केन्द्रीय भूमि जल बोर्ड
जल संसाधन, नदी विकास और गंगा संरक्षण
विभाग, जल शक्ति मंत्रालय
भारत सरकार

Central Ground Water Board
Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

ALMORA DISTRICT
UTTARAKHAND

उत्तरांचल क्षेत्र, देहरादून
Uttaranchal Region, Dehradun

Central Ground Water Board
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REPORT ON

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Almora District, Uttarakhand

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Chapter - 1

Introduction

1.1 General

This report deal with the work carried out under National Aquifer Mapping (NAQUIM), which had been taken up by CGWB under XII five year plan to carry out a detailed hydrogeological investigation. This NAQIUM report is for the work carried out in the Almora district, Uttarakhand during the AAP: 2021-2022. Aquifer mapping can be defined as the combination of geological, geophysical, hydrological, and chemical analyses in a scientific way to characterize the quantity, quality, and sustainability of groundwater resources of the concerned area. The result of these aquifer mapping helps the planner, policymakers, and other stakeholders to manage the resource by developing a long-term aquifer monitoring network and formulating, conceptualization and quantitative found water flow models which can be used for future sustainable development.

Aquifer mapping aims to define hydrogeology and establish a framework based on background information on geology, hydrology, and geochemistry of the important aquifer systems. Thus prompting the paradigm shift from the traditional groundwater development concept to the modern groundwater management concept. The proposed management plans will provide the “Road Map” for ensuring sustainable management and equitable distribution of groundwater resources, thereby primarily improving drinking water security and irrigation coverage. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal-that of groundwater management through community participation. The development of an aquifer management plan in the hilly terrain of the Almora district may also aid various institutions/stakeholders in effectively understanding and managing groundwater resources, both at regional and local levels.

1.2 Objective and Scope

The main objective of the present work is to prepare thematic maps on a 1:50000 scale and thereafter to prepare an aquifer management plan and develop an aquifer/spring information system., preferable under Geographic Information system (GIS) either web-based or software-based for access to all the concerned stakeholders and policymakers.

The aquifer mapping study was carried out keeping in mind the preparation of thematic maps like geology, geomorphology, drainage, land use land cover, etc. and establishing the groundwater occurrence (depth range) by the study of borewells (hand pump wells) in the accessible terrain, which is characterized by the presence of crystalline meta-sedimentary and metamorphic rocks of lesser Himalayas and the central Himalayas. The main lithology comprises of garnetferous-mica schist with subordinate quartzite, phyllite and graphite schists, granite-gneiss in lesser proportion. Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e., the aquifer map and management plan. The robust and implementable groundwater management plan will provide a "Road Map" to systematically manage the groundwater resources for equitable distribution across the spectrum.

1.3 Methodology

In this Naquin work, micro-level hydrogeological data supported by hydrochemical investigations supplemented with the inventory of springs along all-weather motorable roads that connects various villages and habitations. Groundwater prospect maps of National Remote Sensing Center, Hyderabad, topographic maps of the survey of India, Quadrangle map (53O) and geological reports of Geological Survey of India were used. Satellite Images (IRS, LISS – III in optical multispectral, SRTM, Bhuvan satellite maps (ISRO and NRSC) and Google Map images were also studied. Thematic maps on the 1:50000 scale were mostly prepared in the GIS platform using ArcGIS software suite and office software for the preparation of maps and compilation of data respectively.

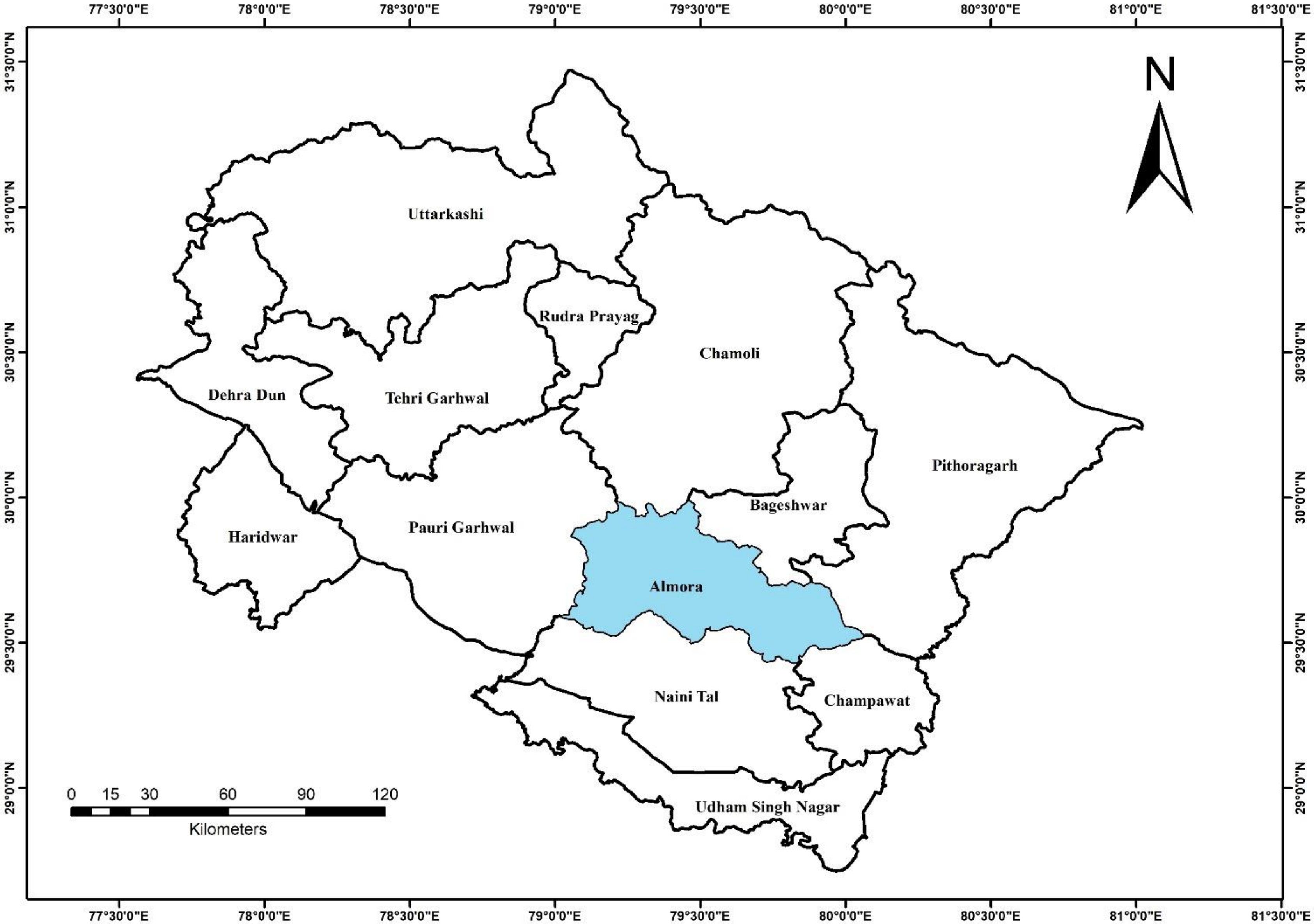


Fig. 1.1 A base map of Uttarakhand state showing all the districts with Almora district Highlighted.

1.4 Study Area

The study area falls in between the North Almora Thrust (NAT) and South Almora Thrust (SAT), covering an area of 2000km2 in parts of Almora under the aquifer mapping programme, AAP: 2021-2022. The area falls under the degree sheet no. 53O with the topographic sheet nos. 53O/1, 53O/2, 53O/5, 53O/6, 53O/9, 53O/10, 53O/11, 53O/14, 53O/15 under Survey of India. The latitudinal and longitudinal extend of the represented as 29°24'57.7"N and 29°58'23.3"N latitude and between 79°04'36.0"E and 80°04'39.2"E Longitude. A base map of Uttarakhand State, showing the location of Almora District in Fig 1.1 and the area covered under Aquifer mapping ($2000km^2$) of Almora district between NAT (North Almora Thrust) and SAT (South Almora Thrust) with blocks and the disposition of the study area – including the coverage under the toposheet numbers 53O/1, 53O/2, 53O/5, 53O/6, 53O/9, 53O/10, 53O/11, 53O/14, 53O/15 is shown in Fig.1.2

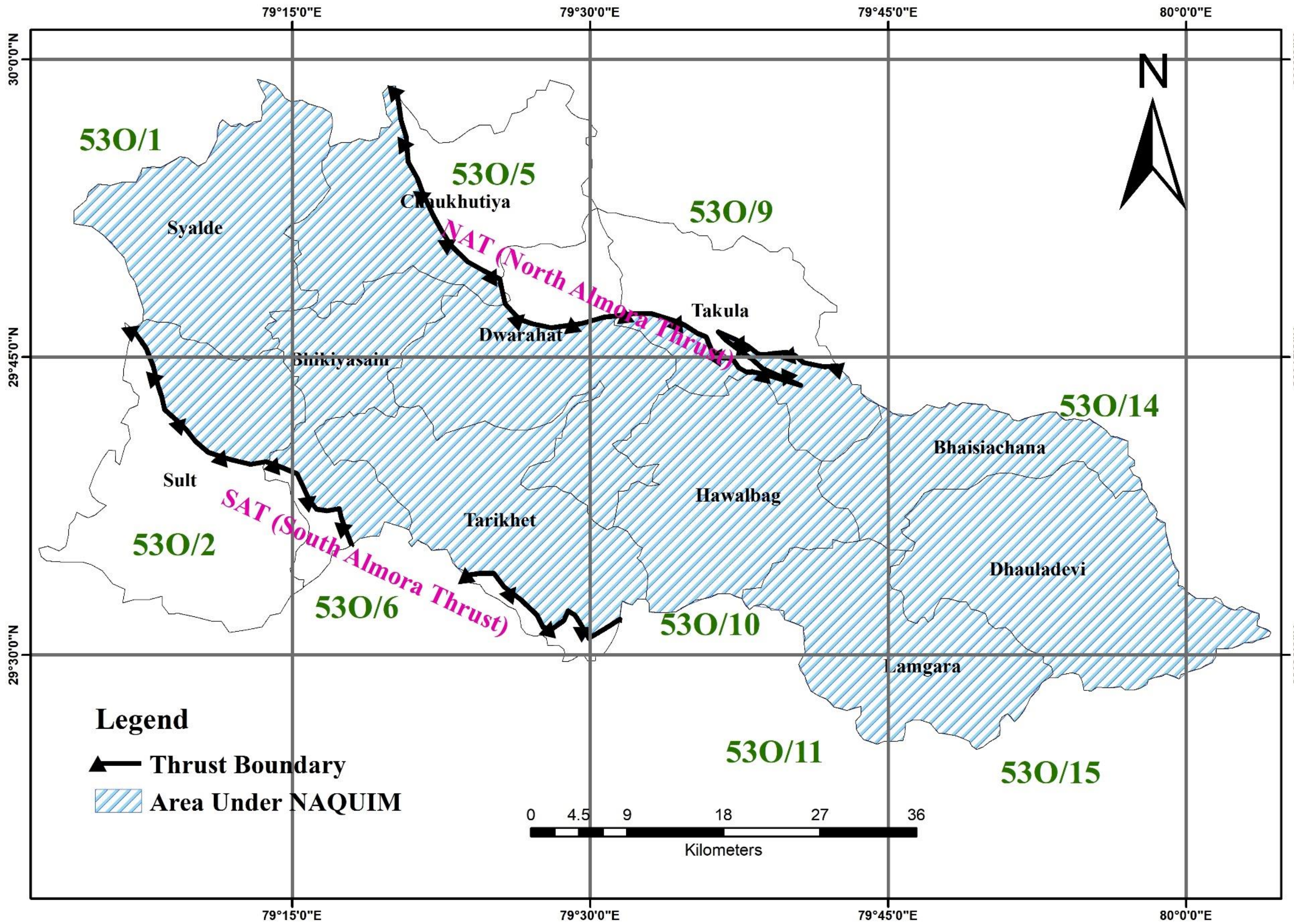


Fig 1.2 Study area of Almora District between NAT and SAT with indicated toposheet numbers.

1.5 Accessibility

The study is connected with Dehradun, the capital city of Uttarakhand, by a network of all-weather roads only as railways and air transportation is not available due to the hilly terrain. It's two days journey to Almora from Dehradun by NH-34, NH-534, NH- 734, NH-109 crossing Rishikesh, Nagina (UP), Dhampur(UP), Kashipur, and finally to Almora. Besides, few state highways and numerous smaller, feeder roads - many of which are difficult to navigate during the monsoon season, connect the major places and semi-Urban areas as well as villages in the study area. The nearest railway station is Kathgodam in Haldwani block, Nainital District which is situated at a distance of about 100kms from Almora, the district Headquarters. The Nearest airports to Almora are Pantnagar Airport (127 km) in Nainital and Naini Saini Airport (125 km) in Pithoragarh. Public transport is mainly in the private jeeps and SUVs like bolero, Scorpio, etc. and buses (mainly during the yatra season of The Jageshwar Dham, Golu baba, etc. viz. from April/May to September/ October and government buses operated by Uttarakhand Transport corporation limited, connecting location like gram pani, Bageshwar, kathgodam, Ranikhet, Bhowali, Nainital, Bhimtal, etc. throughout the year.

1.5 Administrative details

Almora district lies in the Kumaon division of Uttarakhand, covering a total geographic area of 3697.20 km2 surrounded by Pithoragarh and Champawat district to the east, Pauri Garhwal district to the west, Chamoli district to the North, Bageshwar district to the northeast and Nainital district to the south. The district comprises nine tehsils namely, Almora, Ranikhet, Salt, Dwarahat, Taluka, Bhansiya Channa, Hawalbagh, Lamgara, and Dhaula Devi. Its Assembly constituencies are Dwarahat, Salt, Ranikhet, Someshwar (SC), Almora, and Jageshwar. The total population of the district is 622506 (Census 2011). The district has a population density of 198 inhabitants per square kilometer and the sex ratio of Almora has 1139 females for every 1000 males. The overall literacy rate in the district is 81.06%. The administrative map of the Almora district is shown in Fig 1.3.

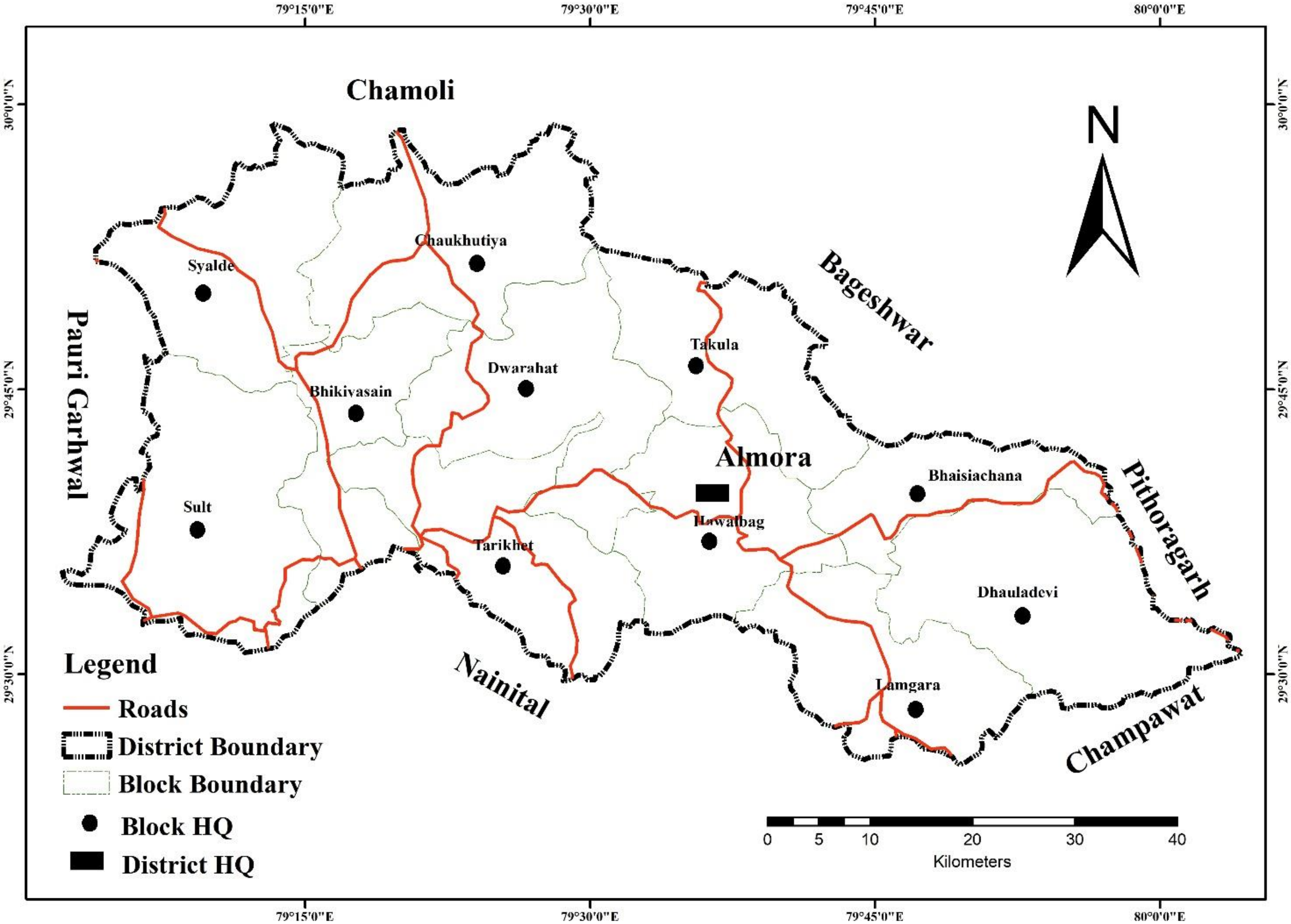


Fig 1.3 Administrative map of Almora

Chapter – 2

Hydrometeorology

2.1 Climate

The climate of the study area depends on the summer monsoon currents and associated cyclone system, westerly disturbances, and local orographic and conventional thunderstorms that occur in the afternoon during pre and post-monsoon. The variation in temperature and rainfall conditions along the ridge and the valley areas is very prominent. The slope and aspect also play an important role in determining the insolation effect. Besides this, the alignment of ranges in leeward and windward directions, the proximity of water bodies and a large stretch of forest cover, and proximity to snow cover are important factors in determining spatial variation in rainfall and temperature.

The area under aquifer mapping is covered by the lesser Himalayas and the central Himalayas. In general, the lesser Himalayas experiences a humid climate with maximum and minimum temperatures of 36 ^{0}C and 0.4 ^{0}C respectively. Central Himalaya experiences a cold, arid climate having a minimum temperature below freezing point during the winter season. Higher reaches and mountainous areas are snow-covered throughout the year.

The climate of Almora is generally humid and cold. The northern and northwestern parts of the district experience sub-zero temperatures during the winter whereas the central and southern parts are comparatively warm and humid. Other parts of the district experience dry, hot summer and cold winter. The long-term climatology of the study area indicates that January is the coldest month while may is the hottest month. The mean minimum and maximum temperatures are -3.7 ^{o}C and 28.8 ^{o}C. The climate here is classified as Cwa by the Köppen-Geiger system. The average temperature in Almora is 16.7 °C as shown in the graph which shows the monthly average minimum and monthly average maximum temperature of the district Almora in fig. 2.1. The maximum temperature recorded in the year 2021 is 32.1 c and the minimum temperature recorded is 1 ^{o}C in the study area. The chief climatic feature of the district is its severe winter which lasts from December to March and during which considerable precipitation occurs often as snowfall, in association with western disturbances passing eastward across north India.

