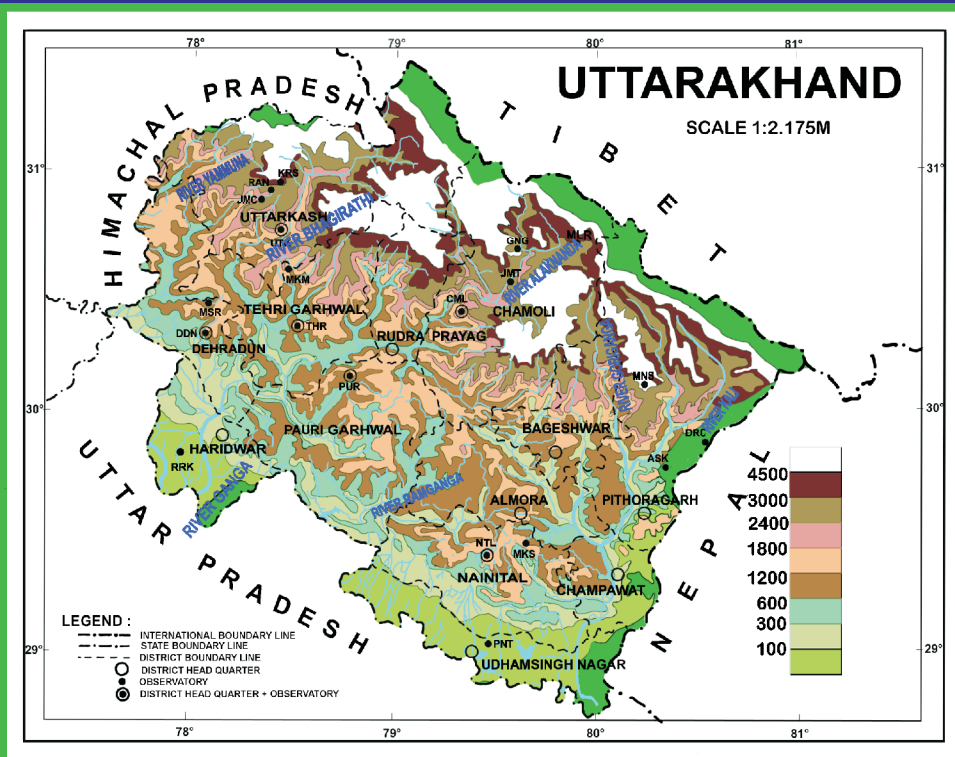




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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

उत्तराखण्ड की जलवायु CLIMATE OF UTTARAKHAND



CLIMATOLOGICAL SUMMARIES OF STATES SERIES - No. 21

ISSUED BY

OFFICE OF THE
ADDITIONAL DIRECTOR GENERAL
OF METEOROLOGY (RESEARCH)
INDIA METEOROLOGICAL DEPARTMENT
PUNE - 411 005



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PREFACE



The importance of meteorology and its economic and social benefits are being increasingly realised all over the world. In our country also, various sectors like agriculture, aviation, power and energy, tourism, shipping, transport industry etc. require climatological information pertaining to different regions of the country for planning and executing the different projects with a view to derive maximum advantage from meteorological and/or climatological conditions. Keeping these requirements in view, it was decided by India Meteorological Department to publish a series of “Climatological Summaries” for each state in the country, incorporating the district climatological summaries. The twenty-first issue in the series of ‘State Climatological Summaries’ is “Climate of Uttarakhand”. The climate of this state is prepared for the first time.

The present publication contains extensive information on rainfall, temperatures, wind, humidity, clouds and other weather parameters in “Uttarakhand” state and in all districts of the state and information on climatic classification, coefficient of rainfall variation, droughts, excessive rainfall, cyclonic storms and depressions, western disturbances and earthquakes are also included in the publication. Uttarakhand state is mostly hilly terrain with several valleys and rivers. Hence climatic conditions vary from place to place in this region. Spatial distribution of two main climatic elements – rainfall and temperature have been elaborated and depicted in maps. Spatial temperatures for representative months of all seasons have been determined by applying lapse rate of respective months considering topographic features of the location. Climatic classification over the state is determined by Koppen’s technique.

The contributions for preparation of climatological summary and related maps have been made by Shri G.S. Dhekne, Shri S.M. Deshpande, Smt. U.S. Satpute, Shri R.S. Wayal, Smt. P.R. Iyer and Smt. P.P. Bhagwat from “Climatological Publication Section” of the Office of the Additional Director General of Meteorology (Research), India Meteorological Department, Pune.

