth to water level range of hand pump in mbgl	1.79-56.28
	➢ Post-monsoon depth to water level range of hand pump in mbgl	1.06-53.58

	➢ Long term water level trend in 10 yrs in m/yr.	-
10	**GROUND WATER EXPLORATION BY CGWB**	
	No of wells drilled (EW, OW, PZ, SH Total)	Nil
	Depth Range (m)	-
	Discharge (liters per second)	-
	Storativity (s)	-
	Transmissivity (m^2/day)	-
11	**GROUND WATER QUALITY**	
	Presence of Chemical constituents more than permissible limit (e.g. EC, F, As, Fe)	Parameters well within permissible limits. Except at Dharali where Nitrate is high and it is due to local contamination
	Type of water	Good, both for drinking & Irrigation purposes.
12	**DYNAMIC GROUND WATER RESOURCES in mcm**	The water resources can't be estimated, as the water table is not continuous.
	Annual Replenishable Ground water Resources	
	Net annual Ground Water Draft	
	Projected Demand for domestic and Industrial Use upto 2025	
	Stage of Ground Water Development	
13	**AWARENESS AND TRAINING ACTIVITY**	
	Mass Awareness Programmes Organized Date Place No of participants	Not yet organized
	Water Management Training Programmes Organized Date Place No of participants	Not yet organized
14	**EFFORTS OF ARTIFICIAL RECHARGE& RAIN WATER HARVESTING**	
	Projects completed by CGWB (No & Amount spent)	Nil
	Projects under technical guidance of CGWB (Numbers)	Nil
15	**GROUND WATER REGULATION AND CONTROL**	
	Number of OE Blocks	Nil
	No of Critical Blocks	Nil
	No of blocks notified	Nil
16	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	Proper management of springs is required, as they are the main source of water for all uses.

DISTRICT GROUNDWATER BROCHURE
UTTARKASHI DISTRICT, UTTARAKHAND

1.0 INTRODUCTION

Uttarkashi district lies in the northwestern part of Uttarakhand state. It is bounded by North Latitude 30° 27′ 18″ and 31° 27′ 42″ and East Longitude 77° 48′ 26″ and 79° 24′ 00″ and falls in Survey of India Degree sheet Nos. 53E, F, I, J and M. The geographical area of the district is 8016 km^2. The district is important from religious point of view as the two holy rivers namely Ganga and Yamuna have their emerging points in this district. Uttarkashi district, the largest district of Uttarakhand, is also important from strategic point of view as it shares its NE boundary with China.

District Uttarkashi is bounded by Himachal Pradesh and China in the north, Tehri Garhwal district on the south, districts Chamoli and Rudraprayag on the east and district Dehradun on the west. Entire area is mountainous with agrarian and economy. Forest cover with 86.59% is the main landuse. The total population, of the district, is 2,95,013 out of which the male and female population is 1,52,016 and 1,42,997, respectively (Census, 2001). The population density is 37 persons/km^2 and the male, female sex ratio is 1000: 964. The overall literacy rate is 65.71%.

Administratively the district is divided into four tehsils namely, Bhatwari, Dunda, Chinyalisaur, Mori, Barkot and Purola. Further it is divided into six developmental blocks viz: Mori, Purola, Naugaon, Bhatwari, Dunda and Chinyalisaur. The details of the blocks are given in Table 1.and their spatial distribution is given in Fig. 1

Table 1. Details of the developmental blocks and tehsils, District Uttarkashi.

S.No	Name of Block	Area (km^2)	Name of Tehsil	No. of Villages	No. of Towns
1	Bhatwari	188.06	Bhatwari	101	2
2	Purola	110.67	Purola	173	1
3	Dunda	184.96			1
4	Chinyalisaur	138.27	Dunda	222	1
5	Mori	204.64			1
6	Naugaon	266.06	Barkot	181	1
Forest		6923.34			
Total Area		**8016**			

DRAINAGE: Bhagirathi river, Yamuna river, Tons river and their tributaries drain the district. Prominent of the tributaries are Kamola, Rupin, Supin, Hanuman Ganga, Indravati, Jahnavi and Khurmola. The main drainage patterns are dendritic, sub-dendritic, trellis, sub-rectangular and rectangular. The major rivers i.e. Bhagirathi, Yamuna and Tons are of antecedent type, where as the drainage in the structurally disturbed area is of subsequent type.