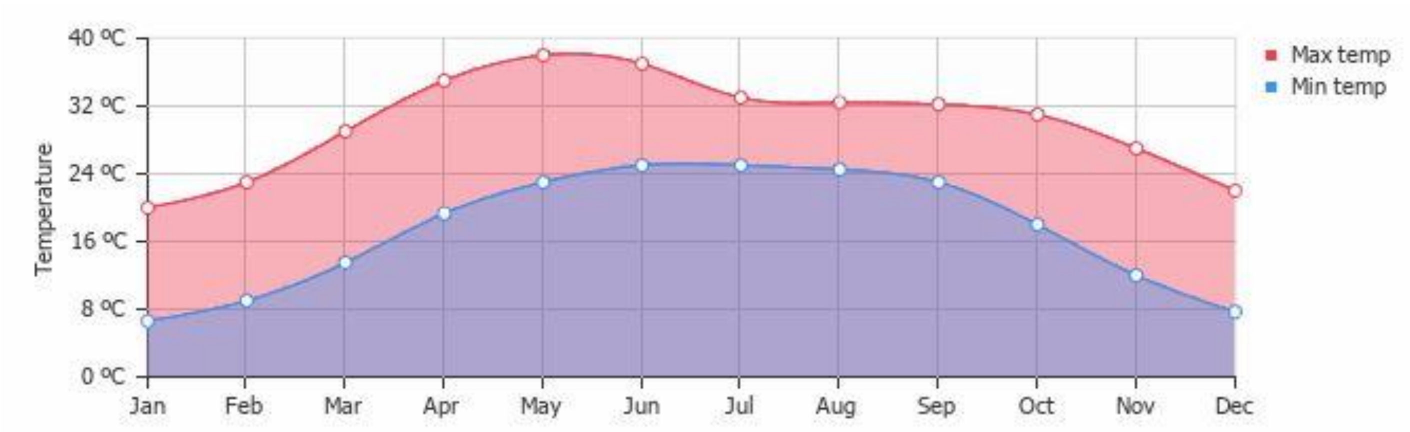


Fig. 2.1 Average temperature variation in the study area

Relative Humidity in the area increases rapidly with the onset of monsoon and reaches a maximum during August, when the peak monsoon period sets in, while minimum during the summer months from April to June with May being the driest month. Skies are heavily clouded during the monsoon months and for short spells when the area is affected by western Disturbances.

2.2 Rainfall

Rainfall is highly variable in space, depending on the altitude in the whole hilly regions of the Himalayas. As a large part of the study area is situated on the southern slopes of the Outer Himalaya, the monsoon currents penetrate through entrenched valleys. The area has the maximum rainfall during the months of July, August, and September as shown in fig. 2.2.

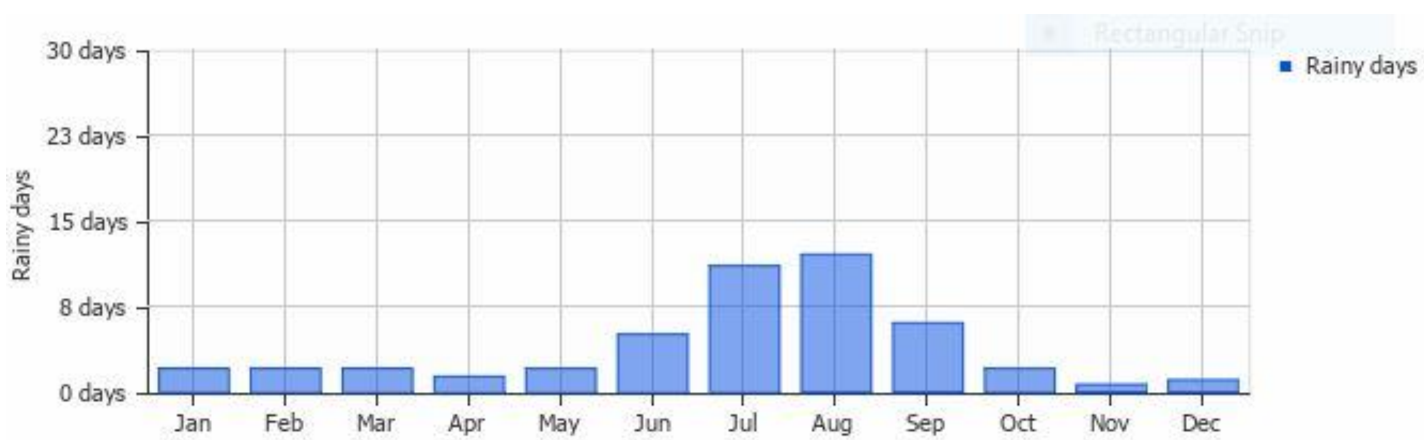


Fig. 2.2 Average rainy days

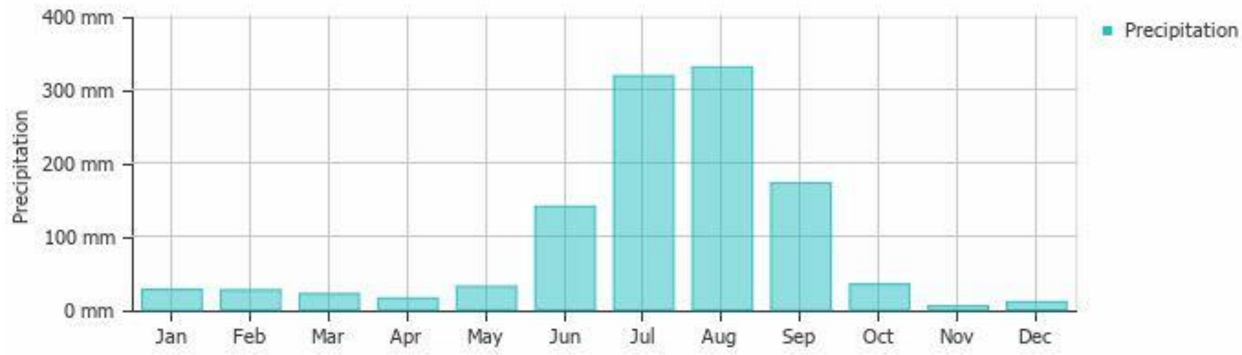


Fig. 2.3 Precipitation month wise in the study area

About 75% of the total rainfall is received during the southwest monsoon season during the period June to September as shown in fig.2.3. The remaining 25% of rainfall occurs as winter and summer rainfall. 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 is frequently associated with thunderstorms. The average annual rainfall of the Almora district is 1029mm. Out of the annual rainfall, a major share from the southwest monsoon, on average July receives most of the rain while November is the driest month of the total annual rainfall. The average annual rainfall varies from 1061mm at Almora through 1332mm at Ranikhet to 1597mm at Kasauni. Historical 22 year rainfall data (**Annexure I**) shows the same trend which is graphically represented in fig. 2.4.

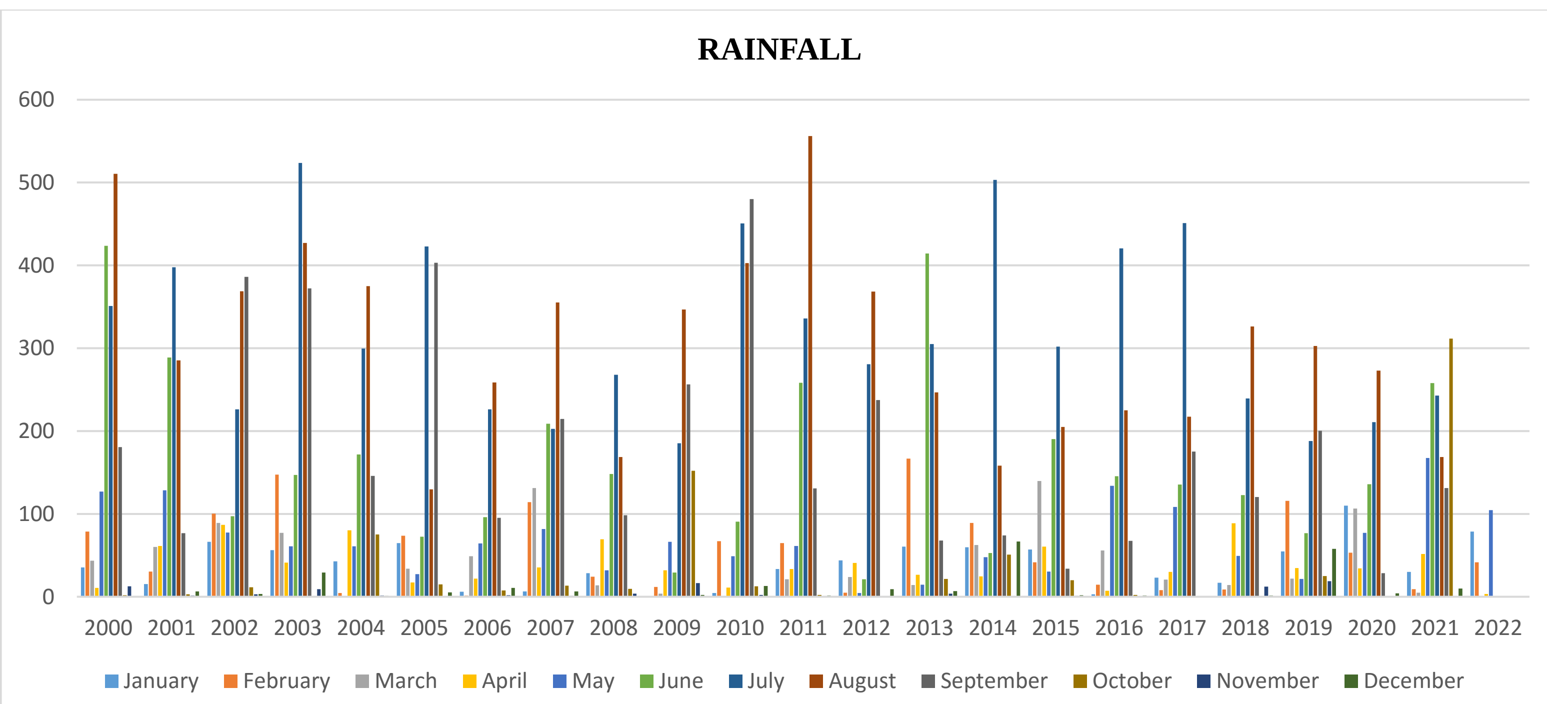


Fig. 2.4 Historical rainfall analysis

Chapter- 3

Geomorphology

3.1 Physiography and slope conditions

Within the study area, two distinct physiographic-cum-tectonic units are exposed viz. the lesser Himalaya and the central (Higher) Himalaya. The average elevation in the southern part of the district is 6939 m amsl and in the northern part is 7603 m amsl. The Master slope of the district is toward the south. The study area is characterized by rugged, mountainous terrain with narrow valleys and deep gorges with high variation in surface relief within a short distance. Kosi River is the most prominent natural drainage in the study area. Kosi is a perennial river that originates from Dharpani Dhar, perched at 2,500 meters in the Baramandal region of Almora district, this Himalayan River is famous by the name of 'Kosila' among the local populace. Having a length of 168 meters, the Kosi River replenishes the farmlands of Kumaon and is a source of water for the wildlife thriving in the Corbett National Park.

Stream profile of the Kosi river and its tributaries hints at slope conditions in the study area. In the catchment area, due to the presence of quartzites and other crystalline rocks, the valley side slopes are usually well cohesive, cliff type. In the lesser elevation area, the valley side slopes are generally of repose type or aggradational. The presence of fault shear zomes as the area lies between two thrusts appears to have widened the valleys.

3.2 Geomorphological setup

Various land system classes in the study area are Structural hills and valleys (highly dissected, Moderately dissected, and low dissected), valley-fill sediments, river terraces, denudation origin piedmont slope, thrust fault (NAT and SAT), and structural lineaments. Geomorphological maps of the study area of about 2000km2 and falling in toposheet numbers 53O/1, 53O/2, 53O/5, 53O/6, 53O/9, 53O/10, 53O/11, 53O/14, and 53O/15 are prepared using Bhuvan satellite rater images and Q GIS Software the result is shown in **Annexure-II**. The geomorphology and lineament maps were prepared using satellite data and other collateral data sources with limited fieldwork. A study of the combined image (map) indicates the presence of river terraces which are covered with deposits of clay, sand, and gravel. Growth of vegetative cover is conspicuous along these terraces can be found along the course of major perennial drainage systems which is observed in the toposheet nos. 53O/1, 53O/5, 53O/9 and

53O/10 as fluvial origin piedoment alluvial plain, older flood plain, Younger alluvial plain. In toposheet 53O/9, denudation origin piedmont slope can be observed along with the river flow. Low dissected structural hills are exposed in the southwestern part of toposheet no. 53O/2, in block Sult. Apart from this the whole study area is covered by highly dissected structural origin hills and valleys as shown in Annexure-II. the study area falls in the part of lesser Himalayan terrain and structural tidges trending WNW-ESE are conspicuous. These are formed of quartzite and phyllite and occur in between two structural hills. They are represented as linear or curvilinear features in aerial photographs and generally show better groundwater potential than the structural hills. Lineaments are manifested as observed/inferred joints, fractures, and faults. In the Almora district, these lineaments cut across rocks like quartzite, phyllite, schist, and gneiss. In general, groundwater potential is high along the lineaments, especially at the intersection of two lineaments. The thrust fault which is denoted by the black lines in figure1.2 are the two most prominent thrusts namely North Almora Thrust separating the Garhwal Group from the Almora-Ramgarh Group and the South Almora Thrust separating the Almora-Ramgarh Group from Bhikhiyasain-Tarikhet Formation. In general, the groundwater potential along the thrust zone is moderate to good, depending on the local hydrogeological condition.

3.3 Land use and Land cover (LULC)

Land cover type is natural differentiation, which describes how much of an area is covered by forest, wetland, agriculture, impervious surface, and other land and water types. Land cover of an area can be determined by analyzing satellite and aerial images. Land use shows how people use the landscape – whether for development, conservation, or mixed uses and therefore, cannot be determined by satellite or aerial remote sensing techniques.

In the study area district, the landcover map of the Almora district with toposheet numbers 53O/1, 53O/2, 53O/5, 53O/6, 53O/9, 53O/10, 53O/11, 53O/14, and 53O/15 were made using WMS server map images by Bhuvan portal of ISRO and further processing the data in QGIS software. Based on the type of use of the natural land system type, the land use pattern was determined and demarcated in the combined Land use Land Cover (LULC) map, which is shown in **Annexure III**. A perusal of the LULC map, based on the latest available database (2015 – 2016), shows that 14 different types of units can be categorized on the map. However, for sake of simplicity, these LULC classes are combined in the 5 five broader subdivisions, a brief description of which is given below:

Cultivated land: Cultivated land which is around 30% of the land use is visible almost all over the Almora as agriculture is the main occupation of the people.

Barren land: Such type of land, devoid of any vegetation, is exposed mostly in the central part of the district. The aerial extent of this land cover is not much, and it is predominantly associated with barren land having sandy areas and scrubland.

Vegetation: Thick, Moderate, and sparse vegetation are found to occur extensively in the study area. The thick vegetation type (dense forest cover) is by far the most extensive, followed successively by the moderate and sparse vegetation type, as observed from the LULC map. The vegetation cover around 51% of the total land use with evergreen and semi-green forest making up to 81% of the total vegetation cover, after deciduous forest making 18% of total forest cover and reaming are scrub forest and plantation forest.

Builtup/settlement: The settlements are very limited in aerial extent, except for the Hawalbagh block which is mostly an Urban area as the district headquarters and other facilities are located nearby. The rural area is scattered with a limited aerial extent.

Waterbodies and Pastureland: The Pasture land is closely associated with cattle grazing, covering limited land only 4.91 Square kilometers of the total land. The waterbodies mostly including river streams and canals cover up to 26.21 square kilometers of the total area.

3.4 Soils

The types of soil which are met within the district are the same as usually found in the hilly areas viz. the gravel sand, sandy loam, clayey loam, heavy clay, and calcareous soils which are shown in **fig.3.1.** They differ in colour and texture according to the locality, altitude, and the composition of the subsoil rocks. The red soil found on slopes and ridges of hills is sandy and when dry, grayish, becoming reddish when moist. The brown forest soil is most 6 extensively found in the hills. It is sandy along sharp gradients and loamy or clayey on milder slopes. The colour of the soil is brown or dark brown depending upon the quantity of organic matter in it. The podsol soil is mostly clayey and dark gray, turning into brown forest soil as a result of cultivation and terracing. The subsoils are often light and unconsolidated even under terraced cultivation. These are incapable of retaining much moisture. The soil depth map of the Almora district as shown in **fig. 3.2** and soil texture map is taken from the National Bureau of Soil Survey and Land Use Planning.

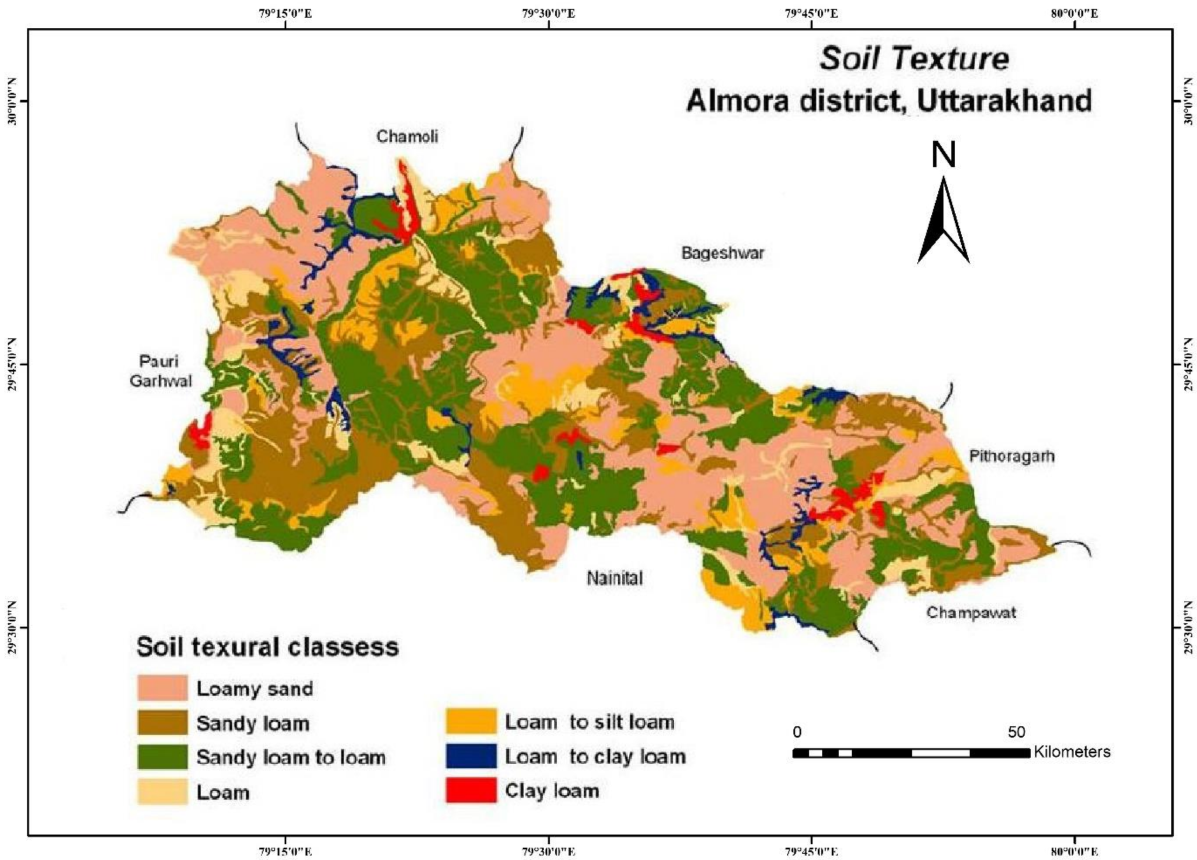


Fig. 3.1 Soil Texture

Soils of Lesser Himalayas

Summits and Ridges (30-50% Slopes)

1. Medium deep, loamy soils, loamy skeletal soils

Side Slopes (30-50%slopes)

2. Medium deep, loamy-skeletal shallow loamy soils.
3. Medium deep, loamy-skeletal shallow loamy soils severely eroded.
4. Medium deep, loamy soils
5. Medium deep, moderate stoniness loamy-skeletal soils
6. Deep loamy soils and slightly eroded associated with loamy-skeletal soils

Fluvial Valley (3-5% slopes)

7. Medium deep, loamy soils

Shiwaliks

Side Slopes (30-50% slopes)

8. Medium deep, loamy soils, moderately eroded soils.

9. Deep, loamy soils and, loamy-skeletal and moderately eroded soils.

Active Flood Plain (0-3% slope)