The publication has been prepared by Dr. T.P. Singh, Director. Shri B. Mukhopadhyay, LACD-ADGM(R) provided the overall guidance for this publication. I appreciate their sincere efforts.

I am hopeful that this publication will be extensive useful source of climatic information in various sectors for development of Uttarakhand state of India.

NEW DELHI
October, 2014.

Dr. L. S. RATHORE
DIRECTOR GENERAL OF METEOROLOGY

**INDIA METEOROLOGICAL DEPARTMENT
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17.	Abstract	The publication contains extensive information on the climate of Uttarakhand state and its districts based on rainfall, temperature, winds, clouds and other weather parameters. The information on droughts and excessive rainfall, depressions and cyclonic storms, Earthquakes are also included in the publication.
18.	Key Words	State Summary, District Summary, Physical Features, Climatic Classification, Heaviest Rainfall, Highest Maximum Temperature, Lowest Minimum Temperature, Rainfall Variability, Seasonal Rainfall, Annual Rainfall, Mean Maximum Temperature, Mean Minimum Temperature.

INTRODUCTION



The climatology of Uttarakhand state of India in terms of various meteorological parameters such as temperature, rainfall, rainfall variability, pressure and winds, relative humidity, clouds, weather hazards, etc. is described in state summary, followed by a detailed description of the climate of each district considering topographic characteristics of the location. In this publication, the districts of Uttarakhand State which were in existence as on 1st January 2012, have been considered and the climatology of these districts, arranged in alphabetical order is presented.

The normals for each month and annual rainfall are generally based on the data for the period 1961 to 2010. The monthly and annual normals of other meteorological parameters used for describing the climate are generally based on data for the period 1981 to 2010, however when data for the sufficient period is not available, normals for the previous period are utilized. The extreme values of temperature and rainfall presented in the publication are based on the updated data upto the year 2013. The data have been obtained from National Data Centre, Pune.

The information on cyclones and depressions affected the state during the period 1891-2013 are included in the state summary. As Uttarakhand state is seismic prone region, the information on earthquakes of moderate or high intensity occurred in the state during the period 1862-2013 are also incorporated in the state summary.

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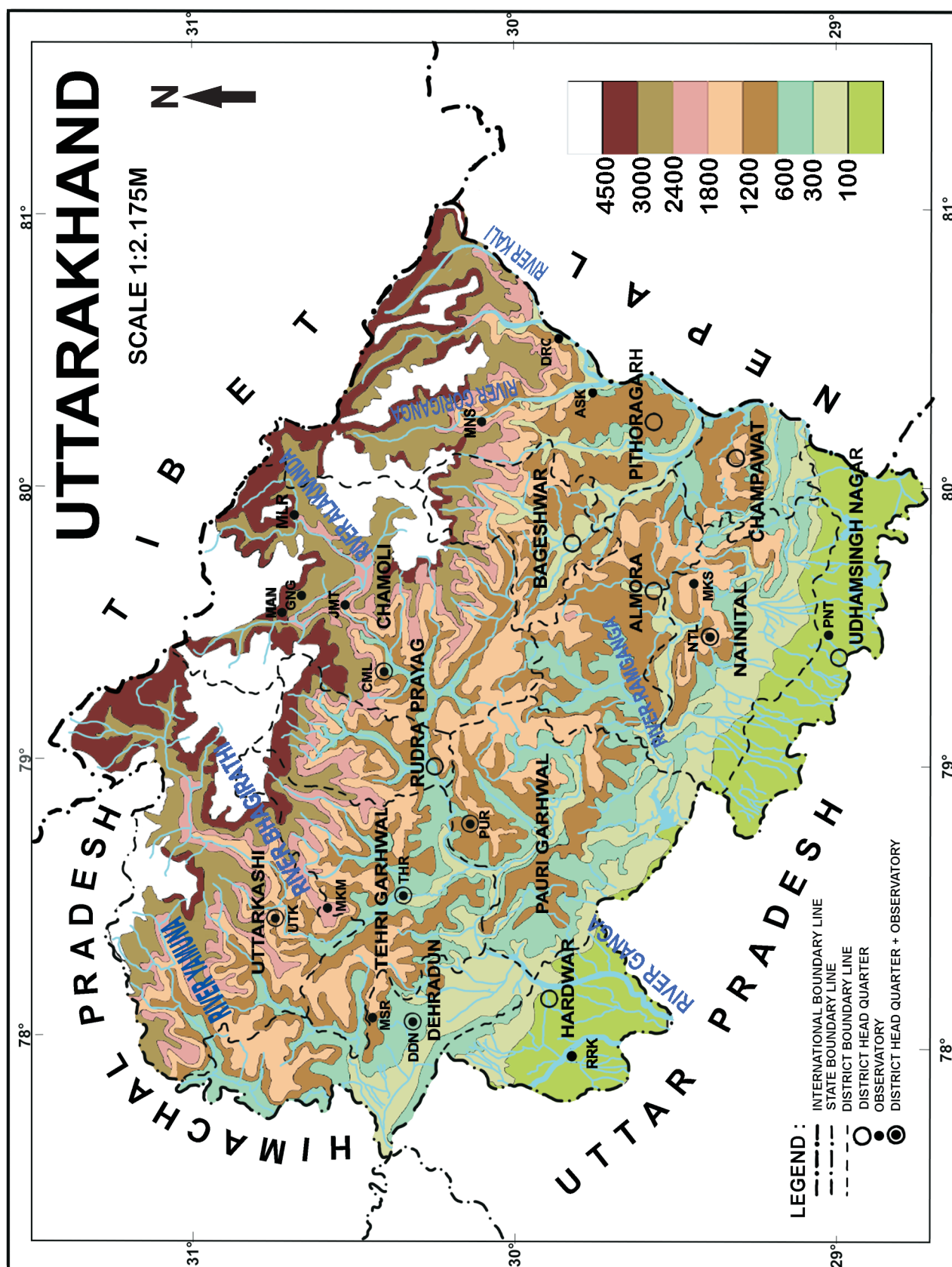
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FIG: 1 :PHYSICAL FEATURES OF UTTARAKHAND STATE