CROPPING PATTERN: Agriculture is the main occupation of the people. The agricultural activities are restricted to river terraces, gentle hill slopes and intermontane valleys. The major crops are rice, wheat, potato, pulses, millets and seasonal vegetables. The net sown area, in the district, is 290.19 sq. km. out of which 157.45 sq. km. is sown more than once in a year. The gross sown area is 448.54 sq. km. out of which 284.66 and 163.68 sq. km. are covered under Rabi and Khariff, respectively.

IRRIGATION: The sources of irrigation are springs, gad, gadheras and rivers. The spring water, which, flows through the gads and gadheras, is diverted to small canals and guls. In areas where sources, for minor irrigation, aren't available lift irrigation is practiced. The total irrigated area, in the district, is 487.74 sq. km. out of which 177.99 and 309.75 sq. km. areas are under Rabi and Kharif, respectively. The principal crops are rice, wheat, barley, maize and potato.

2.0 CLIMATE AND RAINFALL

The climate varies from Sub-tropical monsoon type (mild Winter, hot summer) to tropical upland type (mild and dry winter, short mild summer). The northern part of the district is perennially under snow cover, here the climate is sub-arctic type as the area is represented by lofty Himalayan Range. Severe winter and comparatively higher rainfall are the characteristic features of the northern part. The district is represented by mainly four seasons viz. the cold winter season, (December to February), the hot weather season (March to May), southwest monsoon season (June to September) followed by post monsoon season (October to November).

Rainfall, spatially, is highly variable depending upon the altitude. Larger part of the district is situated on the southern slopes of the outer Himalayas, monsoon currents can penetrate through trenched valleys, the rainfall reaches its maximal in

the monsoon season. About 75% of rain occurs in this zone during the monsoon season, June to September. August is the wettest month. Rainfall rapidly decreases after September and it is minimum in November. About 17% of the annual precipitation occurs in four winter months. The winter precipitation is in association with the passage of the western disturbances and is mostly in the form of snowfall, particularly at higher elevations. The precipitation during the pre-monsoon month, which is about 7% of the annual total and the post-monsoon months, is frequently associated with thunderstorms. The average annual rainfall is 1095.0, 1552.8, 1631.2, 1917.5, 1948.5, 2092.9 mm at the rainguage stations located at Dharasu, Uttarkashi, Rajgarhi, Jamuna Chetty, Rana and Kharsali, respectively.

3.0 GEOMORPHOLOGY AND SOIL TYPE

District Uttarkashi, is represented by highly rugged topography. The elevation in the area ranges from 800 to 7000m amsl. There are very sharp undulations owing to high mountains, narrow valleys and deep gorges. The northern and eastern parts are covered with snow throughout the year. There are a number of glaciers in these parts. Bhagirathi River originates from Gangotri Glacier at Gaumukh on the western slope of Chaukhumba. Yamuna River and Tons River originate from Bunderpoonch glacier. The prominent mountain peaks are Bunderpoonch, Gangotri, Kedarparvat, Kailashparvat and Shivling. The prevalent landforms are lateral moraines, end moraines, U-shaped glacier valleys, V-shaped fluvial valleys, river terraces and Denudational Structural Mountain.

The landforms, mappable on the present scale, are Glacial Valley (GL), River Terrace (RT), Terrace (T) and Denudational Structural Mountain (DSM). The thrusts, lineaments and landslides/Debris slide have a direct bearing with the geomorphology of the area. Taking into the prevailing mappable features along with the thrusts, lineaments and landslides a geomorphological map has been prepared Fig. 2

The geomorphology of an area plays a very significant role in the groundwater movement and occurrence. The hydrogeomorphological aspects of District Uttarkashi are summarized in Table 2. The geomorphic units are given in Table 2 corresponds to Fig. 2.