10. Deep, sandy soils

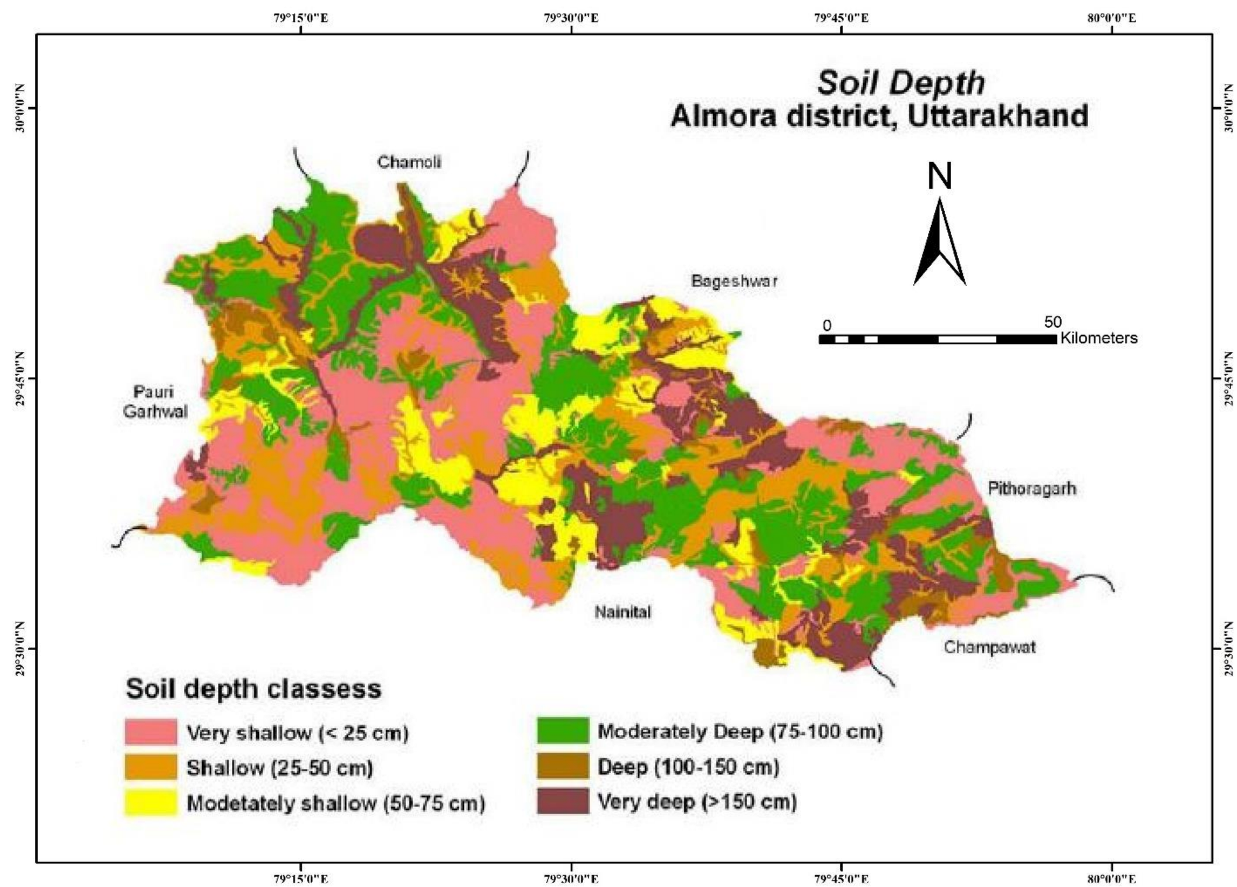


Fig. 3.2 Soil Depth

3.5 Agriculture

Agriculture is the main occupation of the people. However, intensive cultivation is not possible as a major part of the district is mountainous. Agricultural activities are common on gentle hill slopes and in relatively plain, broad river valleys of Kosi, Ramganga, and Saryu. Rice, wheat, barley, maize, mandua, and Sawan are the principal crops grown in the district. The salient feature of the agricultural statistics in the district are given below in table 3**.1.**

CROPPING PATTERN IN ALMORA DISTRICT (AREA IN HA)							
Paddy		Wheat		Barley		Maize	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
17526	4895	35411	4904	2790	29	1689	4
Mandua		Saawaa		Total Pulses		Total Cereals	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
34518	46	12198	0	2075	2	106207	9880

Table 3.1 Cropping Pattern

Mandua and wheat is the principal crop grown in District Almora, followed by Rice and Saawa. The total area under cultivation for pulses like urad, moong, masur, arhar, and chana is 2075 ha.

3.6 Irrigation

Major sources to develop irrigation potential are the perennial river like Kosi, Ramganga, Saryu, and Pindar. However, the main means of irrigation in the district are irrigational canals which run for 537 km in the entire district. The irrigation source with irrigated land distribution is given in table **3.2**.

Canal	Handpump		Dugwell	Lake	Others	Total
	State	Private				
1468	0	0	0	9	4274	5751

Table 3.2 Irrigation source with irrigated land distribution

Irrigation through canals, ghuls, hydrums, tanks (hauj), etc. is practiced widely for major crops like rice and wheat, and madua. Irrigation by geomembrane tanks is a newly introduced technique for irrigation. The high irrigation intensity is a result of surface water irrigation. Apart from this, lift irrigation through hydrums is also practiced by the villagers. There are many areas where irrigation potential is very low or absent. In such areas, groundwater irrigation potential needs to be created after conducting feasibility studies. The conjunctive use of surface and groundwater will enhance the present irrigation potential.

3.7 Drainage

The major perennial rivers flowing in District Almora are Saryu in the eastern part, Kosi in the central part, and Ramganga along with its tributaries in the western part. Besides these rivers, there are a number of streams, such as Bnau River, Sual River etc. which constitute a dendritic to sub-parallel drainage pattern in the district. These small streams and rivulets mainly belong to Ramganga and Kosi river systems. These rivers have got roughly southerly flow direction. The drainage density is pretty high and up to 6th order of streams are present in the district. The terraces both paired and unpaired are very common along the major streams are in the youth stage, therefore they have got erosional degradational tendency. Consequently, the deposition of the alluvial sediment is rather thin over the entire district. The thin alluvial deposits along the major streams are a good productive source repository of the groundwater over the district. The drainage map of the district is given in Fig. 3.3.

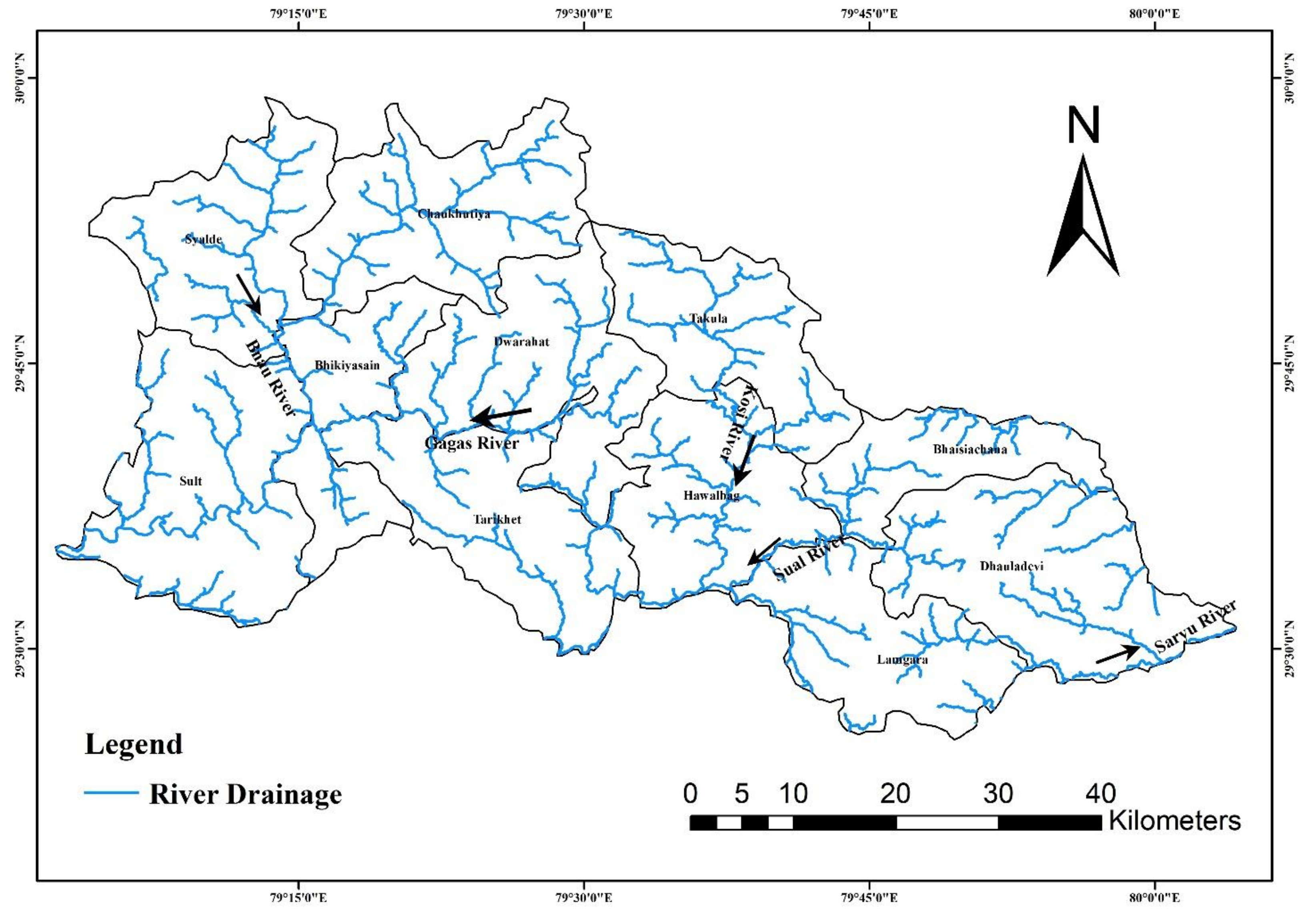


Fig. 3.3 River Drainage of Almora District

Chapter - 4

Geology

4.1 General Geology

The geology of District Almora which comprised our whole study area is complex due to complex deformational episodes characterized by repeated periods of tectonic and structural disturbances. The crystalline metasedimentary and metamorphic rock units exposed in the district have undergone polyphase deformation and regional dynamo thermal metamorphism.

The formation exposed over Almora span a considerable length of stratigraphic time scale possible from Precambrian to upper Miocene. The stratigraphy is not unequivocally established due to tectonic complications and a lack of paleontological records. The mountainous belt exposes Proterozoic rocks which have a general WNW-ESE strike. These rocks have been classified into four groups which in ascending order are Almora Crystalline, Ramgarh Group, Garhwal Group, and Jaunsar Group. The Tertiary Sequence in the area is represented by the Siwalik Group.

The rocks occur in various tectonic settings viz. Almora Crystalline, Ramgarh Group, Garhwal Group, and Bhimtal and Salla Formations have undergone varied grades of metamorphism and suffered acid and basic intrusions. The Siwalik Group of rocks are not subjected to any metamorphic transformation. The geology of the Almora district with all the prominent structures and thrusts is shown in Fig. 4.1

Sub-Himalayan Zone: This zone consists of sediments of the Lower Shiwalik Formation forming the south-western fringe area of the district. It consists of Sandstone and clay intercalations with pseudo-conglomerate at the base. It is separated from the pre-Tertiary rocks by Main Boundary Thrust.

Outer Sedimentary Belt: The outer sedimentary belt is confined between the Main Boundary Fault in the southern part of the district and the South Almora Thrust in the north. The Main Boundary Fault separates the Outer Sedimentary Belt from the Lower Shiwalik group of rock. This belt consists of arenaceous quartzite, phyllite, and slate (Nagthat Fm.) and predominantly argillaceous interbeds of phyllite and quartzite with basic intrusive (Chandpur Fm.).

Crystalline Unit of Almora Nappe: This unit consists of phyllite, schist, gneiss, and granite with occasional intercalation of dolomite and marble. The rocks of the Almora Crystalline Unit form a large synform with the WNW-ESE axial trend and overlie the rocks of the Outer and Inner Sedimentary Belt along the Almora Thrust. The South and North Almora Thrust form two limbs of a single synform. Several gneissic patches occur within the Almora crystalline with non-foliated massive granite at the core. These are believed to have originated due to regional metamorphism of the country rock, the granite possibly representing the end product of granitization.

Inner Sedimentary Belt: The inner sedimentary belt is exposed in the northern part of the district. Generally, the rocks of this unit are unfossiliferous metasedimentaries (Garhwal Group), which have suffered repeated phases of deformation and metamorphism. The formations of the Inner Sedimentary Belt underlie Almora Crystalline and are separated from the latter by North Almora Thrust.

Structure: Many prominent faults traverse the area following more or less similar directions as those of major thrusts. The prominent ones are from south to north and occur between Main Boundary Fault and South Almora Thrust. Besides a number of transverse faults are also present. There are two main synclinal axes with roughly NW-SE trend. The first one runs just north of Almora Town through Central Crystalline Belt while the other runs parallel to the Gomti River. Apart from these, a number of synclinal and anticlinal axes are observed in many areas of the district. The general strike of the rock units exposed in the district varies from place to place but by and large, the strike is either NW-SE or E-W. The dip of country rocks is variable and ranges from 20 to 60° with variable dip directions depending on the nature of folding.

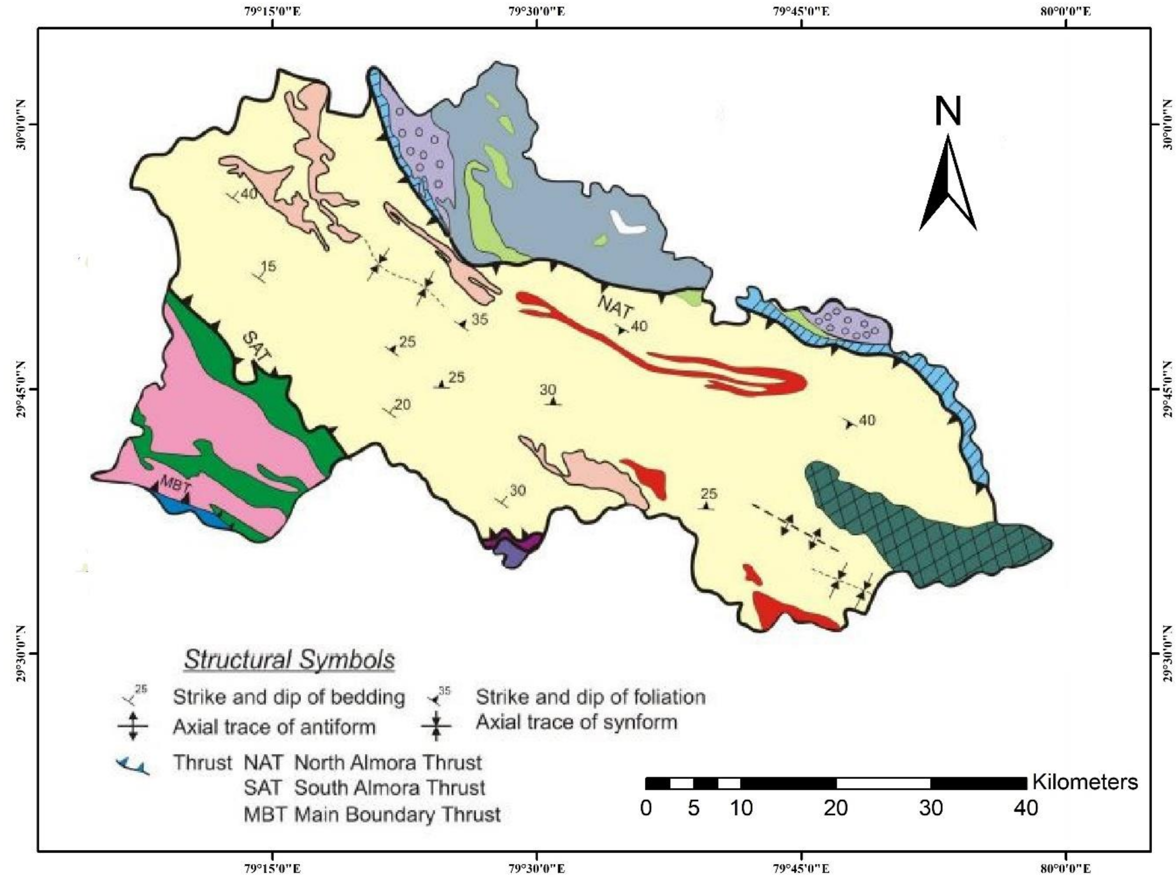
4.2 Major Thrusts

The prominent faults/thrusts exposed in District Almora are as follows:

Main Boundary Fault: It is a major tectonic plane of great magnitude, which has brought high-grade metamorphic rocks of the Central Crystalline Group to rest over the low-grade metasedimentary rocks of the Garhwal Group. The lack of a transitional zone between these two groups point toward the existence of a major fault zone. The thrust has a sharp outline with a low dip of 250 to 450 towards the northeast.

South Almora Thrust: The South Almora Thrust separates the Bhowali Formation from the rocks of the Outer Sedimentary Belt. This minor thrust is exposed in the southwestern part of the district and roughly trends NNE-SSE.

North Almora Thrust: Separating the Central Crystalline Group from the Inner Sedimentary Belt, the North Almora Thrust (NAT) runs nearly parallel to the South Almora Thrust (SAT). The NAT runs parallel to the SAT to the north of Dwarahat but swerves to the east of Dwarahat and runs nearly E-W for some distance before continuing with the NW-SE trend from Someshwar. The thrust has a general dip varying from 350 to 450 with a southerly dip direction but at places, the thrust becomes sub-vertical with a high dip.



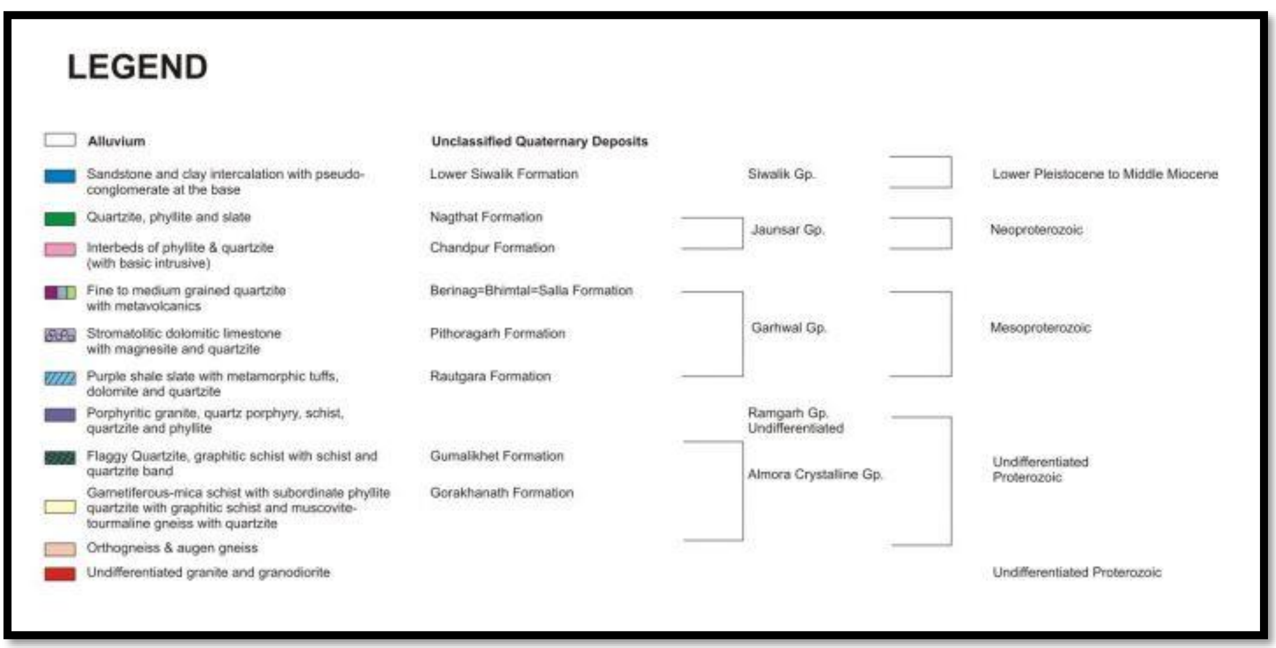


Fig.4.1 Geology and Thrusts of Almora district

Chapter - 5
Data Collection and Generation

5.1 Data collection and Compilation

The primary data such as spring locations, discharge, water quality, and lithological unit inputs were available with CGWB, UR, Dehradun and utilised as baseline data. However the ancillary data such as irrigation facilities, rainfall, climate data, Land use and land cover data, etc., have been collected from various sources like the National Bureau of Soil Survey and Land Use Planning, Geological Survey of India, BHUVAN (ISRO) and various state govt. departments and other internet sources and complied.

The data collection and compilation for various components were carried out as given below:

***Hydrogeological data*:** Current and historical (last 5-6 years) discharge data of springs available for Almora district from the combined study of Geological Survey of India and Central Groundwater board Dehradun.