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FIG: 1(a) : INSET

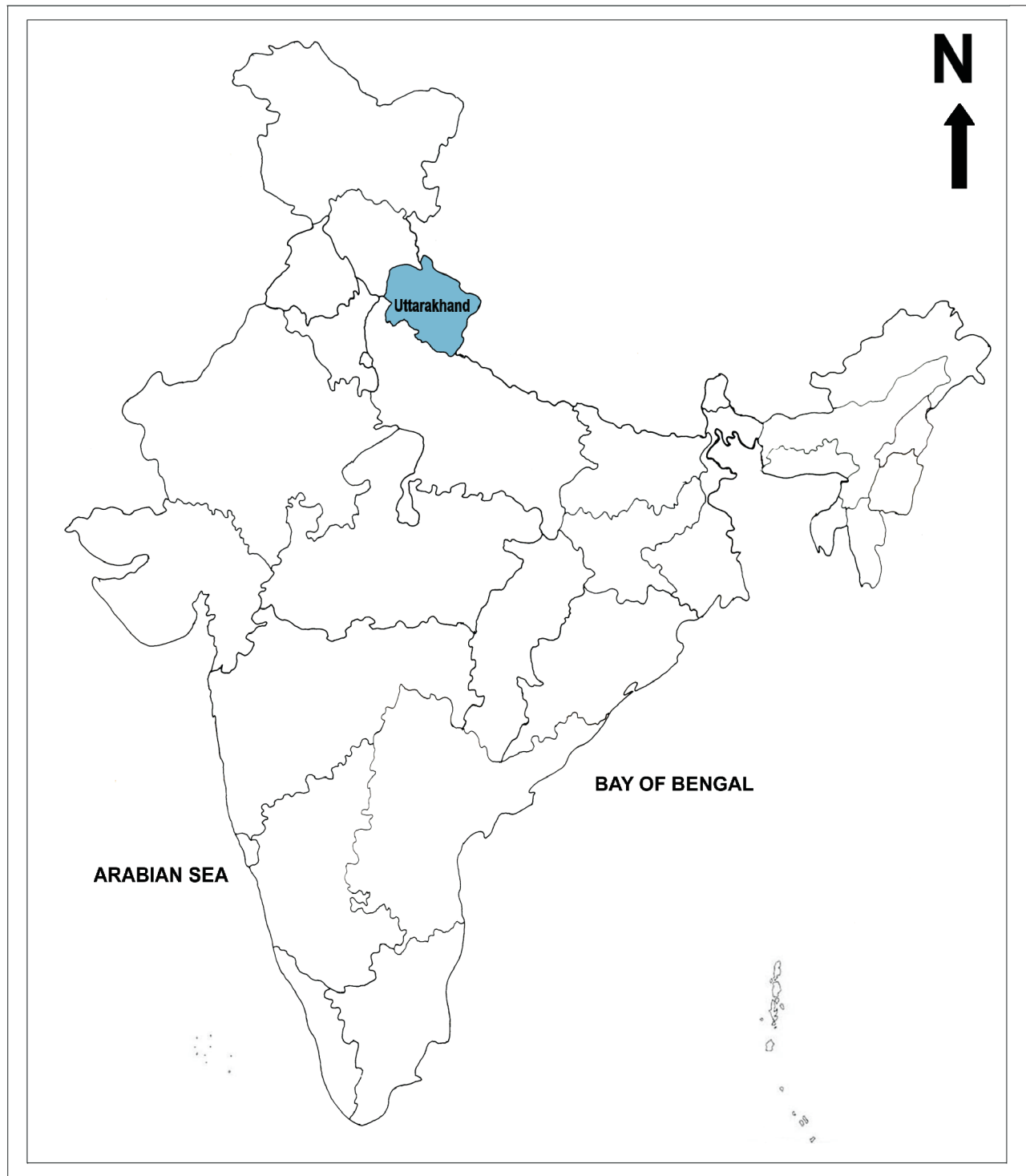