The soil types are controlled by the topography and rock types. The soils, on the Summits and Ridges, are shallow to moderately shallow, excessively drained, sandy, loamy-skeletal. The soils are slightly to moderately acidic in nature. The soils occurring

on very Steep slopes are very shallow to shallow, excessively drained sandy/loamy-skeletal/ loamy without soil development with Lithic contact within 50cm of the surface. They are slightly to moderately acidic, very severely eroded, strongly stony with low available water capacity. The upper valley slopes in Galcio-Fluvial valleys consists of moderately shallow, excessively drained, coarse, loamy, slightly acidic and moderately stony. Lower valley slopes, of the glacio-fluvial valleys, are occupied with moderately shallow, well drained, sandy-skeletal/coarse-loamy, slightly acidic, slightly eroded and strongly stony soils with low available water capacity.

The broader valley slopes, in fluvial valleys, have deep, well drained, fine-loamy, moderately acidic and strongly stony. The narrow valley slopes, on the other hand, are occupied by moderately deep to deep, well drained, coarse loamy, slightly to strongly acidic.

4.0 GROUNDWATER SCENARIO

4.1 GEOLOGY

Geology, amongst many derivatives, plays an important role in shaping the ground water scenario of an area. So, it becomes imperative to know the geology of District Uttarkashi. The geology, of the area, is highly complex, since the rock formations have undergone repeated tectonic activities. The geology, of the area, is explained with the help of supersequences, which are based on the chronology of the group of rocks. The brief description of the supersequences is as given below:

ARCHAEAN SUPERSEQUENCE

Central Crystallines Group

The central crystalline rocks are well exposed in the Higher Himalaya of Yamuna and Bhagirathi valleys of district Uttarkashi. The rocks of Central Crystalline Group form the oldest crystalline basement of the Himalaya. The gneisses, migmatites, crystalline schist, thick quartzite with conspicuous horizons of calc-silicates with psammite gneisses in the upper part form bulk of the metasediments.

The major geological formations of the Central Crystallines along with the lithology are given in Table 3:

Table 3. Geological formation of Central Crystallines along with lithology

Geological Formation	Lithology
Badrinath	Garnet, Sillimanite, Muscovite and kyanite, migmatites, calc-silicates. Leucogranite, pegmatite and garnet amphibolite.
Panduleshwar	Banded quartzite gneiss and interbedded quartz mica-schist, para-amphibolite
Joshimath	Garnet mica-gneiss, staurolite and kyanite-gneisses, garnet amphibolite.
Bhimgora Quartzite	White quartzite with gneiss and schist
Ragsi	Mica-schist.

PALAEOPROTEROZOIC SUPERSEQUENCE

Garhwal Group

The Garhwal Group forms the most extensive Group of rocks in district Uttarkashi. The rocks of palaeoproterozoic time-span are grouped in Garhwal Group. It forms the major part of the Lesser Himalaya and is represented by thick sequence of low-grade metasediments consisting of quartzite with penecontemporaneous mafic metavolcanics and carbonate rocks. Garhwal Group is limited in the north by the Main central Thrust and in the south by the Main Boundary Fault. In Lesser Himalaya, it is exposed in two tectonic linear zones separated by the rocks of Vaikrita Group. The northern zone forming the inner Lesser Himalaya, is exposed to the north of main exposure of the Vaikrita Group with which it is in tectonic contact-the North Almora Thrust and encloses outliers of Vaikrita Group of rocks. In the southern zone, it is of limited distribution and is exposed between the Main Boundary Fault (MBF) and the South Almora Thrust. However, South Almora Thrust is out of the administration ambits of district Uttarkashi.

The Garhwal Group is divided into four geological formations, viz. Uttarkashi, Rautgara, Tejam and Berinag, chronologically.

The main rock types are quartzite, slate, limestone, dolomite, phyllite, intraformational conglomerate etc. These rocks are intruded by acid and basic igneous rocks.