Hydrochemical data: Springwater quality data from 25 springs of pre-monsoon has been collected and compiled.

Exploratory drilling: Groundwater exploration data of three existing exploratory wells complied.

Geophysical data: No Vertical electrical soundings (VES) were conducted in the study area earlier

Hydrology data: Data on various irrigation projects, their utilization status, and area irrigated from the irrigation department

Hydrometeorological data: Long-term rainfall data from IMD and Almora district reports were compiled.

Land use and Land cover data: It is retrieved from the BHUVAN platform of the Indian Space Research Organization and compiled and processed using GIS software.

Cropping Pattern data: Data on prevailing cropping patterns from District statistical dairy and agriculture department were compiled.

5.2 Data availability and data gap analysis

After taking into consideration, the data available with CGWB on Groundwater exploration, geophysical survey, spring discharge monitoring, and spring water quality, the data were compiled. The requirement, availability, and gap of major data inputs i.e., exploratory wells, geophysical data, and water quality data are detailed in table 1.3

S. No	Items	Data Requirement	Data Availability	Data Gap
1	Climate	Season-wise Rainfall pattern	Annual Rainfall of Meteorological Stations	Time series data Rainfall
2	Soil	Soil map and Soil infiltration rate	Soil Map	Soil infiltration rate
3	Land Use	Latest Land use pattern	Till 2015-16	Land use and data map. The latest updated data required
4	Geomorphology	Detailed information on the geomorphology of the area	Satellite data available	District-level information on 1:50000
5	Geophysics	Geophysical data of the study area	No data	Entire area unexplored
6	Geology	Detailed information on the geology of the area	Quadrangle map available	The map on 1:50000 to be provided by CHQ
7	Exploration data	Detailed information on the subsurface of the area	No data Available	16 EW more required up to the depth of 300 m for

				complete exploration details.
8	Hydrogeology	Water Level	No data Available	16 OW more required up to the depth of 300 m and Hydraulic characters of individual aquifers are not available
10	Water Quality	Water quality and its suitability for Drinking, Irrigation & Industrial purposes	Data available for Springwater	Aquifer wise Groundwater quality data need to be collected

Table 5.1 Data gap analysis

Based on the data gap analysis, it indicates that the existing groundwater data are not adequate to represent the area. Existing Exploratory wells data is not adequate for a better understanding of its behavior in terms of subsurface geology. Therefore, there is a need to increase the density of exploratory wells in the area. Map showing Data Gap Analysis in establishing Exploratory Wells and piezometer in Almora District is shown in fig. 5.1 the details of the location are given in Annexure IV.

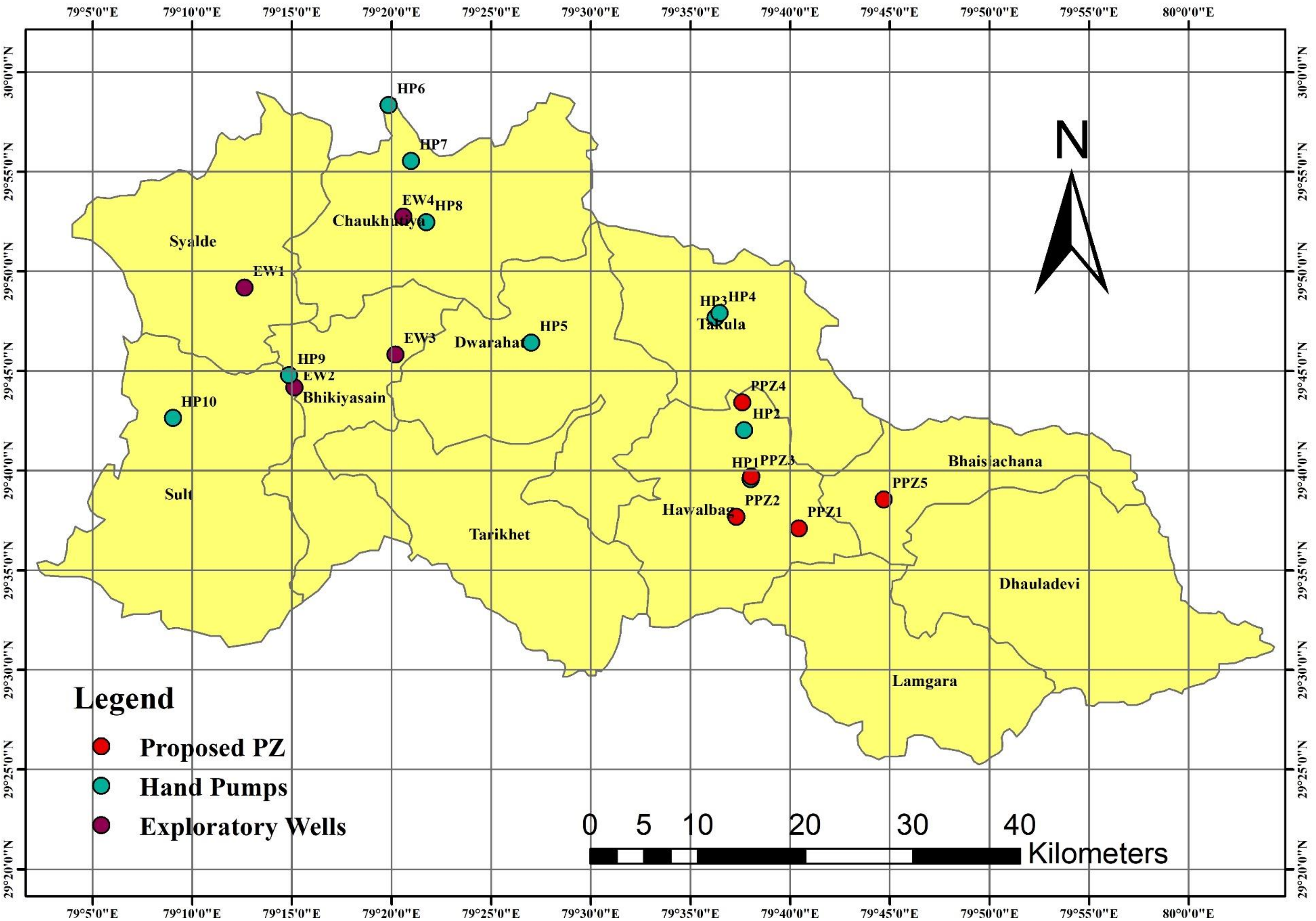


Fig. 5.1 Data Gap Analysis in establishing Exploratory Wells and piezometer in Almora District

Chapter - 6

Hydrogeology

6.1 General

The complex geotectonic setup of the study area between the North Almora thrust and South Almora thrust makes it difficult to fully understand the regional and local hydrogeological scenario. Groundwater in the district generally occurs locally within disconnected bodies under favorable geohydrological conditions such as in channel and alluvial terraces of river valleys, joints, fractures and fissures of crystalline and metasedimentary rocks, well-vegetated and relatively plain areas of valley portions, and in subterranean caverns of limestone and dolomitic limestone country rocks. The occurrence and movement of groundwater depend not only on the nature of the litho units and the nature of the interspaces/ interstices but also on the degree of interconnection between them, the vertical and aerial extension of joints, faults, and/or shear zones and the local and regional geomorphology. Groundwater emerges as springs and seepage (locally called Sorots and Naulas) under favorable physiographic conditions such as in gently sloping areas, broad valleys of rivers, and along with lithological contacts. The discharge of springs depends on the area contributing recharge to the aquifer and the rate of recharge.

Rainfall is the major source of recharge for groundwater. Direct infiltration takes place through the saprolite zone, fractures, and joints and then moves along interconnected openings. Despite a good amount of rainfall over the district to recharge the groundwater storage, the highly hilly terrain causes either excessive surface runoff or overland flow or losing precious groundwater in the form of springs and seepage to the lower reaches. Sporadic rainfall accumulation over the district, in form of ponds, is common. The hydrogeological map of District Almora is shown in Fig. 6.1.

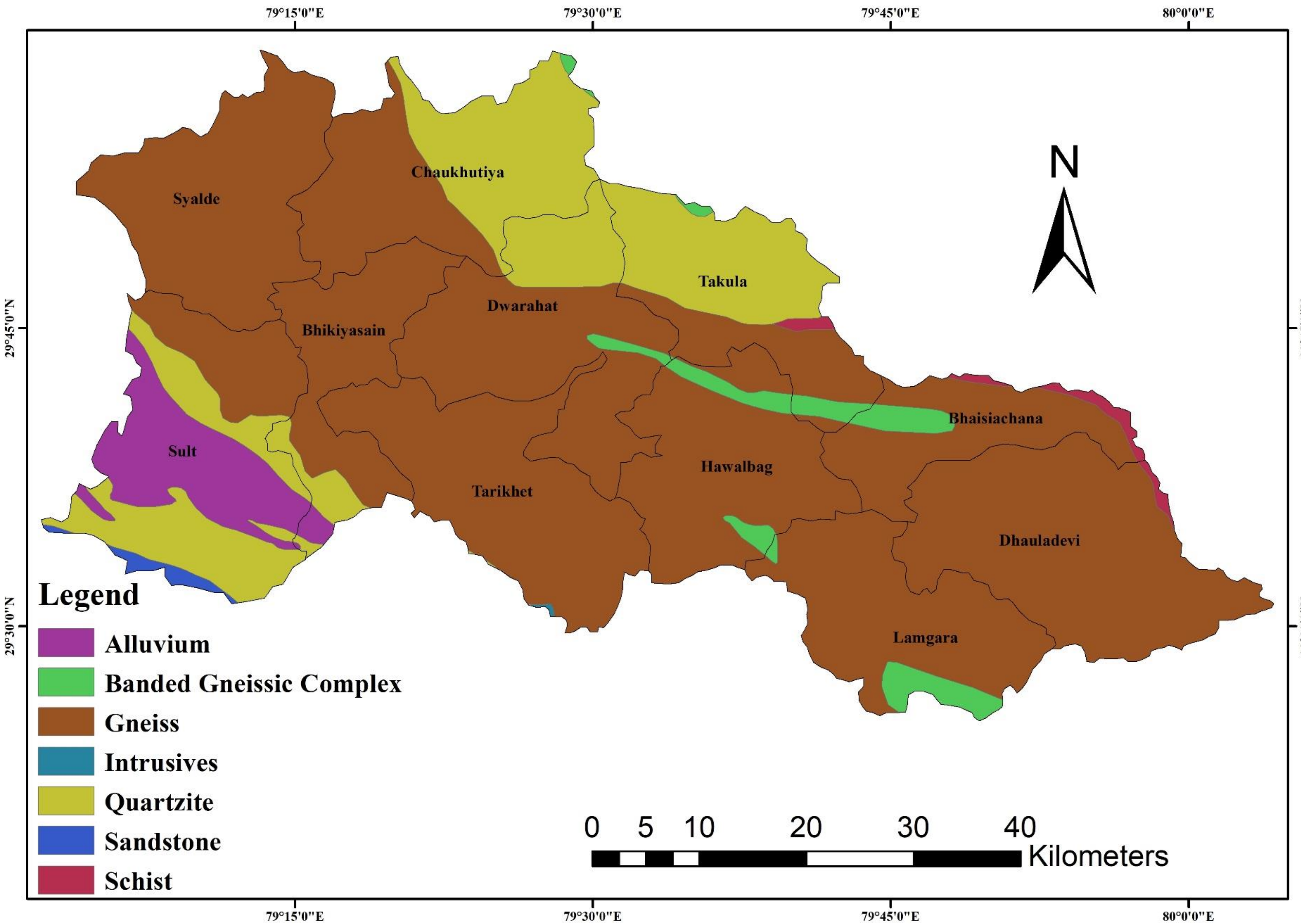


Fig. 6.1 Hydrogeological map of Almora District

6.2 Study on springs

A number of systematic surveys were taken up by the workers of the Central Ground Water Board in the district. A brief account of these studies is given below:

a) During the period 1975-1977, S. Venkatesan and S. C. Bhattacharya carried out detailed studies during which 110 cold-water springs were inventoried. The authors had classified springs based on lithology and range of discharge. Out of the total of 110 springs, 24 occur in quartzite with a discharge range of 1-80 LPM, 5 springs occur in phyllite with the discharge of 7-130 LPM, 14 springs in gneiss with a discharge of 1-50 LPM, and 67 springs occur in mica schist with a discharge of 0.5-28 LPM. The authors observed that the springs are varying from 5th to 8th order as per Meinzer's classification.

b) During the period 1977-1979, 100 cold springs and two groups of warm sulfur springs were inventoried by S. C. Bhattacharya. Based on lithology, a total of 110 springs were classified as follows:

Quartzite – 54 springs, discharge ranges from 0.5-150 LPM
Schist/Granite gneiss – 28 springs, discharge ranges from 0.5-20 LPM
Slate – 7 springs, discharge ranges from 1-12 LPM
Shiwalik sandstone – 1 spring, discharge 50 LPM
Dolomite/Limestone – 2 springs, discharge 0.5-12 LPM
Phyllite – 16 springs, discharge ranges from 1-30 LPM

It was observed that most springs originate from carbonate rocks like limestone and dolomite and they are varying in magnitude from 3rd order to 7th order.

c) During the AAP 2002-2003, a total of 127 springs and one dug well were surveyed by T. K. Pant. During the survey, it was revealed that all springs are rain-fed with some springs, particularly those located in the valleys, fed by the rivers. The seasonal variation in spring discharge has indicated that monsoon recharge has a direct bearing on the spring discharge. The hydrogeology of different formations based upon the hydrological behavior of springs in the Almora district is summarized below:

Quartzite: A total of 25 springs were inventoried in quartzite, which is exposed in a fairly large part of the district. The discharge of springs in quartzite was found to be varying from 0.5 to 40 LPM and the water temperature was ranging from 10.0 ^{0}C to 24.0 ^{0}C. Groundwater in quartzite generally occurs in the secondary porosity developed in the form of joints, fractures, and fissures.

Granite Gneiss: The granite gneiss belongs to the Central Crystalline Group and normally outcrops as linear bodies. A total of 29 springs were surveyed in this rock type. Discharge of the springs was found to be varying from 0.1 to 20 LPM whereas temperature was varying from 10.0 ^{0}C to 22.0 ^{0}C.

Schist and Phyllite: A total of 70 springs were surveyed in schist and phyllite, the low-grade metamorphic rocks. The discharge of springs was found to be varying between 0.1 and 25 LPM while water temperature was ranging between 14.0 ^{0}C and 19.0 ^{0}C.

Limestone and Dolomite: Three springs were surveyed in limestone and dolomite of the Almora district. The discharge of the springs was generally low and found to be varying from 2.0 to
8.0 LPM. The water temperature of the springs was varying from 17.0 ^{0}C to 19.0 C. Besides the springs, one dug well was inventoried in the alluvial cover of the river terrace in Chaukhutia block. The diameters of the dug well were 2.0 m, the depth was 6.0 m while the static water level (pre-monsoon, 2002) was 2.58 m bgl.

d) During the AAP 2009-2010, a total of 128 springs/gadheras were surveyed by Prahlad Ram. He had observed that in the Almora district springs are the main sources of water for drinking and domestic purpose. Most of the springs are situated at high altitudes, which have been tapped and supplied to nearby villages/towns. The springs which are situated at lower altitudes are primarily used for drinking and domestic purpose for the local populace. Few springs in the Almora district are used for irrigation purposes also like at village Birkhanmua, Chaukhutia block.

Spring discharge was measured both during pre-monsoon and post-monsoon. In pre-monsoon discharge of spring ranges from a barely perceptible seepage to 90 LPM with an average discharge of 11 LPM. The pre-monsoon water temperature was found to be varying from 12.0 ^{0}C to 24.0 ^{0}C with an average temperature of 19.0 ^{0}C. During post-monsoon, the spring

discharge was varying from <0.5 to 129 LPM with an average discharge of 16.82 LPM. He observed that two types of springs are found in the district viz. Perennial Spring and Ephemeral Spring. It was found that the ephemeral springs are more sensitive to variation in rainfall as compared to the perennial springs.

The highest pre-monsoon discharge of 90 LPM was recorded at village Birkhanmua, Chaukhutia block whereas the lowest discharge was 0.2 LPM at Bridha Jageshwar. During post-monsoon, the highest discharge was 129 LPM at Birkhanmua whereas the lowest discharge was 0.5 LPM at Nakuta. The highest water temperature of spring in pre-monsoon was 22.0 ^{0}C at several locations like Kharak Tallya, Boonga Nali, Kui, Basoli, etc. whereas the lowest temperature was 12.0 ^{0}C at Bridha Jageshwar and Binsar.

e) During the AAP 2017-2018, a total of 22 springs were surveyed by Ms. Monalisha Singh. Spring discharge was measured by her both during May 2017 (pre-monsoon), September 2017, November 2017 (post-monsoon), and February 2018. During pre-monsoon, discharge of spring ranges from 0.11 to 58 lpm (liters per minute). The pre-monsoon water temperature was found to be varying from 18.0 ^{0}C to 22.0 ^{0}C . During post-monsoon, the spring discharge was varying from 1.08 to 68.18 lpm. The highest pre-monsoon discharge of 58 lpm was recorded at Dhansari, whereas the lowest discharge was 0.11 lpm at Ramghat. During post-monsoon, the highest discharge was 68.18 lpm at Peepal Dhar whereas the lowest discharge was 1.08 lpm at Mehragaon.

f) During the AAP 2021-2022, a total of 27 springs were surveyed by the author. Spring discharge was measured by the author both during May 2020 (pre-monsoon), September 2020, November 2020 (post-monsoon), and January 2021. During pre-monsoon discharge spring ranges from 1.3 to 42.85 lpm (litres per minute) with an average of 8.90 lpm. The pre-monsoon water temperature was found to be varying from 13.1 ^{0}C to 21.1 ^{0}C . During post-monsoon, the spring discharge was varying from 0.55 to 50 lpm with an average of 9.73 lpm. The highest pre-monsoon discharge of 42.85 lpm was recorded at Bhoolgaon, whereas the lowest discharge was 1.3 lpm at Golucheena. During post-monsoon, the highest discharge was 50 lpm at Bhoolgaon whereas the lowest discharge was 0.55 lpm at Mehragaon. The maximum fluctuation is observed at Peepal Dhara at 25.37 lpm and minimum at Golucheena -0.3 between pre and post-monsoon, as discussed earlier it can be said that Golucheena is a perennial spring as flow remain almost unaffected by the monsoon. The details of spring with pre-monsoon and post monsoon flow and fluctuation between those are given in table 6.1. A detailed map of springs map location in the district of Almora is given in fig. 6.2 and details of those springs with lithology, location, and elevation are given in **Annexure V**.

Sl No.	***Location Details***	**May-20**	**Nov-20**	**Fluctuation**
1	Patali Talla	9.84 lpm	7.5 lpm	-2.34
2	Patali Malla	7.14 lpm	2.86 lpm	-4.28
3	Baniya Diggi	4.44 lpm	1.88 lpm	-2.56
4	Goluchheena	1.3 lpm	1.00 lpm	-0.3
5	Katarmal	14.63 lpm	25 lpm	10.37
6	Dharanaula	9.11 lpm	10 lpm	0.89
7	Palna	2.42 lpm	1.33 lpm	-1.09
8	Bhagtola	SP has been dried	1.05 lpm	-
9	Jholi	8.11 lpm	13.63 lpm	5.52
10	Itola	2.59 lpm	2.73 lpm	0.14
11	Chanoda	4.14 lpm	2.31 lpm	-1.83
12	Paitsaal	3.29 lpm	7.5 lpm	4.21
13	Guruda-I	11.11 lpm	3.33 lpm	-7.78
14	Chhani Bartola	7.94 lpm	14.29 lpm	6.35
15	Dhansari	20.38 lpm	23.08 lpm	2.7
16	Deepakot	10.52 lpm	12.00 lpm	1.48

17	Dhalnagaon	6.38 lpm	6.12 lpm	-0.26
18	Simalkhet	2.96 lpm	8.57 lpm	5.61
19	Peepal Dhar	24.63 lpm	50 lpm	25.37
20	Khagsapani	17.14 lpm	2.68 lpm	-14.46
21	Ramghat	9.68 lpm	0.86 lpm	-8.82
22	Naula	5.31 lpm	3 lpm	-2.31
23	Mehragaon (Someshwar)	3.24 lpm	0.55 lpm	-2.69
24	Lodh	2.98 lpm	5.45 lpm	2.47
25	Bhoolgaon	42.85 lpm	50 lpm	7.15
26	Dudholi	4.11 lpm	5 lpm	0.89
27	Deghat	4.10 lpm	1.07 lpm	-3.03

Table 6.1 Details of spring with pre-monsoon and post-monsoon flow and fluctuation

The spring hydrographs of few springs from the historical data available (refer **Annexure VII**), namely Dhansari, Chinoda, Dharanaula and Palna sprins have been plotted with time to show the variation with time as well as the declining discharge of the springs given in **Annexure VIII**. It is quite observable that this declining discharge in not only limited to plotted springs its common trend in most of the springs, as it is common known fact that around 90% population of the hilly region like Almora is dependent on these springs locally know as Shorat or Naulla for Domestic use as well as for drinking purpose. So, spring rejuvenation is the only way to chane this declining trend which is discuused later.

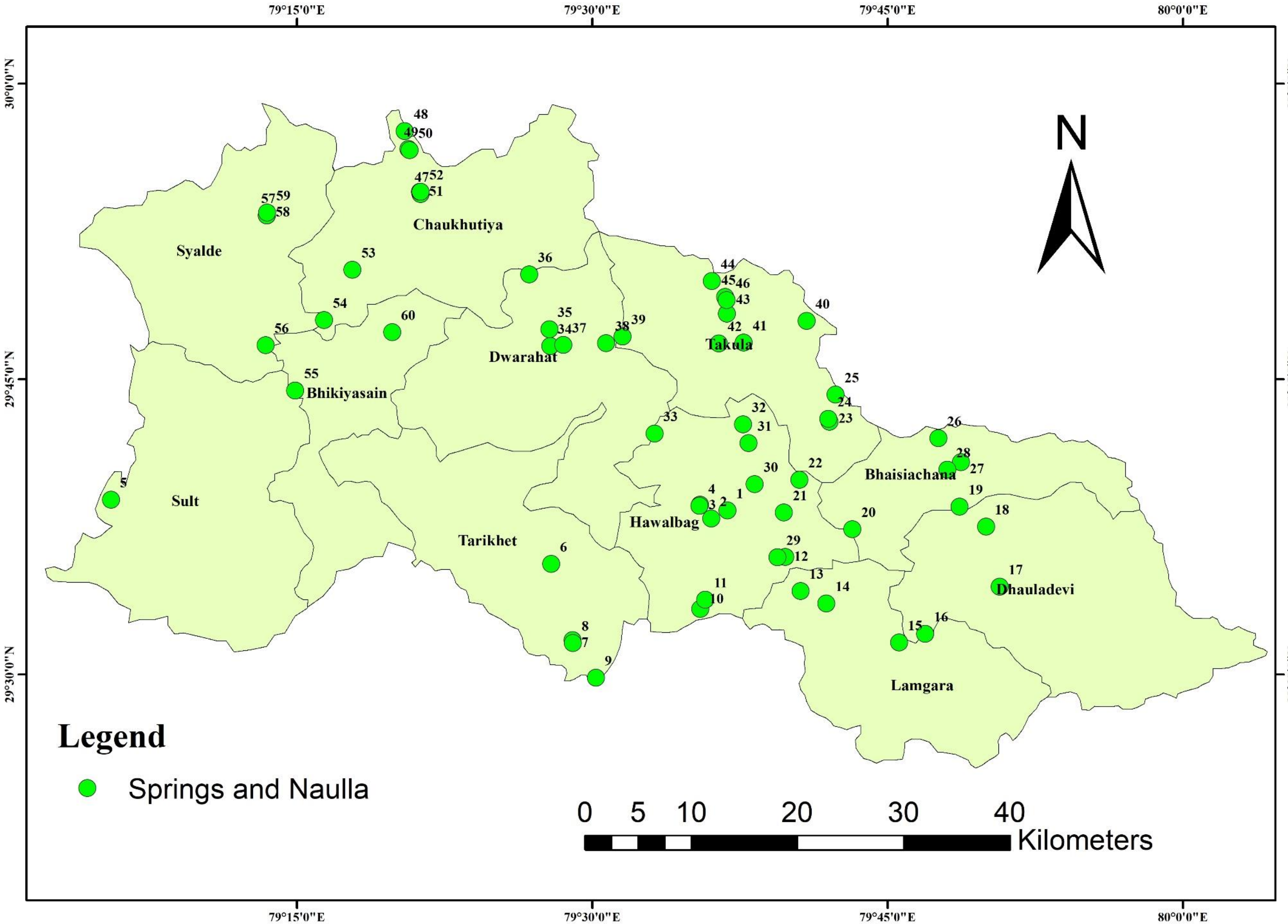


Fig. 6.2 Springs of Almora District

6.3 Study on Hand Pumps

A total of 10 hand pumps as given in table 6.2 were established and monitored during AAP: 2017-18 for the purpose of Aquifer Mapping. The depth to water level, both during pre-monsoon and post-monsoon, was recorded. A perusal of the data has indicated that during pre-monsoon, the minimum depth to water level was 5.8 m bgl at Bhagtola while the maximum depth to water level was 41.3 m bgl at Paisia. During the post-monsoon, the shallowest water level of 5.4 m bgl was recorded at Bhagtola while the deepest water level of 41.74 m was observed at Paisia. Water level fluctuation (rise or decline) was done from the pre-monsoon and post-monsoon depth to water level data. Analysis of water level fluctuation indicates that a minimum rise of 0.35m was observed in a hand pump at Kausani near Someshwar while the maximum rise of 4.28 m was observed at Itola. A decline in water level in hand pumps was found to be ranging from a minimum of 0.44 m at Paisia to a maximum of 2.96 m at Panduakhal.

Hand Pumps were monitored in Almora District during May & November 2017 for the purpose of Aquifer Mapping (DTW in mbgl)							
Sl. No.	**Name**	**Block**	**Location**	**Latitude**	**Longtitude**	**May-17**	**Nov.-2017**
1	HP1	Hawalbagh	1 km before Itola Spring	29.65946	79.633685	11.1	6.82
2	HP2	Hawalbagh	1 km after Bhagtola Spring	29.700358	79.628106	5.8	5.4
3	HP3	Takula	1.5 km from Someshwar towards Kausani	29.79478	79.604491	7.1	6.75
4	HP4	Dwarhat	0.5 km from HP3 towards Kausani	29.798424	79.607558	5.85	6.45
5	HP5	Chaukhutia	Near Sai Baba Temple, Dwarahat	29.773622	79.450233	19.5	5.42
6	HP6	Chaukhutia	Panduakhal	39.972344	79.330875	17.4	20.36
7	HP7	Chaukhutia	Rampur	29.925634	79.349734	17.96	13.78
8	HP8	Chaukhutia	1.5 km before Chaukhutiya	29.87436	79.362432	24.15	24.6
9	HP9	Bhikiyasain	700 m before Naula Spring	29.746307	79.247643	12.4	11.04
10	HP10	Sult	1 km from Paisia towards Jalikhan	29.710557	79.15068	41.3	41.74

Table 6.2 Hand Pump Details

6.4 Groundwater Resources

Groundwater is an important source of water supply in an area. However, due to hilly tracts, its utilization in a major part of the Almora district is much less than the desired level. Besides, the complex hydrogeological setup coupled with the lack of a hydrogeological database hampers precise estimation of groundwater resource potential and its development in the district. Hence, no figure on an estimation of annual groundwater recharge is available for the district.

6.5 Groundwater Quality

Groundwater contains minerals carried in solution, the type, and concentration of which depend upon several factors like soluble products of rock weathering and decomposition in addition to external polluting agencies and changes in space and time. As a result of chemical and biochemical interaction between groundwater and contaminants from urban, industrial, and agricultural activities along with geological materials through which it flows, it contains a wide variety of dissolved inorganic chemical constituents in various concentrations. The character of groundwater in different aquifers over space and time proved to be an important technique in solving different geochemical problems. In order to study the hydrochemistry of groundwater in District Almora, a total of 26 representative groundwater samples were collected from springs in District Almora during the AAP 2021-22. The water samples were analyzed for major and minor cations and anions using standard procedures in the chemical laboratory of Central Ground Water Board, Northern Region, Lucknow. The analytical results of water samples have indicated that different inorganic constituents are present in variable amounts in the groundwater of the Almora district. The analysis result is given in Annexure VI. A brief description of the various Physico-chemical parameters and inorganic constituents is given as follows:

pH: pH of groundwater in the Almora district was found to be varying from 7.13 at Palna to a maximum of 8.02 at Semalkhet. The average value of pH was calculated as 7.58.

Electrical Conductivity (EC): The EC in the district was found to be varying from 81 µS/cm at Garuda to 710 µS/cm at Bhoolgaon. The average EC of groundwater samples was 269.27 µS/cm at 25 ^{0}C. It was observed that the EC of the samples was within permissible limits as per the standard guidelines on drinking water.

Bicarbonate (HCO_3): Concentration of bicarbonate in groundwater in the district was found to be varying from 12.2mg/L at Guruda to a maximum of 390.4 mg/L at Bhoolgaon.

Chloride (Cl): Chloride concentration in groundwater of the Almora district was varying from 7.09 mg/L at Paitsal, Dudhli, Dhansari, Khagsapani etc. to a maximum of 63.82 mg/L at Naulla. It was found that groundwater is suitable for drinking as far as chloride concentration is concerned.

Sulphate (SO_4): Sulphate concentration in groundwater was found to be ranging from 3.5 mg/L at Mehergaon to a maximum of 46 mg/L at Naulla.

Nitrate (NO_3): Concentration of nitrate in groundwater was found to be varying from not detectable at Bhagtola to 119 mg/L at Dharanaula. Only one sample (Dharanaula) has shown nitrate higher than the acceptable limit (>45 mg/L), which may be attributed to local contamination of groundwater by anthropogenic activities like unhygienic practices by the local populace. In general, nitrate concentration in groundwater of the study area of the Almora district indicates that water is fresh and suitable for drinking purposes.

Fluoride (F): Fluoride concentration in groundwater was found to be ranging from not detectable to a maximum of 0.95 mg/L at Bachuradi. In general, suitable for drinking purposes on the basis of fluoride concentration.

Calcium (Ca): Concentration of calcium in groundwater of Almora district was found to be varying from 4 mg/L at Khagsapani to 68 mg/L at Bhoolgaon. Hence, groundwater can be categorized as suitable for drinking purposes as calcium concentration is much below the acceptable limit.

Magnesium (Mg): Magnesium concentration in groundwater was found to be varying from 2.4 mg/L at Deghat, Mehergaon, Dudhli, etc. to the maximum of 37.2 mg/L at Bhoolgaon. Except for one sample values are lower than the acceptable limit for magnesium (30 mg/L) indicating that groundwater is suitable for drinking and domestic purpose.

Sodium (Na): Sodium concentration in groundwater was found to be varying from 2 mg/L at Dhansari, Dudhli, Guruda to 68 mg/L at Dharanaula. Due to the unavailability of guidelines on the basis of sodium and potassium concentration on groundwater, the suitability for drinking purposes is beyond consideration.

Potassium (K): Concentration of potassium in groundwater of Almora district was ranging between not detectable to 31 mg/L at Bhoolgaon.

Total Hardness (TH) as $CaCO_3$: Total Hardness in groundwater was found to be ranging from 30 mg/L at Garuda to a maximum of 325 mg/L at Bhoolgaon.

Total Dissolved Solids (TDS): TDS in groundwater was found to be ranging from 53 mg/L at Garuda to a maximum of 462 mg/L at Bhoolgaon, which is permissible as per water quality standards.

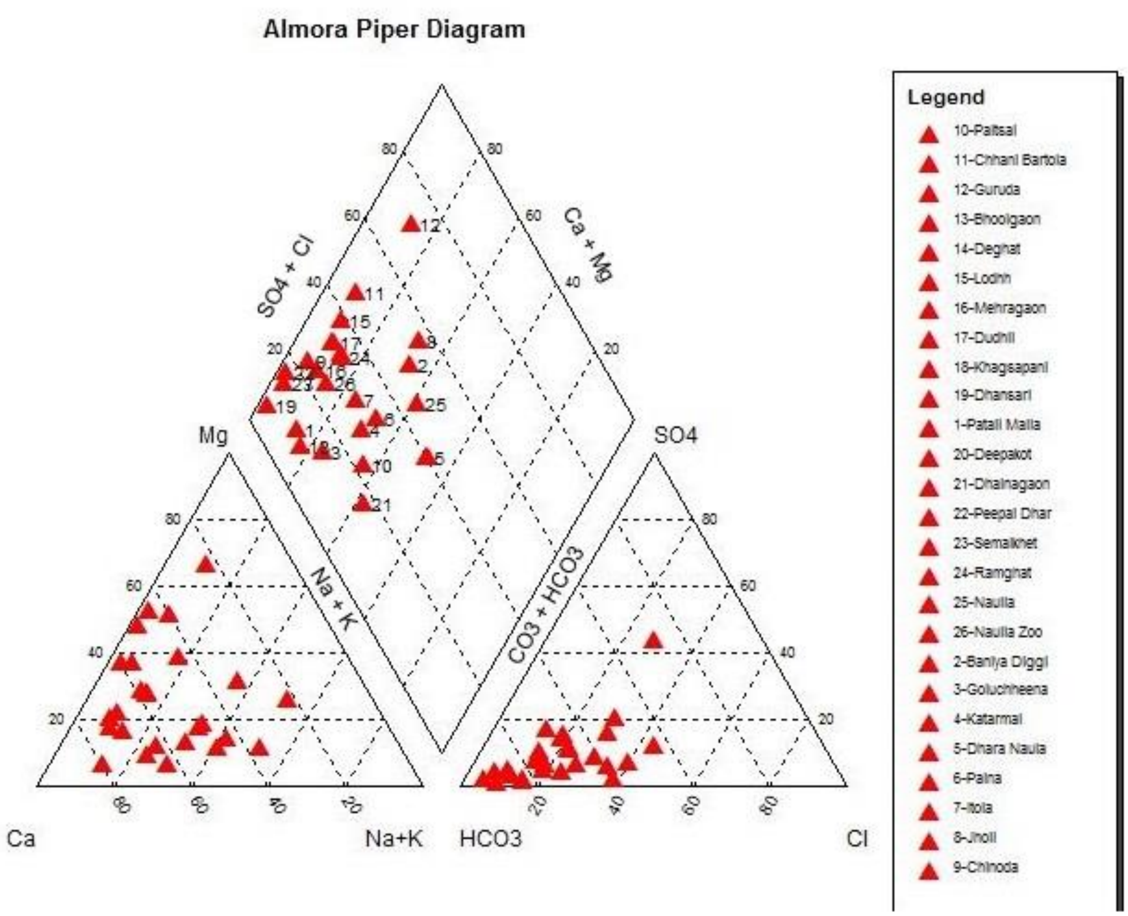
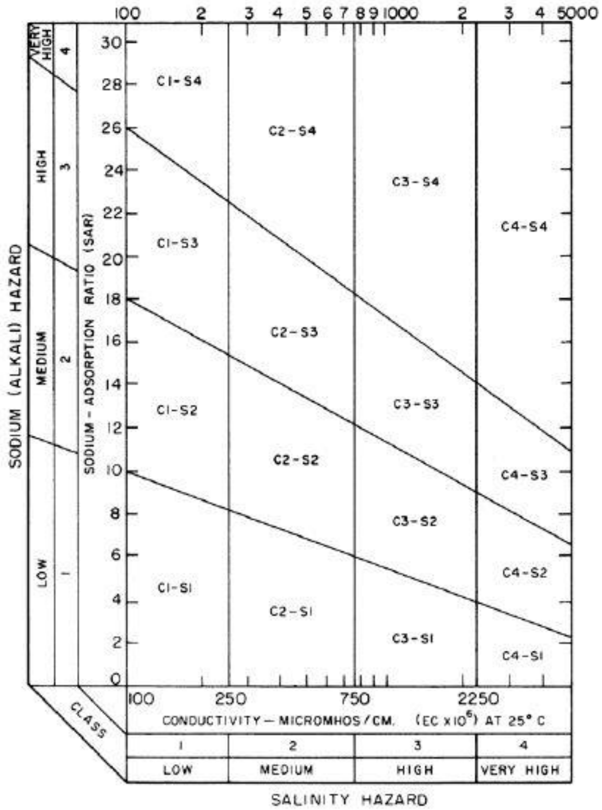


Fig. 6.3 Piper Diagram of Water samples



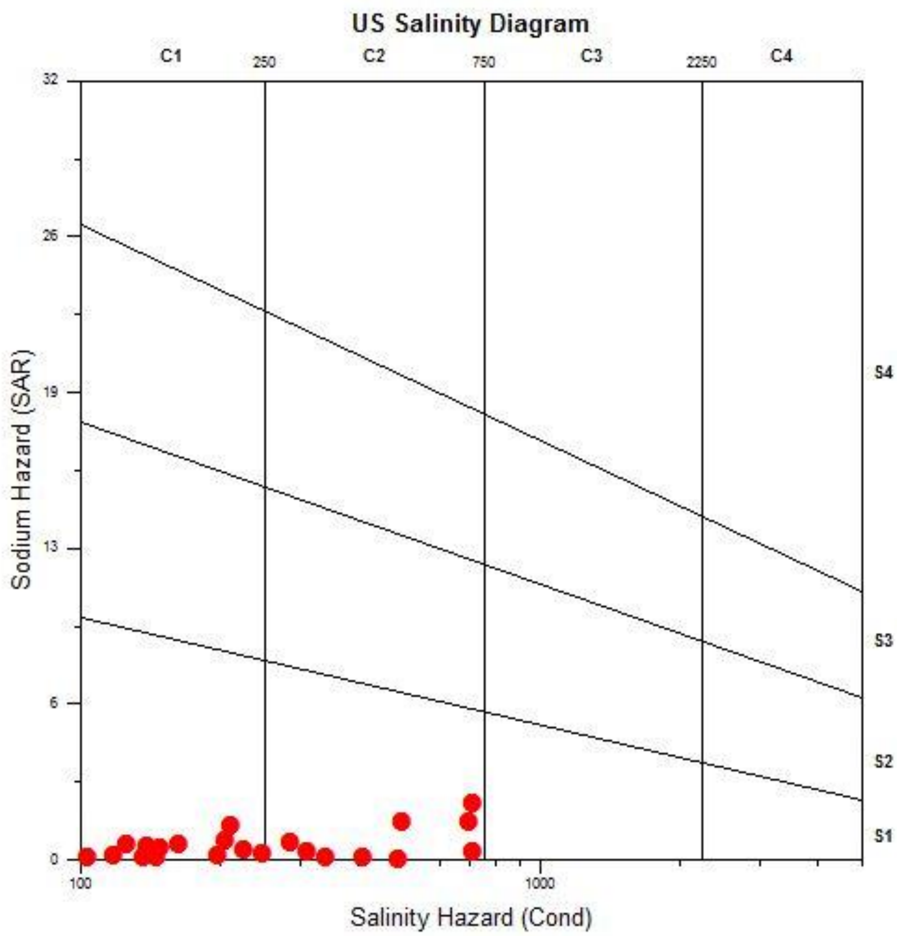


Fig. 6.4 US Salinity diagram

On the basis of the concentration of various elements and selected Physico-chemical parameters, it can be concluded that groundwater in the Almora district is fresh and suitable for drinking, domestic and irrigational use.

- Water quality: Freshwater
- The dominant cations: Ca^{2+}, Mg^{2+}
- The dominant anions: HCO_3^-
- Water facies: (Ca^{2+}-Mg^{2+})-HCO_3^- type
- The water is fit for drinking and domestic purpose

Chapter – 7
Groundwater Management Plan

7.1 Groundwater Development

Taking into consideration the extremely rugged topography in major parts of the Study area, it is not feasible to go for large-scale groundwater development. However, small to medium-scale development may be planned and materialised in a systematic manner. The growth of the population is mainly dependent upon perennial spring sources.

In District Almora, the Uttarakhand Pey Jal Nigam has implemented several schemes for water supply. Besides using suitable and dependable springs, lift water schemes were also implemented.

In the eleven developmental blocks of the Almora district, a total of 1158 rural water supply schemes are existed out of which 782 are working to their full strength (Fully Functional category), 241 are working on their partial strength (Partially Functional category) and 135 schemes have been shut down and are under the Non Functional category. In general, each individual scheme is tapping one or more springs. The said water supply schemes are working by gravity flow. These water supply schemes are implemented by the Uttarakhand Pey Jal Nigam and maintained by the Uttarakhand Jal Sansthan. Of late, the Additional Construction Branch of the Drinking Water Resources Development Construction Corporation, Almora has drilled India Mark II hand pumps in different villages along the road. The hand pumps are tapping fractures within 100 m below ground level. In addition to these hand pumps, the Uttarakhand Jal Sansthan, Almora Division has also executed drilling work and installed India Mark II hand pumps for augmentation of drinking water supply. These hand pumps have been drilled by the DTH Rigs with ODEX attachment in various villages of the district along the motorable roads.