MESOPROTEROZOIC TO NEOPROTEROZOIC SUPERSEQUENCE

Higher Himalaya

Vaikrita Group

Vaikrita group (Supersequence) of rocks represents the higher grade metamorphics of the Higher Himalaya pervasively penetrated by young Tertiary granite. The rocks comprising, this group, are micaceous schists, talcose rocks, phyllites and gneisses overlying mainly the granite gneisses. Vaikrita Group includes the metasedimentaries exposed between the granite-gneisses constituting the Central Crystalline and the overlying Martoli Group and its equivalents.

In the Bhagirathi valley, the rocks of this group are exposed between Sukhi and Harsil. The rocks of this group, in Yamuna valley, are exposed north of Yamnotri, overlying the Central Crystalline with an apparent unconformity. The Gangotri Granitoid intrudes both the Vaikrita and Martoli Groups and includes biotite granite, tourmaline granodiorite, tourmaline aplite and pegmatite. In the Gangotri glacier basin, tourmaline granodiorite occurs in the form of laccolithic body intrusive into the black slates in the Bahgirathi peak region and form the Shivling 'massif'.

Lesser Himalaya

This supersequence, in Lesser Himalaya, is represented by two groups, viz. the older Jaunsar Group and the younger Dudatoli Group. These two groups are briefly described below.

Jaunsar Group:

The rocks of this group are continuously exposed in the outer Lesser Himalaya from the Tons Valley in the west to eastern boundary of the district and beyond. It is divided into three formations, viz. Mandhali, Chandpur and Nagthat.

The main rock types of Jaunsar Group are quartzite, slate, phyllite, siltstone, greywacke and sandstone

Dudatoli Group:

The equivalent of Dudatoli Group, in Uttarkashi district, is the Jutogh Group. The oldest of the Jutogh Group Formation is disconformably overlies the Chandpur Formation. The main rock types are phyllites and quartzites.

NEOPROTEROZOIC TO PALAEOZOIC SUPERSEQUENCE

Tethys Himalaya:

Martoli Group is represented by a thick sequence of unmetamorphosed to feebly metamorphosed rocks in district Uttarkashi. The rocks of this group are exposed in Tons and Bhagirathi River basins. The main rock types are silver grey phyllite with interbedded thin quartzite, garnetiferous grey phyllite, foliated quartzite with biotite bearing phyllite, thin laminated greenish grey, brown purple quartzite slate with thin calcareous lenses.

ORDOVICIAN TO CARBONIFEROUS SUPERSEQUENCE

The development of this supersequence is restricted to the Tethys Himalayan zone only. There is no record from Lesser Himalaya where the rocks of Martoli Group are unconformably overlain by the rocks of early Permian period. In the Tethys Himalaya this supersequence comprises the Sumana and Kanawar Groups. The rocks of the Sumana Group range in age from Early Ordovician to Devonian and it is divided into Ralam and Garbyan formations. The rock types are purple conglomerate, purple to greenish grey quartzite, quartzite with bands of calcilutite, calc-siltstone and brown dolomictic limestone with chlorite layers in the lower part. The sequence of limestone and black shale unconformably overlying the Sumana Group constitute the Kanawar Group. The rock types are sandy dolomite, carboneceous shale, limestone and quartzite, which conformably lie over the Sumana Group.

LATE PERMIAN TO LATE TRIASSIC SUPERSEQUENCE

In district Uttarkashi only the rocks of Lower Lilang Group are exposed in its northeastern part. Chocolate limestone is the main geological formation of this group, which consists of limestone alternating with thin greenish black shale.

4.2 HYDROGEOLOGY

A large part of the district is perennially under snow cover (Fig. 2). Groundwater investigations can't be carried out in the snow-covered areas due to the accessibility problem. Hyrogeologically, the area may be divided into two, viz. (1) Alluvium and (2) Hard rocks. These are briefly described hereunder:

(1) Alluvium: Alluvium occurs along the river courses and in their flood plains. The alluvial deposits are paper thin to as thick as 50.0m. These are unconsolidated deposits. Alluvium is mainly consists of sand, gravel, silt and clay. At places, big boulders are buried within the alluvium. The alluvial thickness is more where the valleys are broad and ground slope is gentle such as Purola, Harsil and Chinyalisaur valleys. The alluvium is both porous and permeable and hence suitable for groundwater development.