Groundwater development for irrigational use is almost nil in the district. However, surface lift schemes like Hydrums systems may become successful for irrigational purposes, especially in the lower reaches of mountains, near *Nal*as, and small rivers/streams. Group of springs (Gadheras) having high discharge may be tapped at higher elevations of the hills by making Gulls (surface flow schemes) and small canals for the supply of water round the year. The urban water supply position of the study area is an important town viz. Almora, as described below.

Almora: The district headquarter, Almora is located in the southern part of the district at an average altitude of 1600 m. Though during the pre-Independence period the water supply was only 25 litre per capita per day (lpcd) the present requirement is 150 lpcd whereas only 126 lpcd is being met. In the year 1928 Baldhyoti spring was tapped and used for water supply to the town. However, due to the gradual decrease in spring discharge, a gravity scheme was implemented by tapping nine springs having a cumulative discharge 45 LPM at Syahi Devi. Thereafter in the year 1946, a river lift scheme on the Kosi River has implemented about 12 km from Almora, whose capacity was 1.60 MLD. During the period 1999 to 2000, the Uttar Pradesh Pey Jal Nigam started a second pumping station on Kosi River and the capacity was increased to 9.50 MLD. This pumping scheme was developed in three stages with a total head of 715 m. The scheme caters to water supply in Almora Town and sixteen nearby villages. A population of about 75,000 benefited from the implementation of the scheme having a water supply of 126 lpcd.

7.2 Groundwater management

Water Conservation and artificial recharge: Due to the high Average Annual Rainfall in the Almora district, there is a good scope of water conservation through Roof Top Rainwater Harvesting. Due to the high land slope in the major part of the district, a significant amount of rainfall goes waste as immediate surface runoff or overland flow, resulting in very less percolation to shallow aquifers. In such areas construction of suitable water, conservation structures are required. Gully plugs and contour bunds are quite suitable for this purpose as they arrest surface runoff, increase soil moisture, recharge the shallow aquifers, help in preventing soil erosion, and increase the discharge of nearby springs and naulas. Construction of small check dams, nala bunds, and continuous contour trenches depending on the local topographic and hydrologic conditions can be taken up in project mode. Continuous contour trenches would cover the entire slopes uniformly whereas nala bunds constructed in a series would cover the entire stretch of drainage in the hilly tracts. The local populace should be adequately trained through training and mass awareness programmes on artificial recharge and rooftop rainwater harvesting in feasible areas.

Area Suitable for GW Recharge using LDA (Lineament density analysis): Lineaments are physical discontinuity of the Earth’s surface and linear plan landscapes critical for infiltration. Lineaments also defined as structurally controlled and naturally occurring linear or curvilinear features which indicate the presence of faulting and fracturing zones. Linear features in a terrain demonstrates a fundamental geological structure such as folds, faults, joints, or fractures as secondary porosity. Lineaments characterize the weak zones which disturb groundwater flow, increasing infiltration to the subsurface. The lineaments increase groundwater recharging potential implicitly if linked to an aquifer as it enhance the permeability and secondary porosity thus act as a good indicator of groundwater potential zones. The lineaments were converted to an LD map of Almora district as shown in Fig 7.4, using the Line Density Tool in the Spatial Analysis Tool inverse distance to a power function of the GIS environment. The LD was interpolated with Geospatial Data Abstraction Library (GDAL) toolbox with Inverse distance weighted (IDW). High LD areas are suitable for groundwater recharge, and low LD is not suitable for groundwater recharge and discharges. The High LD areas are in Sult, Tarikhet, Takula and Dhauladevi as can be observed from the fig 7.4 shows the promising areas for Groundwater Recharge, on ground verification of this can lead to high GW recharge and quantification of the water recharge and other socio-econmic feasibility for construction of recharge structures.

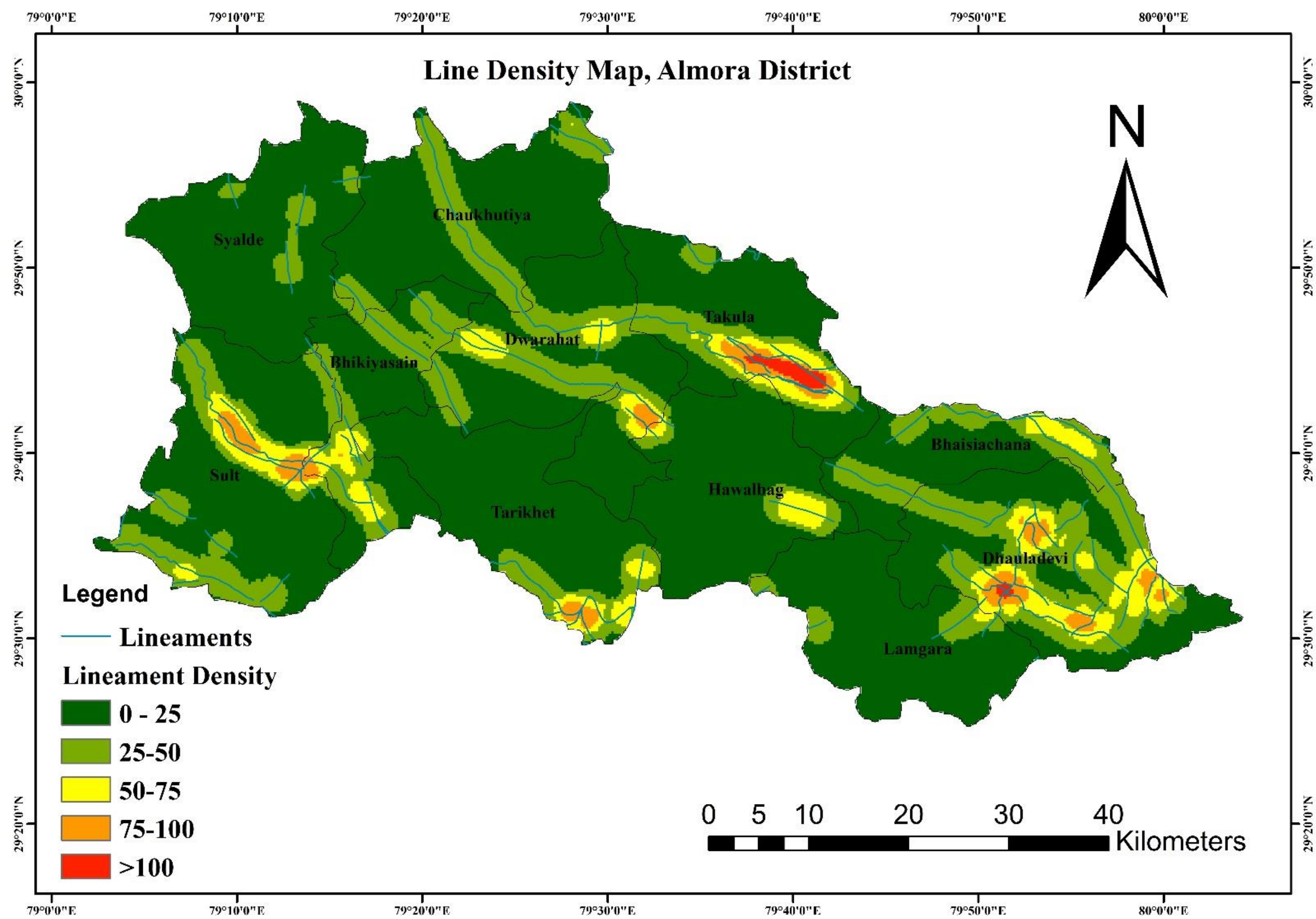


Fig 7.4 Lineament Density Map of Almora District.

Supply Side Management: Supply-side management of water resources focuses on increasing the volume of water availability through many ways like a) finding new resources, b) increasing storage capacity, c) diverting water to increase water supply at a particular location, and d) using technology to create clean, potable water from a previously utilized source. The techniques employed for increasing water supply are often expensive, meaning that places with fewer financial and technological resources are unable to implement them easily.

The supply-side management of the aquifer management plan envisages the potential of water supply from natural sources (springs, gadheras) and man-made sources (hand pumps and mini tube wells) within the study area. The following points may be considered for supply-side management in the study area:

1. Water storage-cum- conservation structures may be constructed at places having gently sloping topography and easy approachability conditions. Through these open channel (guhls) and closed channel (pipe) based flow irrigation systems may be developed for increasing the water availability in water scarcity like peri-urban and urban centers of the study area.
2. Overall, the groundwater development is very low and there is no groundwater-based irrigation system in the area. For increasing the utilized potential, spring-based water storage and distribution system may be developed on perennial springs at khagsapani and Bhoolgaon.
3. Although many springs are tapped by gravity schemes by the state government agencies and gram panchayats (e.g. lodh spring in Someshwar district), it is observed that the concept of rainwater harvesting is almost non-existent in the area. Due to the high rain in this lesser part of the Himalayas, there is tremendous potential for both rooftop and open area harvesting. Site-specific studies are required in this direction. The studies may be taken up in association with state government departments, self-help groups, and NGOs working in the water sector.
4. Artificial recharge is not recommended for this region as it is a highly structurally controlled tectonic prone region as the high flow of water due to high slope seepage of water in the formation may lead to slope failures and landslides. However, in the area of quartzite, granitoid is exposed, and managed recharge in the shallow fractured aquifers may be recommended after a detailed hydrogeological and geophysical survey.

5. To sum up the components of the holistic supply-side management initiative in the aquifer mapping area, it is imperative that an increase in water use efficiency (EUW) practices and change in cropping pattern (depending on actual site conditions) are to be adopted on priority so that the groundwater resources potential may be utilized in an optimal manner.

Demand-side management: Demand-side water management can be defined as reducing the volume of water that is being used by the stakeholders for specific purposes like household use, farming, municipal or industrial needs. The main objective of demand-side water management is to increase water use efficiency (WUE) throughout the year. In the present context, the demand side of the aquifer management plan is complex due to inadequate knowledge of groundwater management practices, the existence of NGOs working in the water sector, seasonally variable groundwater demand, lack of awareness of water resource augmentation and conservation measures – even among the majority of literal people (local resident) and lack of capacity building initiatives coupled with social and behavioral issues.

Major aspects of the demand side Aquifer management Plan in the study area are enumerated below:

1. For reducing demand and curbing wastage of precious groundwater, a spring box may be constructed wherever spring discharge is not very high (<60LPM) so as to protect the spring source from anthropogenic contamination, provide sedimentation, and minimize the surface runoff.
2. Water User Agencies (WUA) may be constituted to protect and conserve the pristine spring source e.g. by fencing around the source so as to prohibit grazing and trampling by animals and unhygienic practices by the local populace near the spring source. A corpus fund may be made at the village or community level so that the objectives of participatory groundwater management are fulfilled.
3. Due to negligence recharge to shallow, localized, fractured rock aquifers, suitable methods of water conservation need to be implemented on priority, preferably in high-density population areas like Hawalbagh block. Second-order streams are to be considered first due to relatively higher water availability so that water resource augmentation may be done. Staggered and /or continuous contour trench, gully plug, and vegetative barrier (check dam, Gabion) may be constructed at suitable locations after a ground hydrogeological survey.
4. In order to reduce wasteful use of groundwater in the hilly terrain, capacity-building programmes need to be organized at the block and/or village level so that local farmers,

villagers, and gram panchayat members understand the importance of water conservation and reducing wastage of the precious water resources.

5. Instead of the traditional ghul system of irrigation, wherein water flows in open channels, it is always better to adopt a better WUE. If the buried piped water supply system is adopted for irrigational use, the possibility of damage to the pipelines (which results in huge distribution loss) would become minimal. This is an important aspect of water resource management, keeping in mind the structural and tectonic disturbance prevalent in the lesser and central Himalayas.
6. Wherever possible, a change in cropping pattern has to be adopted. For example, in parts of Hawalbagh, Dwarahrat block, cropping patterns may be changed from paddy, which is a water-intensive crop, to soya bean or maize, which has less crop water requirement. Moreover, advanced irrigation practices like sprinkler or drip irrigation should be adopted depending on the technological feasibility and economic viability.
7. The sustainable water demand of the floating population during tourist seasons can be mitigated by creating awareness of the importance of efficient water use practices among the economically affluent tourist population. Bathtubs and showers may be utilized to a minimum in the big tourist resorts and luxury hotels on Almora Jageshwar road so that demand-side management can be effectively implemented through lifestyle changes.
8. An effective participatory groundwater management programme involving the local community, NGOs, or Self Help Groups should be implemented on priority by the policymakers, planners, and administrators.

Spring rejuvenation and spring management: Springs are the primary source of water for the rural households in the study area. Despite the key role that they play, springs have not received their due attention and are today facing the threat of drying up e.g. Lodh spring. Spring discharge is reported to be declining due to increased water demand, changing land use patterns, ecological degradation, and erratic trends in precipitation. These springs are known as dhara, naula, kuan locally.

There is, hence, an urgent need to restore, revive and sustain springs. Lack of knowledge, understanding, and awareness on springs has further compounded the problem while also inducing elements of conflicts and haphazard development. Land-use changes, rapid urban expansion and growing commercial consumption are affecting forests and impacting spring water availability.

The water from the Himalayan Rivers is not readily accessible to the densely populated villages and towns in the study area. These fast-flowing rivers cut deep gorges and flow several hundred meters below, while the glaciers are far above this critical eco-zone of the hills. In the hills of the Himalayas, communities depend on rain-fed springs and streams for meeting their water requirements.

It is important to note the fact that while glaciers are easily considered to be the source of the mighty Himalayan rivers, most of them are fed by springs. Any significant depletion in such spring flows at river origins' will surely impact the flow of rivers. Hence, a high dependency on one hand and an increased sensitivity to depletion on the other, make Himalayan springs a source that has become greatly vulnerable in the current context, despite their being part of a strong heritage, tradition, and culture in the region. It becomes important to recognize spring water depletion as a nationally pertinent problem and to address it straightaway through preventive and corrective measures. Around 80% population of the concerned area is dependent on these springs.

The task of the revival of springs is gigantic, it can be achieved through systematically coordinated, combined national, state, and local level initiatives involving all possible stakeholders and partners including governments, communities, and people at large.

Studies conducted have shown that the revival of springs is possible by taking up artificial groundwater recharge works in the recharge area (spring shed) of the aquifer. Based on the experiments, an eight-step action plan was designed which provides a step-by-step procedure for reviving springs. These eight steps are as follows:

- Comprehensive mapping of springs and spring sheds.
- Setting up a data monitoring system.
- Understanding socio-economic and governance systems of springs.
- Hydrogeological mapping.
- Creating a conceptual hydrogeological layout of the springshed.

- Classification of spring type, identifying mountain aquifer, and demarcating recharge area.
- Developing springshed management and governance protocols and
- Impact assessment.

Springs being groundwater, the principles of groundwater management and Common-Pool Resources (CPR) applies to them as well. A strong infusion of hydrogeology was introduced through some of the early pilots stated in the sections above. A hydrogeological approach to spring-revival and spring shed management, complemented by socio-ecological inputs, engineering surveys and strong decentralized governance in mountain water security makes springs resilient to climate variability and helps communities access to water throughout the year and manage it better. Demystification of knowledge, embedding the understanding of water as a common pool resource and management of the resource by local communities and community resource persons through appropriate institutional levels, forms the core aspects of this approach. Water security plans which include recharge augmentation, demand management and resource governance are developed through a consultative process with all stakeholders and the community. A community that understands the scientific and governance aspects of spring shed management can take responsibility for its resource and plan long-term management protocols to ensure safe and adequate water for both lifeline and livelihood activities.

Sum up:

Almora district is part of the sub-Himalayan and Lesser Himalayan range and is underlain by a complex stratigraphical sequence ranging from Precambrian to upper Miocene age. Due to the lack of primary porosity in these formations over the district, groundwater occurs in localized disconnected bodied in joints, fractures and shear zones. A thin cover of alluvial sediments is found as terraces within the narrow flood plains of the main streams and are the only formations having primary porosity and low groundwater prospect. The springs oozing at favorable locations are the major source of ground water. Springs of higher order with higher discharge are also found and are beings used to augment water supply to rural and urban areas. The seasonal observations taken on these springs indicate that springs are rain-fed. The highest discharge has been found during the post-monsoon season. The quality of groundwater, as well as surface water over the entire district, is excellent and suitable for drinking and irrigation use. The chemical analysis of the water samples collected during the survey shows that the chemical constituents are well within the specified limit.

To meet the drinking water needs, the springs need to be studied carefully and scientifically developed for sustained water supply. Water conservation and recharge practices for augmentation of spring discharge (spring rejuvenation) may be undertaken.

The overall hydrogeological scenario of the Almora district indicates that there is no significant groundwater-related issues and problems. However, some local problems encountered in the district and their possible remedies are listed below:

1. Poor quality of groundwater in some naulas. This may be due to misuse and/or disuse of the structures. This problem may be tackled by the development and renovation of the structures, cleaning of dirt and other garbage and periodic maintenance of the springs and gadheras.
2. The villagers need to be trained by the district authorities and state/central government departments so that they can understand the importance of spring-based water supply.
3. There is a scarcity of safe drinking water in some villages in the district. This is mainly due to the unavailability of hand pumps and springs in the vicinity. The problem can be solved either by installing hand pumps inaccessible locations or by storing rainwater in storage tanks and utilizing it through small check dams and gully plugs in suitable areas.

Conclusion and Recommendations

On the basis of findings of the aquifer mapping work in the study area of the Almora District, the conclusions and recommendations are as follow:

- Discharge analysis of the 25 springs shows that during pre-monsoon, the highest discharge (42.85 LPM) was recorded at Bhoolgaon located in Takula block was recorded whereas the lowest discharge (1.3 LPM) was Goluchhena located in Tarikhet Block.
- About 48% of the springs revealed anomalous discharge, wherein post-monsoon discharge is reduced compared to that of pre-monsoon. This is attributed to several factors like widening of roads, disturbance of recharge area caused by landslides and blockage of the main office of the spring's source where discharge was measured.
- In general, moderately high ground water potential exists in areas having gentler slopes and lying in close proximity to river systems.
- Due to the unavailability of subsurface geological data, delineation of preliminary aquifer boundaries and units is not possible.
- Geophysical survey and logging are recommended for deciphering the exact potential zones and acquiring subsurface data.
- Springs at Khagsapani and Patali Malla indicates anomalous discharge pattern wherein pre-monsoon discharge exceeds the post-monsoon discharge. This is attributed to factors like (a) tectonic disturbance/landslide in the recharge area, (b) isolation of the spring flow system from precipitation, (c) blockage in the spring flow pathway inside the fractured and/or jointed rock aquifers and (d) negligible or no contribution from the winter rainfall.
- On the basis of hydrochemical data generated during previous studies and the current study, it is concluded that groundwater is suitable for drinking purposes.
- Integration of parameters like (a) condition of accessibility, (b) proximity to a village/habitation, (c) suitable geomorphological landforms, (d) variability in ground slope, and (e) lineament density may result in the demarcation of zones having high groundwater potential.
- Conjunctive use of surface and groundwater should be practiced in order to reduce the load on aquifers. Wastage and polluting of springs should not be allowed in any case.

- It is also proposed to adopt On-Farm practices such as bench terracing, construction of farm ponds, afforestation, diversification of crops, etc. Alternate cropping systems having lower requirements of water should be encouraged in accordance with the irrigation water availability. Modern irrigation practices like drips and sprinklers, and skip furrow methods of irrigation, should be adopted as these methods can effectively save 30-40% of irrigation water.
- A water budget should be formulated for the overall district in a block-wise or village-wise manner and farmers should be encouraged to grow crops accordingly for that particular season/year.
- Comprehensive supply-side management and demand-side management plans may be formulated for increasing water use efficiency and minimize wastage of water resources.
- The need of the hour is to conduct participatory groundwater management in the area which will further help in bringing more awareness among the common farmers and local people.
- All efforts should be taken to ensure treatment of waste disposal both solid and liquid from industries and urban areas to prevent pollution of ground water and surface water.
- The perennial springs at Khagsapani have a substantial water resources potential of about 22506 m^3/year. There is an urgent necessity of harvesting the unutilized water resources keeping in mind the low groundwater development in the area.
- As the area receives substantial rainfall during the monsoon period, there is a very good scope of sustainable water resources management through the adoption of rooftop rainwater harvesting. The practice may be initiated in government buildings like district collectorate, hospitals, government colleges and schools and can be followed by private hotel and resort owners.
- Participatory groundwater management should be taken up at village and community levels through the gram panchayat/Panchayat Raj Institutes, local NGOs and self-help groups. The district administration should be more proactive in addressing the issues of water scarcity and contamination.
- Training on water conservation, rainwater harvesting and watershed management may be organized at the village and/or block level so that the local populace, farmers and state government officials working in the water sector may become aware of various techniques of sustainable groundwater management including spring shed management and integrated watershed management practices.

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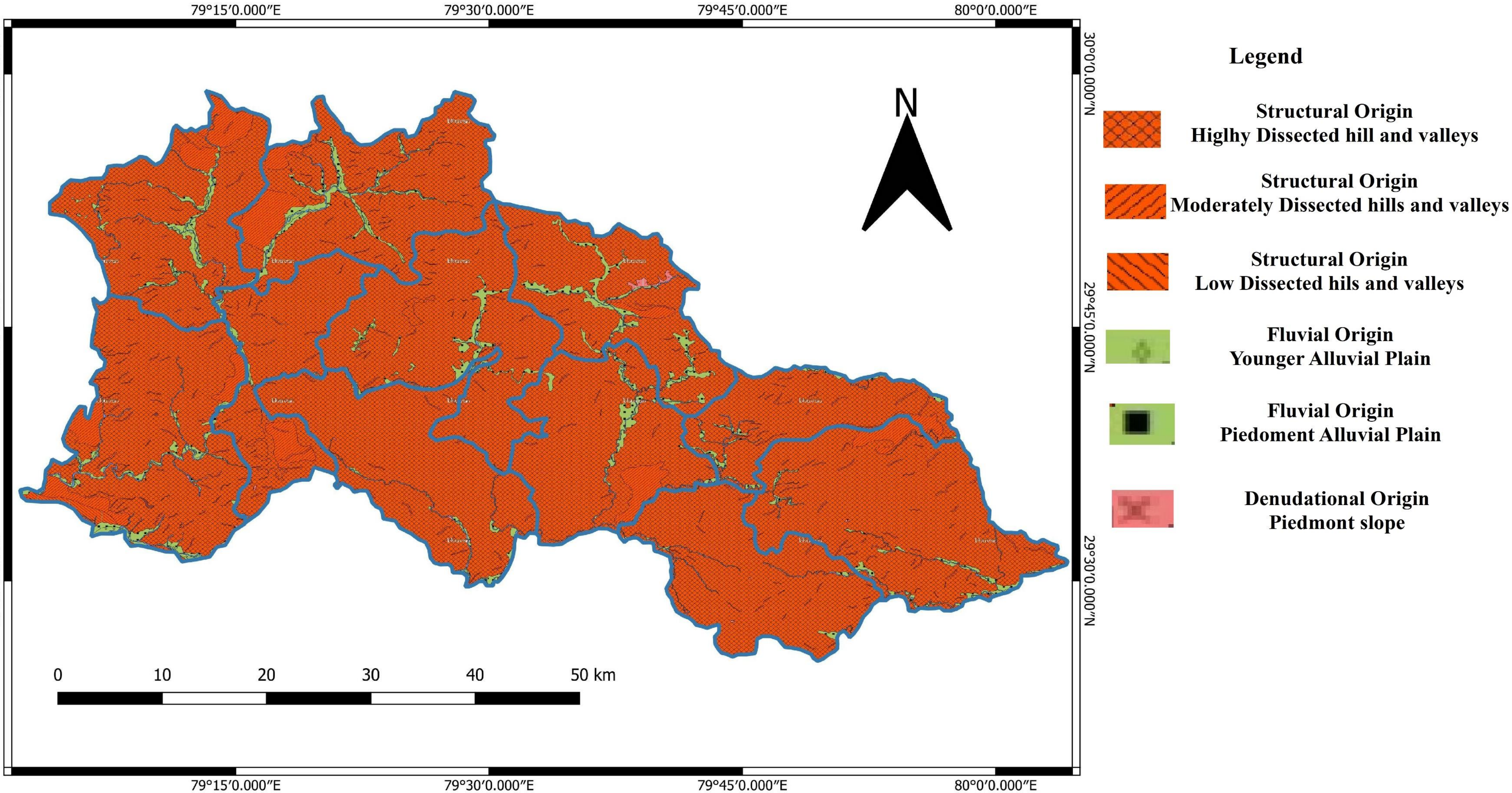
Annexure-I

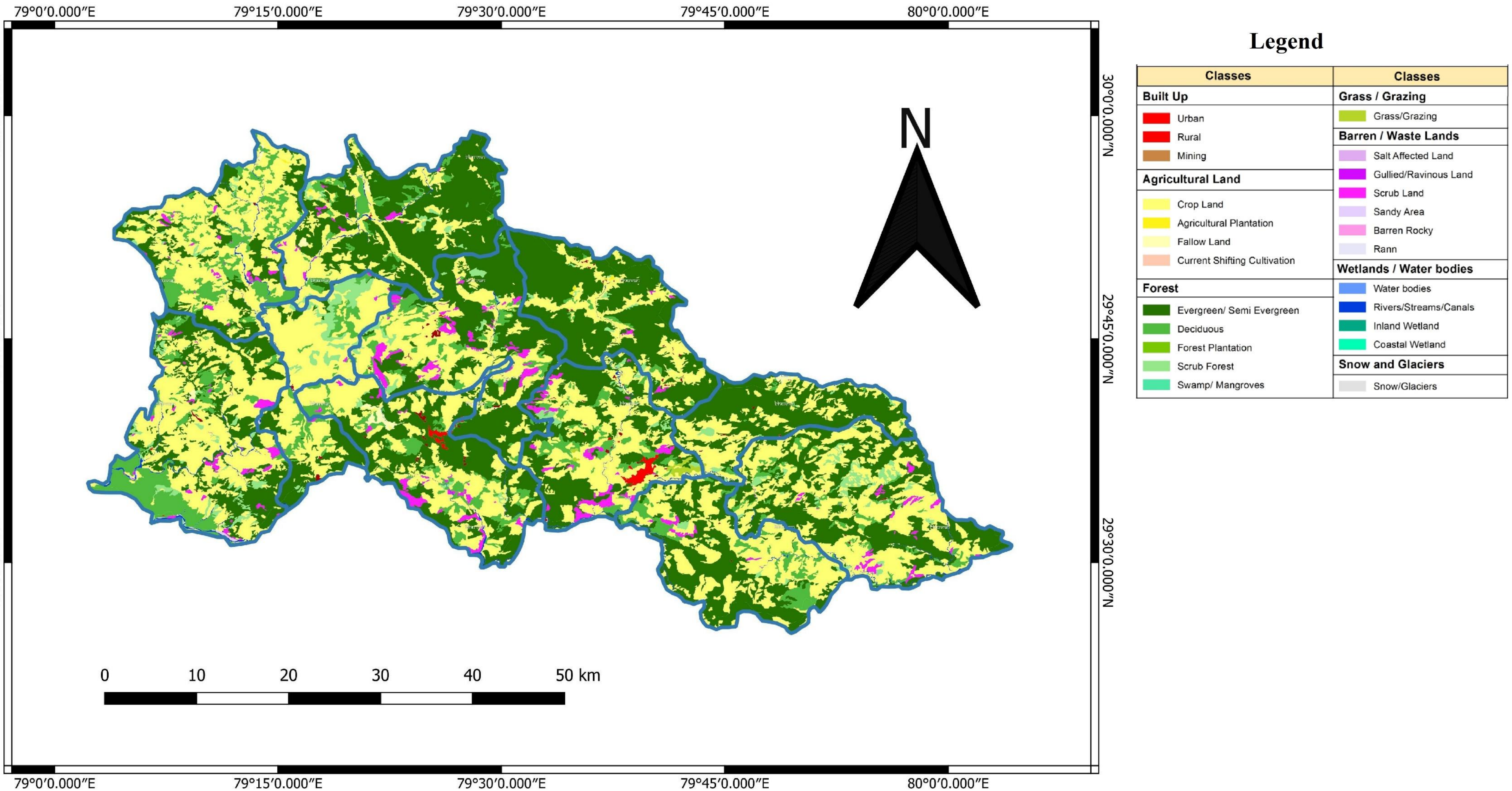
Monthly rainfall (in mm) data for Almora District from 01-Jan-2000 to 31-May-2022																							
Year/Month	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
January	35.55	15.29	66.21	56.19	42.94	64.77	6.11	6.61	28.57	0.5	4.61	33.57	43.78	60.4	59.68	57.01	2.95	22.92	17.04	54.78	110.03	29.88	78.7
February	78.49	30.26	100.43	147.48	4.53	73.52	1.34	114.32	24.25	11.94	67	64.66	5.03	166.59	89.24	41.67	14.44	7.99	8.95	115.82	53.1	8.99	41.65
March	43.37	60.32	89.01	76.97	0.26	34.01	48.75	131.36	13.77	3.88	0.05	20.97	23.67	14.34	62.39	139.7	56.05	20.91	14.24	21.89	106.48	5.02	0.6
April	10.52	61.45	86.69	41.38	80.1	17.08	22.01	35.44	69.5	31.96	11.21	33.44	40.79	26.42	24.72	60.48	7.21	29.99	88.56	34.72	34.2	51.51	3.53
May	127.07	128.45	77.5	60.86	61.07	27.23	64.52	81.64	31.89	66.21	49.09	61.41	4.42	14.56	47.61	30.57	133.9	108.49	49.23	21.7	77.1	167.61	104.75
June	423.63	288.88	97.27	147	171.78	72.44	96.25	208.94	148.1	29.22	90.49	258.44	21.17	414.38	52.93	190.25	145.44	135.48	122.85	76.88	135.67	257.85	-
July	350.97	397.63	226.3	523.55	299.5	422.85	226.41	202.61	268.15	185.32	450.8	335.82	280.83	305.05	503.25	301.95	420.71	451.16	239.21	188.01	210.88	242.75	-
August	510.46	285.18	368.78	427.16	374.89	129.67	258.89	355.46	168.53	346.7	402.89	556.36	368.46	246.76	158.36	204.99	225.03	217.46	326.45	302.76	273.14	168.77	-
September	180.67	76.65	386.31	372.28	145.89	403.28	95.37	214.76	98.53	256.42	479.95	130.87	237.28	67.95	73.96	33.97	67.33	175.16	120.54	200.5	28.52	131.14	-
October	1.77	3.09	11.63	0.34	75.17	14.92	7.6	13.3	9.51	152.13	12.69	2.36	0	21.41	50.81	20.13	2.08	0.38	0.73	25.14	0	311.8	-
November	12.7	1.4	2.78	9.26	1.27	0.44	1.88	0.97	3.71	16.32	2.03	0	0	3.68	0	1.22	0	0	12.31	18.89	0.05	0	-
December	0.72	6.47	3.35	29.31	1.04	5.15	10.56	6.55	0	2.28	13.18	1.53	9.23	7.02	66.74	1.9	1.34	0.34	1.4	57.87	3.94	9.89	-

Annexure II



Geomorphological Map of Almora District

Annexure III



Land Use and Land Cover (LULC) of Almora District

Annexure - IV

List of Hand pumps

S. No.	Name	Block	Location	Latitude	Longitude
1	HP1	Hawalbagh	1 km before Itola Spring	29.65946	79.633685
2	HP2	Hawalbagh	1km after Bhagtola Spring	29.700358	79.628106
3	HP3	Takula	1.5 km from Someshwar towards Kausani	29.79478	79.604491
4	HP4	Dwarhat	0.5 km from HP3 towards Kausani	29.798424	79.607558
5	HP5	Chaukhutia	Near Sai Baba Temple, Dwarhat	29.773622	79.450233
6	HP6	Chaukhutia	Panduakhal	29.972344	79.330875
7	HP7	Chaukhutia	Rampur	29.925634	79.349734
8	HP8	Chaukhutia	1.5 km before Chaukhutiya	29.87436	79.362432
9	HP9	Bhikiyasain	700 m before Naula Spring	29.746307	79.247643
10	HP10	Sult	1 km from Paisia towards Jalikhan	29.710557	79.15068

List of Exploratory wells

S. No.	Name	Block	District	Latitude	Longitude
11	EW1	Syalde-II	Almora	29.8197	79.2106
12	EW2	Naula	Almora	29.7361	79.2522
13	EW3	Jalali	Almora	29.7636	79.3367
14	EW4	Bhatkot	Almora	29.8791	79.3431

List of proposed Piezometers

S. No.	Name	Block	Distict	Latitude	Longitude
15	PPZ1	Hawalbagh	Almora	29.6183	79.674
16	PPZ2	Hawalbagh	Almora	29.628	79.6218
17	PPZ3	Hawalbagh	Almora	29.6616	79.6342
18	PPZ4	Hawalbagh	Almora	29.7237	79.6266
19	PPZ5	Bhaisiachana	Almora	29.6425	79.74494

Annexure - V

DETAILS OF SPRINGS IN ALMORA DISTRICT									
Spring Location ID	Spring Name	Location Details	Coordinates		Elevation (m)	Date of inventory	Lithology	Population dependent
			N	E				
1	Katarmal, Spring	1.2 km ahead of G.B. Pant Institute on Kosi-Ranikhet Road, on LHS of the road, adjacent to a tea shop.	29°38'20.4"	79°36'52.5"	1244	25-05-2018	Quartz-mica-schist	GB Pant Institute of Himalayan Enviroment and Devlopment and local people shopkeeper are dependent on this Spring
2	Jholi, Spring	3 km ahead of Katarmal spring on Kosi-Ranikhet Road, on LHS of the road	29°37'55.2"	79°36'03.0"	1351	25-05-2018	Slump covered	Far from village only used by the passenger
3	Kaurali, Spring	3 km ahead of Jholi Spring on Kosi-Ranikhet Road on LHS of the road	29°38'37.4"	79°35'28.9"	1439	25-05-2018	Quartz Schist	Since last 10-12 year its dead
4	Kaurali, Naulla	200 m ahead of Kaurali Spring on the RHS of the road, accessed by Kacha road.	29°38'34.3"	79°35'26.8"	1430	25-05-2018	Quartzite interbanded with Schist	Its in critical condition after 2010 Landslide near about the area
5	Dwarsu, Naulla	8 km ahead of Kaurali Spring on Kosi-Ranikhet road on the LHS of the road Dwarshukh Village	29°39'31.3"	79°32'22.8"	1679	25-05-2018	Quartzite	100-150 People are dependent
6	Baniyadiggi, Spring	10 km ahead of Ranikhet on Ranikhet road towards Garampani on LHS of the road at Baniyadigi	29°35'37.4"	79°27'55.6"	1538	25-05-2018	Quartzite	Near about 500 people are dependent
7	Patali Malla, Spring	13 km ahead of Baniyadiggi Spring on Ranikhet Road towards Garampani on LHS of the road	29°31'45.0"	79°29'00.6"	936	25-05-2018	Quartz mica schist	Near about 50 people are dependent
8	Patali Talla, Spring	300 m ahead of Patali Malla Spring on LHS of the road	29°31'35.6"	79°29'01.3"	921	25-05-2018	Quartz mica schist	Near about 200 people are dependent
9	Kakrighat, Spring	5 km before Kakrighat on Bhowali-Almora road on RHS of the road	29°29'50.0"	79°30'12.0"	922	25-05-2018	Garnet-mica-schist	Far from nearby village
10	Chausali-I, Naulla	7 km from the road on the left side of the bifurcation on Bhowali-Almora road, on the RHS near a Shiv temple	29°33'19.6"	79°35'29.7"	1256	25-05-2018	Garnet-Mica-Schist	30 people

11	Chausali-II, Naulla	3.5 km from the road on the left side of the bifurcation on Bhowali-Almora road, on the RHS.	29°33'48"	79°35'44.7"	1167	25-05-2018	Quartz-Phyllite interbanding sequence	20-25
12	Dhara Naula, Spring	75 m down on the RHS on a lane on the left side of a shop on Almora-Barechhina Road, Dharanaula	29°35'58"	79°39'48"	1552	26-05-2018	Concreted	80-100
13	Palna, Spring	14 km ahead of Dharanaula Spring on Lohaghat-Devidhura-Almora road, on the RHS side of the road	29°34'14.8"	79°40'34.6"	1574	26-05-2018	Quartzite and Schist interbanding	50
14	Gara Pani, Spring	6 km ahead of Palna spring on Lohaghat-Devihura-Almora road on the LHS of the road Garampani Shiva Temple Bindhya Basini	29°33'36.6"	79°41'53.6"	1926	26-05-2018	Schist Mylonite	20-30
15	Aydi Devta, Naulla	300 m ahead on the road bifurcating towards left to Suakhan, on the RHS of Aydi Devta Temple 100 m down	29°31'37.8"	79°45'34.9"	1838	26-05-2018	Schist Mylonite	Only by the road traveller
16	Dubroli, Naulla	4.5 km ahead of Aydi Devta Naulla, on raod to Suakhan on the RHS of the road, 100 m uphill	29°32'03.9"	79°46'54.4"	1736	26-05-2018	quartzite-Phyllite	Few people
17	Rupu Dhara, Spring	600 m before Suakhan 18 km after Dubroli Naulla	29°34'27.3"	79°50'41.2"	1849	26-05-2018	Phyllite	200-300
18	Jageshwar, Spring	600 m from the bifurcation on Almora-Pithoragarh road to Jageshwar road on the RHS	29°37'30.6"	79°50'00"	1890	26-05-2018	Quartzite(Irregular multiple fracture)	50
19	Panua Naulla, Spring	4.5 km from Jageshwar Spring on Pithoragarh-Almora Road, on the LHS, 100 m down at the base of a tree	29°38'31.6"	79°48'39.5"	1942	26-05-2018	Concreted and plant root covered	600
20	Petsal, Spring	15 km from Panua Naula spring on Pithoragarh-Almora road on LHS near a tea stall	29°37'22.5"	79°43'12.9"	1352	26-05-2018	Quartzite and Schist interbanding	150
21	Kalimath, Spring	3.6 km from L.R. Shah Road, Bal Dhoti on the road to Salla on RHS of the road	29°38'13.5"	79°39'44.2"	1695	27-05-2018	Quartz-mica-schist	50
22	Sirkut, Spring	6.5 km from Kalimath spring on the road to salla on RHS of the road	29°39'53.4"	79°40'31.1"	1566	27-05-2018	Quartz and Schist interbanding	50
23	Meherkola , Tapped Spring	18 km from Sirkut Spring on Almora-Bageshwar road on RHS of the road	29°42'50.0"	79°42'03.1"	1368	27-05-2018	Schist	50
24	Meherkola Spring	350 m ahead of Meherkola Tapped spring on RHS of the road	29°42'58.7"	79°41'59.9"	1385	27-05-2018	Schist	30
25	Kangar, Spring	7 km from Meherkola spring on RHS of the road	29°44'25.7"	79°43'33.5"	1532	27-05-2018	Gneiss Mylonite	60
26	Badibagar, Spring	10.5 km on Kafligair-Kholsir-Kanyarichhina road from Kangar, on RHS of the road	29°43'02.6"	79°47'45.3"	1056	27-05-2018	Quartzite	100