Groundwater is mainly developed through handpumps. The depth of the handpumps tapping alluvium ranges from 27 to 45m. Around Uttarkashi town, the groundwater is developed through dugwells at limited extent. The depth and diameter of these dugwells ranges from 4.0 to 10.5m and 1.0 to 2.50m respectively. All the dug wells are fitted with one horsepower pump. One dug well is located at village Matli in Dunda block. The depth and diameter of this dug well are 19.0mbgl and 1.30m respectively. The pre-monsoon and post-monsoon Depth to Water levels range from 1.45 to 8.51 and from 0.87 to 7.60 mbgl, respectively. The seasonal water level fluctuation, for 2005, range from 0.20 to 0.95m.

Geophysical investigations carried out in Purola, Harsil and Chinyalisaur valleys reveal that the top and bottom layers have high resistivity values and don't have groundwater potential. The middle layer constituted of alluvium and weathered mantle of the basement have low to moderate values of resistivity ranging between 180 and 750 Ωm. The middle layer is promising from groundwater point of view and this layer requires detailed exploration to know the groundwater potential. Thickness of alluvium as deduced from resistivity surveys in Purola, Harsil and Chinyalisaur valleys are 55, 10 and 37m, respectively.

(2) Hard rocks: Barring the alluvial deposits along the river courses and flood plains, entire area of District Uttarkashi is covered by hard rocks. The main rock types are quartzites, phyllites, slates, gneisses of varying degree of metamorphism along with granite intrusives and metabasics. The topography is highly undulating and geological formations are moderately to steeply dipping. Due to frequent undulations of high

magnitude a continuous water table doesn't exist. Wherever, permeable formation overlies an impermeable one, the water table exists, its extension depends upon the distribution of the aquifer forming rocks and topography.

The rocks have undergone intensive metamorphism and recrystallization. The pre-existing rocks got mineralogically and physically rearranged at temperatures higher than the ones at which the rocks were originally formed. This resulted in sealing the primary porosity of the rocks. The area of Uttarkashi district was reshaped by repeated tectonic activities, which gave rise to the development of folds, faults and joints. These structures helped developing the secondary porosity and permeability. The so developed porosity and permeability pave the path for groundwater movement and occurrence where they exist in combination with the favourable topography, the water table is formed and at such locations the hand pumps are installed to develop groundwater. Many of these hand pumps yield water perennially, which is a testimony to the sustaining water table. The total depth and discharges of few hand pumps in different geological formations are given in Table 4.

The hand pumps tapping different formations were inventoried. The various aspects of the hand pumps are summarized, geological formationswise, in Table 5. Maximum number of hand pumps is constructed in Garhwal Group of rocks. A perusal of Fig.3 reveals that the number of hand pumps constructed in the Lesser Himalayan formations is much higher than the ones constructed in the Central Crystallines. It is because the rocks of Central Crystallines have undergone a higher grade of metamorphism than the Lesser Himalayan rocks. The depth of the hand pumps ranges from 27.45 to 97.60 mbgl. The Pre-monsoon Depth to Water (DTW) ranges from 1.79 to 56.28 mbgl whereas the Post-monsoon DTW ranges from 1.06 to 53.58 mbgl. The seasonal Water level fluctuations, range from –0.52 to 2.70

The occurrence of springs is a common phenomenon in District Uttarkashi. The moving groundwater surfaces out as springs at the contact of different rock types and through joints/fractures etc. The topographic breaks also are the favourable location for spring formations. Various aspects of springs, geological formation, are summarized in Table 6. A perusal of Fig.3 reveals that the maximum number springs are located in Lesser Himalayan formations. The pre-monsoon and post-monsoon discharges of springs range from 2 to 216 lpm and from 1.36 to 232 lpm respectively. The seasonal fluctuation, in the spring's discharge ranges from -1 to 50 lpm. The springs have been

developed for drinking and irrigation water supplies. The hot water springs are more common in Central Crystallines than the Lesser Himalayan rocks. The water resources can't be estimated, as the water table is not continuous. The Hydrogeological map of Uttarkashi district is shown in Fig. 3.