27	Khankari, Spring	1.5 km ahead of Pinewood Gest house on Berinag-Almora road on the LHS of road	29°40'46.9"	79°48'43.5"	1559	27-05-2018	Quartzite	Dead
28	Binsar, Spring	1.5 km after Khankari Spring on Berinag-Almora road on the LHS of the road	29°40'24.2"	79°48'02.1"	1669	27-05-2018	Quartz-mica-schist	40
29	Sunari Naula, Spring	500 m after Hotel Bhagwati, Main Bazar, Almora, 200 m down on the RHS of the road	29°35'57.4"	79°39'24.3"	1502	27-05-2018	Schist	
30	Itola, Spring	4.5 km from the bifurcation near Kosi Market on Almora-Someshwar road on LHS of the road	29°39'40.2"	79°38'15.3"	1190	28-05-2018	Quartzite and Schist interbanding	150
31	Bhagtola, Spring	6 km from Itola Spring on Almora-Someshwar road on LHS of the road	29°41'45.5"	79°37'56.6"	1211	28-05-2018	Schist Mylonite	30-40
32	Patharia, Spring	4 km from Bhagtola Spring on Almora-Someshwar road on LHS of the road	29°42'42.2"	79°37'39.7"	1325	28-05-2018	Schist	10
33	Golchhina, Spring	100 m from Golu Devta Mndir on road from Patharia to Majkhali on the LHS of the Road	29°42'14.6"	79°33'10.1"	1457	28-05-2018	Schist Quartzite interbanding	20-30
34	Dank, Naulla	700 m from the bifurcation on Dwarahat-Someshwar road towards Dunagiri, 500 m down on the LHS	29°46'40.8"	79°27'52.5"	1697	29-05-2018	Schist	30
35	Dwarigair, Spring	4 km from the bifurcation on Dwarahat-Someshwar road towards Dunagiri on the LHS	29°47'32.2"	79°27'50.0"	1908	29-05-2018	quartzite-Phyllite	120
36	Dunagiri, Spring	4.5 km ahead of Dunagiri temple, 500 m on the left road at the bifurcation on the LHS	29°50'19.1"	79°26'48.3"	2097	29-05-2018	Phyllite-slate	50
37	Dhari Tapped, Spring	2.4 km before Kalika Temple, Lodh on Dwarahat-Someshwar road on the RHS	29°46'44.5"	79°28'32.1"	1493	29-05-2018	tapped and concreted	
38	Bhatura Tapped Spring	4 km before Golu Devta Temple, Lodh on Dwarahat-Someshwar road on the RHS	29°46'49.9"	79°30'42.8"	1530	29-05-2018	Quartzite	50
39	Lodh, Spring	650 m before Golu Devta Temple, Lodh on Dwarahat –Someshwar road on the RHS	29°47'09.9"	79°31'32.6"	1604	29-05-2018	Schist	30
40	Bhoolgaon, Spring	10 km from Someshwar on Girechina Road to Bageshwar, on the RHS	29°47'57.6"	79°40'53.2"	1554	29-05-2018	Quartz-mica-schist	500
41	Mehragaon, Spring	3.5 km from Someshwar on Girechina Road to Bageshwar, on the LHS	29°46'51.9"	79°37'41.6"	1408	29-05-2018	Quartzite	20
42	Someshwar, Spring	350 m from Someshwar on a Kacha road on the LHS, opposite to Gyanodaya School	29°46'48.5"	79°36'25.6"	1395	29-05-2018	Quartzite	50

43	Chinoda, Spring	3.5 km from Someshwar on Someshwar-Kausani road on the LHS	29°48'19.3"	79°36'50.7"	1455	29-05-2018	Quartzite	40
44	Chhani, Spring	4 km from Chinoda spring on Someshwar-Kausani road on the RHS	29°49'59.5"	79°36'4.4"	1504	29-05-2018	Slump covered	50
45	Garuda-I, Spring	1 km from Gandhi Ashram, Chinoda on Someshwar-Kausani road on the RHS	29°49'10.6"	79°36'45.6"	1483	29-05-2018	Slump covered	40
46	Garuda-II, Spring	350 m after Garuda-I spring on Someshwar-Kausani road on the LHS	29°49'00.7"	79°36'49.7"	1473	29-05-2018	Quartzite	20
47	Peepal Dhar, Spring	2.7 km from Chaukhutiya on NH-109 towards Pandwakhal on the RHS	29°54'24.4"	79°21'16.9"	1000	30-05-2018	Quartzite	40
48	Parsara (Simalkhet), Spring	12 km from Peepal Dhar spring f on NH-109 towards Pandwakhal on the RHS	29°57'35.6"	79°20'29.3"	1440	30-05-2018	Quartzite	150
49	Dhalnagaon, Spring	7 km from Parsara spring on NH-109 towards Chaukhutiya on the LHS	29°56'41.4"	79°20'40.5"	1106	30-05-2018	No exposure	30-40
50	Bijrani Seepage, Spring	100 m from Dhalnagaon spring on NH-109 towards Chaukhutiya on the LHS	29°56'37.9"	79°20'43.5"	1110	30-05-2018	25th May, 2017 cloud brust destroyed all	100-150
51	Dhansari-I, Spring	270 m ahead of Peepal Dhar spring on the LHS on NH-109 towards Pandwakhal	29°54'31.5"	79°21'15.9"	1006	30-05-2018	Quartzite schist	50
52	Dhansari-II, Spring	50 m before Dhansari-I spring on NH-107 towards Pandwakhal on the RHS	29°54'30.7"	79°21'17.1"	1010	30-05-2018	Slump covered	20
53	Deepakot, Spring	8.0 km from Chaukhutiya on Chaukhutiya-Masi road, on the RHS near an Atta Chakki	29°50'33.6"	79°17'49.6"	880	30-05-2018	Gneiss Mylonite	40
54	Ramghat, Spring	2.3 km ahead of Masi Bus stand on Masi road towards Jainal, on the LHS before a small shop	29°48'0.6"	79°16'22.8"	849	30-05-2018	Quartz mica schist	30-40
55	Naula, Spring	11.2 km ahead of Ramghat spring, 50 m down on the RHS, adjacent to a shop in Naula	29°44'25.8"	79°14'55.5"	784	30-05-2018	Slump covered and Ramganga river material	
56	Turachaura, Spring	7.7 km on road to Syaldeh from the bifurcation on Jainal road, on the LHS 100 m before bridge	29°46'43.3"	79°13'25.3"	840	30-05-2018	Quartzite	50
57	Kotsari-II, Spring	11.2 km from Champanagar Bus stand on road to Deghat, on LHS	29°53'18.9"	79°13'29.0"	959	30-05-2018	Quartz-mica-schist	40-50
58	Kotsari-I, Spring	40 m ahead of Kotsari II spring, on road to Deghat, on LHS	29°53'19.3"	79°13'28.7"	959	30-05-2018	Quartz-mica-schist	50
59	Deghat, Spring	850 m before Deghat, on RHS of the road, 50 m down	29°53'27.6"	79°13'29.9"	949	30-05-2018	Quartzite	50
60	Suraygwal, Naulla	12.4 km on Paithani to Rikhari road via Jalali, from the bifurcation on the road to the right of NH-109, on RHS	29°47'23.1"	79°19'50.6"	1206	31-05-2018	Quartzite	30

Annexure - VI

Sl.No.	Sample Location	Block	District	pH	Conductivity µmho/cm at 25°C	CO_3	HCO_3	Cl	F	NO_3	SO_4	Hardness as CaCO3	Ca Hardness	Mg Hardness	Na	K	SiO_2	PO_4
						mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	Patali Talla	Tarikhet	Almora	7.85	406	nil	207	14	BDL	14	12	180	56	9.6	11.5	1.2	28	nd
2	Patali Malla	Tarikhet	Almora	7.84	308	nil	159	7.1	BDL	6.3	6.5	130	48	2.4	8.4	2.1	28	nd
3	Baniya Diggi	Tarikhet	Almora	7.62	206	nil	61	21	BDL	5.2	20	70	20	4.8	15.4	1.4	33	nd
4	Katarmal	Hawalbagh	Almora	7.36	284	nil	110	21	BDL	19	5.5	100	36	2.4	17	5.7	40	nd
5	Kalimath	Hawalbagh	Almora	7.98	488	nil	281	7.1	BDL	BDL	4.4	220	80	4.8	9.5	3.3	45	nd
6	Dhara Naula	Hawalbagh	Almora	7.55	706	nil	171	64	BDL	119	5.9	160	48	9.6	68	18	38	nd
7	Palna	Hawalbagh	Almora	7.13	163	nil	61	14	BDL	10	5	55	16	3.6	11	2.2	42	nd
8	Suakhan	Hawalbagh	Almora	7.61	244	nil	134	7.1	BDL	BDL	5.7	120	36	7.2	1.1	1.1	20	nd
9	Paitsal	Hawalbagh	Almora	7.42	125	nil	61	7.1	BDL	BDL	5	40	8	4.8	9.1	2.4	36	nd
10	Itola	Hawalbagh	Almora	7.28	148	nil	61	7.1	BDL	5.2	12	60	20	2.4	8.4	1.2	31	nd
11	Jholi	Hawalbagh	Almora	7.92	139	nil	37	21	BDL	5.5	8.2	50	16	2.4	9.5	2.4	27	nd
12	Goluchheena	Tarikhet	Almora	7.63	226	nil	110	7.1	BDL	BDL	5.1	80	28	2.4	8.5	5.1	29	nd
13	Chinoda	Takula	Almora	7.61	198	nil	98	14	BDL	BDL	5.3	100	24	9.6	3.1	BDL	23	nd
14	Guruda	Takula	Almora	7.24	81	nil	12	7.1	BDL	BDL	15	30	8	2.4	2	BDL	12	nd
15	Bhoolgaon	Someshwar	Almora	7.94	710	nil	390	21	BDL	46	5	325	68	37	13	31	22	nd
16	Chhani Bartola	Takula	Almora	7.56	146	nil	49	21	BDL	5	5.2	70	12	9.6	2.2	1.3	18	nd
17	Dudhli	Someshwar	Almora	7.46	84	nil	37	7.1	BDL	BDL	5	40	12	2.4	2	BDL	17	nd
18	Khagsapani	Chaukhutiya	Almora	7.32	90	nil	37	7.1	BDL	BDL	5.2	40	4	7.2	2.1	BDL	13	nd
19	Dhansari	Chaukhutiya	Almora	8.01	408	nil	244	7.1	BDL	5	5	220	40	29	2	1.1	16	nd
20	Deepakot	Chaukhutiya	Almora	7.62	212	nil	61	21	BDL	11	5.2	45	8	6	21	2.3	33	nd
21	Dhalnagaon	Chaukhutiya	Almora	7.96	497	nil	268	28	0.95	6.4	6.5	160	48	9.6	45	14	20	nd
22	Peepal Dhar	Chaukhutiya	Almora	7.89	490	nil	268	28	BDL	BDL	5	260	52	31	2	1	18	nd
23	Semalkhet	Chaukhutiya	Almora	8.02	341	nil	183	14	BDL	9	6.1	180	44	17	2	1.5	16	nd
24	Deghat	Someshwar	Almora	7.7	118	nil	43	7.1	BDL	5	8.1	50	16	2.4	2.8	1.6	28	nd
25	Ramghat	Bhikiasain	Almora	7.62	248	nil	85	14	BDL	BDL	15	90	24	7.2	5.4	3	28	nd
26	Naulla	Bhikiasain	Almora	7.33	696	nil	195	64	BDL	43	46	200	64	9.6	51	22	36	nd
27	Naulla Zoo	Bhikiasain	Almora	7.51	138	nil	61	7.1	BDL	6.4	7.1	60	16	4.8	3.5	2	37	nd
28	Lodhh	Someshwar	Almora	7.39	136	nil	49	14	BDL	5.1	5.6	65	20	3.6	2.3	1	29	nd
29	Mehragaon	Someshwar	Almora	7.38	103	nil	49	7.1	BDL	BDL	3.5	50	16	2.4	2	1	19	nd

List of Chemical Analysis of water sample of Almora District

Note:

nd = Not detectable

BDL = Below detection limit

Annexure VII

Sl No.	Block	Location Details	Jan-22	May-22	Jan-21	May-21	Aug-21	Nov-21	Jan-20	May-20	Aug-20	Nov-20	Jan-19	May-19	Aug-19	Nov-19	Jan-18	May-18	Aug-18	Nov-18	Jan-17	May-17	Aug-17	Nov-17	Jan-16	May-16	Aug-16	Nov-16	Jan-15	May-15	Aug-15	Nov-15	Jan-14	May-14	Aug-14	Nov-14	Jan-13	May-13	Aug-13	Nov-13	Jan-12	May-12	Aug-12	Nov-12
1	Tarikhet	Patali Talla	17.301	13.09	8.57	16.48	15.45	17.27	8.11	9.84	9.87	7.5	1.15	5.34	10.71	11.54	6.04	5	5.2	5	9.32	9.19	5.73	19.11	13.48	30	12	37.5	11.11	17.24	NA	13.04	16.17	Dry	21	8	12	1.15	20	5.69	NA	10	17.74	2.88
2	Tarikhet	Patali Malla	11.481	8.57	7.14	5	2.18	4.52	12.5	7.14	3.06	2.86	7.67	2.26	1.62	6	7.41	2.22	7.08	Dry	6.1	18.63	8.09	6.16	20.68	16.66	15	9.68	5.26 pm	12.05	NA	13.04	19.67	10	23	4	30	26.43	25	3.07	NA	5	19.9	27.55
3	Tarikhet	Baniya Diggi	5.98	Dry	2.4	10.33	6.85	4.11	4.29	4.44	2.95	1.88	8.5	3.73	7.5	6	7.44	4	4.38	8.82	1.76	1.62	12.1	6.13	0.97	3.75	5	4.41	1.5	2.23	NA	1.3	NA	6.12	24	30	NA	NA	NA	NA	NA	NA	NA	NA
4	Tarikhet	Goluchheena	1.856	0.23	0.67	3.14	5.46	2.69	NA	1.3	1.45	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Hawalbagh	Katarmal	46.08	20	20	10.71	41.15	61.6	15	14.63	25.41	25	10.08	16.79	13.33	15	21.9	17.14	11.43	26.07	14.81	8.52	18.52	28.3	13.14	15	60	20	11.11	11.36	30.3	20	24.29	20.47	60	12	24	24.19	50	5.85	NA	25	33.03	43.92
6	Hawalbagh	Dharanaula	8.71	7.5	7.5	NA	8.23	8.34	8.1	9.11	7.74	10	27.04	10.21	8.33	6.82	5.45	12	27.33	10	8.8	9.06	8.96	8.93	3.89	3.75	4.29	1.43	4	3.95	4.12	4	9.74	5.71	8	48	6	6.45	10	44.38	NA	NA	6.82	10.47
7	Hawalbagh	Palna	4.64	2.38	1.33	5.65	4.4	7.72	1.71	2.42	1.99	1.33	5.25	1.48	2.4	1.43	2.11	1.71	7.33	0.89	2.11	1.92	3.18	3.58	4.24	1.15	10	3	3.16	1.99	2.48	15	2.9	2	3	21	2	1.58	2.3	17.03	NA	NA	1.41	2.06
8	Hawalbagh	Bhagtola	Collapsed due to rockfall	0.97	4	5.96	1.46	Collapsed due to rockfall	Dry	SP has been dried	1.15	1.05	Dry	Dry	Dry	Dry	Dry	0.62	2.66	Dry	1.8	1.03	12.99	NA	1.89	1.76	20	2.5	1.67	0.71	13.12	2.22	3	1	3.87	32	1.5	0.97	5.66	26.3	NA	NA	NA	NA
9	Hawalbagh	Jholi	15.94	10.71	8.57	8.77	14.21	13.58	2.4	8.11	2.56	13.63	8.32	7.88	8.57	5	10.75	12	9.67	7.5	13.64	18.29	10.91	15.87	4.28	Dry	5	15	3.7	1.58	NA	2.88	NA	8.82	10	8	NA	NA	NA	NA	NA	NA	NA	NA
10	Hawalbagh	Itola	4.33	1.66	2.5	4.15	6.95	4.3	6	2.59	3.37	2.73	2.84	1.43	6	2.31	Seepage only	1.87	6.19	3.53	3.02	2.08	5.69	4.07	1.89	2.14	6.67	4	2.75	2.42	4.73	2.61	3.05	1.73	3.35	16	NA	NA	NA	17.05	NA	NA	NA	NA
11	Takula	Chanoda	2.24	1.36	1.36	4.6	1.7	1.49	2.73	4.14	2.41	2.31	1.65	0.52	3.33	2	0.87	0.8	4.2	1.72	1.58	0.94	3.62	1.19	0.92	1.3	3.53	2.22	0.74	2.11	4.47	0.44	2.04	0.99	1.2	65	1.5	0.41	6	62	NA	NA	NA	NA
12	Takula	Paitsaal	9.68	4.09	2.4	NA	29.91	NA	NA	3.29	5.33	7.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	Takula	Guruda-I	2.89	1.58	2	9.27	6.75	3.67	1.88	11.11	23.51	3.33	13.6	1.24	7.5	1.5	14.02	1.33	17.2	24	5.55	13.82	15.96	15.46	10.25	1.76	5	12.03	11.54	1.99	17.75	NA	20.4	15.99	18.18	20	17	1.82	12	17.47	NA	NA	NA	NA
14	Takula	Chhani Bartola	16.55	6.38	8.57	18.77	23.88	22.45	5.45	7.94	13.15	14.29	5.74	5.89	20	6	7.41	6	24.16	8.57	8.55	5.36	21.58	7.26	6.59	6	30	11.54	7.5	7.42	38.96	10.34	8.68	57.97	19.35	20	NA	NA	NA	18.53	NA	NA	NA	NA
15	Chaukhutiya	Dhansari	22.27	4.41	7.5	19.6	17.05	18.16	13.04	20.38	30.62	23.08	25.64	7.82	27.27	4	36.59	8.57	18.1	35.29	15.46	58.82	115.38	58.82	12.9	37.5	42.85	124.28	3.16	0.29	258.62	37.5	150.75	60	150	3	150	94.34	100	1.29	NA	NA	NA	NA
16	Chaukhutiya	Deepakot	13.15	8.57	20	11.93	14.1	12.24	10	10.52	11.52	12	11.32	7.15	12	7.5	11.49	6	10.77	12	10.83	7.79	12.35	11.24	6.42	6.6	15	12.15	7.79	9.4	NA	8.82	8.35	7.5	5	12	7.5	6	4.41	7.58	NA	NA	NA	NA
17	Chaukhutiya	Dhalnagaon	15	7.5	4.29	11.55	20.5	16.86	9.38	6.38	10.68	6.12	9.99	6.95	26.09	10	24.39	7.5	17.34	18.75	7.58	5.08	28.85	12.88	7.8	7.5	6	9.38	8.3	18.87	NA	5	NA	7.4	15	20	NA	NA	NA	NA	NA	NA	NA	NA

18	Chaukhutiya	Simalkhet	9.54	2.61	3	14.74	28.92	14.35	5.77	2.96	15.76	8.57	4.64	1.81	40	0.6	9.68	1.87	56.81	15	3.05	8.26	32.61	10.45	2.69	1.76	20	5.16	3	2.12	NA	2.85	NA	1.81	30	30	NA	NA	NA	NA	NA	NA	NA	NA
19	Chaukhutiya	Peepal Dhar	41.6	12.85	75	24.03	81.52	32.96	20	24.63	25.59	50	19.51	18.91	35.29	20	41.1	20	65.21	85.71	NA	8.26	83.33	68.18	28.58	30	43.64	142.86	11.38	15.82	NA	177.27	NA	58.82	76.7	60	NA	NA	NA	NA	NA	NA	NA	NA
20	Chaukhutiya	Khagsapani	3.75	0.94	2.19	26.54	11.59	6.2	NA	17.14	12.54	2.68	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
21	Bhikiasain	Ramghat	10.55	7.5	Dry	NA	NA	14.14	Dry	9.68	4.54	0.86	Dry	Dry	Dry	Dry	9.62	3.53	0.93	Dry	3.43	0.11	2.92	23.81	13.42	3.52	6	Could not locate	12.77	10.88	NA	21.43	18.18	15.79	46	4	24	15.79	42.85	2.55	NA	NA	NA	NA
22	Bhikiasain	Naula	2.42	2.14	3.53	3.13	4.04	2.73	5.45	5.31	4.39	3	6.6	5.15	4	4	6.61	7.5	6.9	6	5.33	11.76	7.01	6.41	6.32	7.5	7.5	11.76	2.22	4.07	NA	4	NA	28	NA	32	NA	NA	NA	NA	NA	NA	NA	NA
23	Someshwar	Mehragaon (Someshwar)	2.72	1.58	0.375	1.98	1.04	0.68	0.36	3.24	1.63	0.55	0.56	0.49	1.82	2.4	0.56	0.52	2.56	0.8	1.27	0.97	2.37	1.08	0.89	8.57	3.53	1.41	0.52	0.61	13.95	NA	7.39	2.88	10	16	10	4	10	14.07	NA	NA	NA	NA
24	Someshwar	Lodh	6.05	4.17	3.75	5.76	9.05	7.75	0.3	2.98	8.02	5.45	2.17	0.94	8.57	2.5	18.07	3	8.14	2.4	2.05	2.28	4.49	8.31	4.24	3.3	12	3.9	3.24	2.82	11.69	NA	6.28	5.25	-	8	NA	NA	NA	7.42	NA	NA	NA	NA
25	Someshwar	Bhoolgaon SP	51.37	21.43	40	68.49	103.4	66.82	42.86	42.85	81.39	50	37.95	30.25	85.71	50	31.58	25	58.68	75	6.63	24	93.75	46.15	14.56	30	Not Measured	41.74	12.24	33.71	66.66	8.57	53.57	35.29	120	6	52	32.86	5.45	4.1	NA	NA	NA	NA
26	Someshwar	Dudholi	14.9	4.41	4.29	71.59	24.5	18.71	NA	4.11	11.29	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
27	Someshwar	Deghat	4.5	7.89	0.78	2.21	4.2	2.03	NA	4.1	1.63	1.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Annexure VIII