4.3 GROUND WATER QUALITY

97 numbers of water samples collected from hand pumps got analyzed for EC, pH, Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride and Nitrate. The geological formationwise details, in respect of, hand pumps of different chemical parameters are given in Table 7. The Water quality of spring water is studied with the help data of 71 numbers of samples. The geological formationwise details, in respect of, spring water quality is given in Table 8. The ranges of different chemical parameter, in District Uttarkashi, are given in Table 9.

Table 9. Variations of different chemical parameter, District Uttarkashi

Parameter	Hand pumps	Springs
Electrical Conductivity	54 - 599 µmohos	18-4000 µmohos
pH	8 - 8.17	7.5 – 8.2
Calcium	4 – 32 mg/l	4 – 128 mg/l
Magnesium	2.4 – 40 mg/l	1.2 – 68 mg/l
Sodium	1.4 – 46 mg/l	0.7 – 660 mg/l
Potassium	0.4 – 68 mg/l	0.4 – 68 mg/l
Bicarbonate	18 – 262 mg/l	0.1 – 106 mg/l
Chloride	7 – 71 mg/l	7 – 71 mg/l
Nitrate	Nd – 194 mg/l	Nd – 50 mg/l
Fluoride	0.1 – 1.0 mg/l	0.1 – 1.0 mg/l
Total hardness as $CaCO_3$	10 – 190 mg/l	10 – 190 mg/l

Barring few local contaminations the water in the area is suitable for domestic and irrigation requirements. The nitrate concentration at Dharali is anomalously high, this is due to local contamination.

5.0 GROUNDWATER MANAGEMENT STRATEGY

The district Uttarkashi is mainly occupied by Himalayan Mountain ranges. Around 50% of the area is perennially covered under snow. Hence there is no scope of ground water development in the area. However, at lower reaches, there is scope of ground water development through hand pumps. For this, hydrogeological investigation is required at micro level so as to decipher the rock formation, which has sufficient secondary porosity like joints, fractures, lineaments etc. These discontinuous aquifers along with favourable physiographical set-up can help to develop ground water by hand pumps.

Besides, there are number of natural springs which can be utilized to cater the need for drinking and irrigation. There are numerous springs with sufficient discharge, the water of these springs can be channelized for irrigation. During non-monsoon period, the discharge of springs gets reduced. To augment the discharge and sustainability of these springs, small surface water reservoir can be developed at suitable locations on higher level. The reservoir can be developed by constructing gully plugs, check dams, gabion structures etc. at suitable places. These reservoirs will not only provide surface water availability but will also help in recharging the aquifers.

In Uttarkashi district, four valleys have been identified with sufficient thickness of valley fill deposits. Ground water in these valleys can be developed by constructing large diameter dug wells and shallow tube wells. The large diameter dug wells and shallow tube wells will able to sustain the discharges between 250 to 1000lpm.

6.0 RECOMMENDATIONS

On the basis of hydrogeological, geomorphological and geophysical studies, following recommendations are made:

(1) The Uttarkashi district is occupied by Himalayan ranges, therefore large-scale development of ground water is not possible.

(2) Ground water can be developed through Hand pumps and Springs in the area occupied by Lesser Himalaya.

(3) Small-scale ground water development can be made in the identified valleys viz. Harsil, Purola, Uttarkashi and Chinyalisaur by constructing shallow tube wells and large diameter dug wells.

(4) Small surface water reservoir may be developed at suitable locations so as to increase the recharge of the aquifer and surface water availability

(5) The water of the high discharge springs may be channelized for irrigation at lower altitude.

(6) Due to sufficient rainfall and more number of rainy days, roof top rainwater harvesting in urban as well as rural areas may be promoted to cater the domestic requirement.

(7) Organizing Mass Awareness Programme is required to aware the public regarding harvesting of Rainwater.