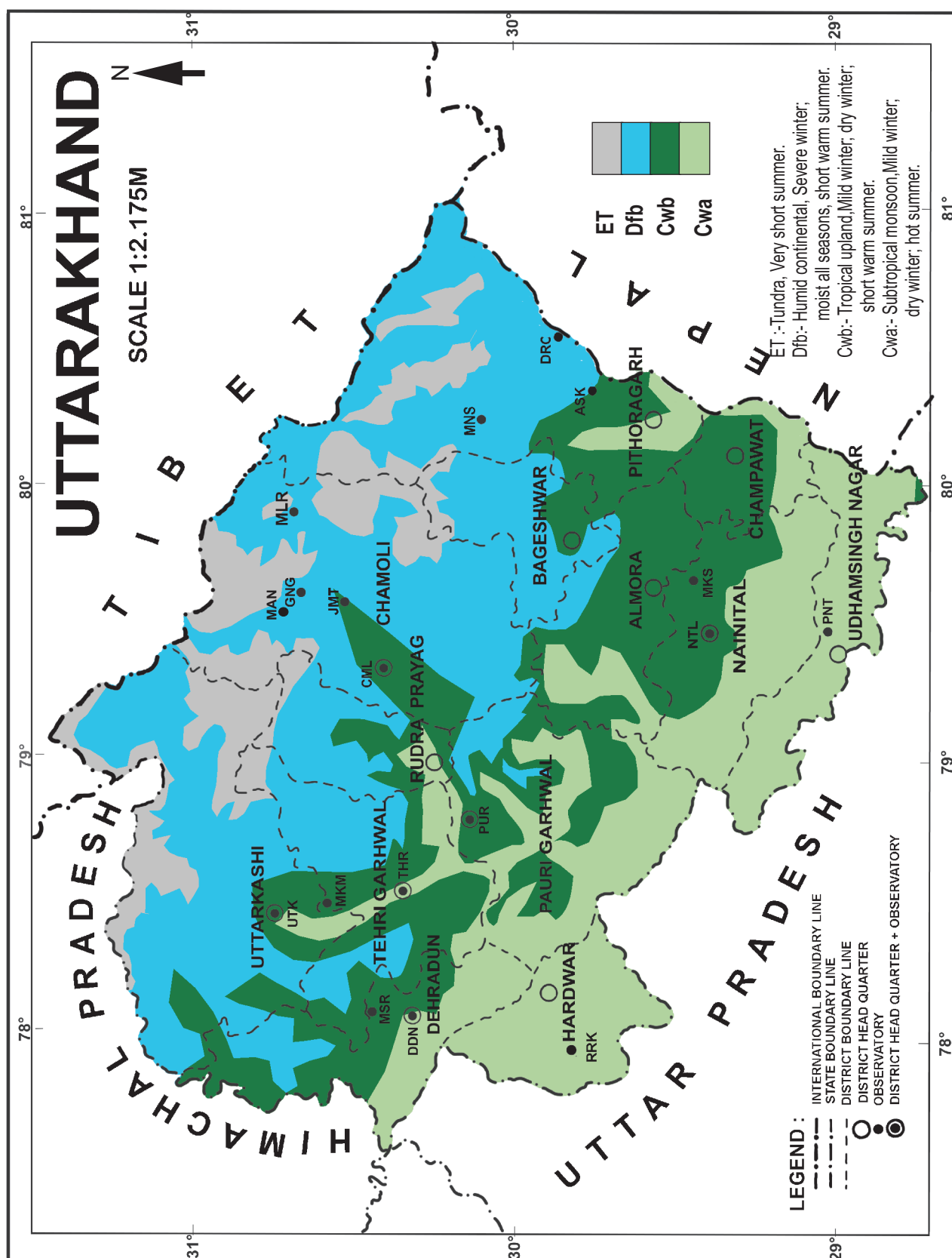


FIG: 2 : CLIMATIC CLASSIFICATION



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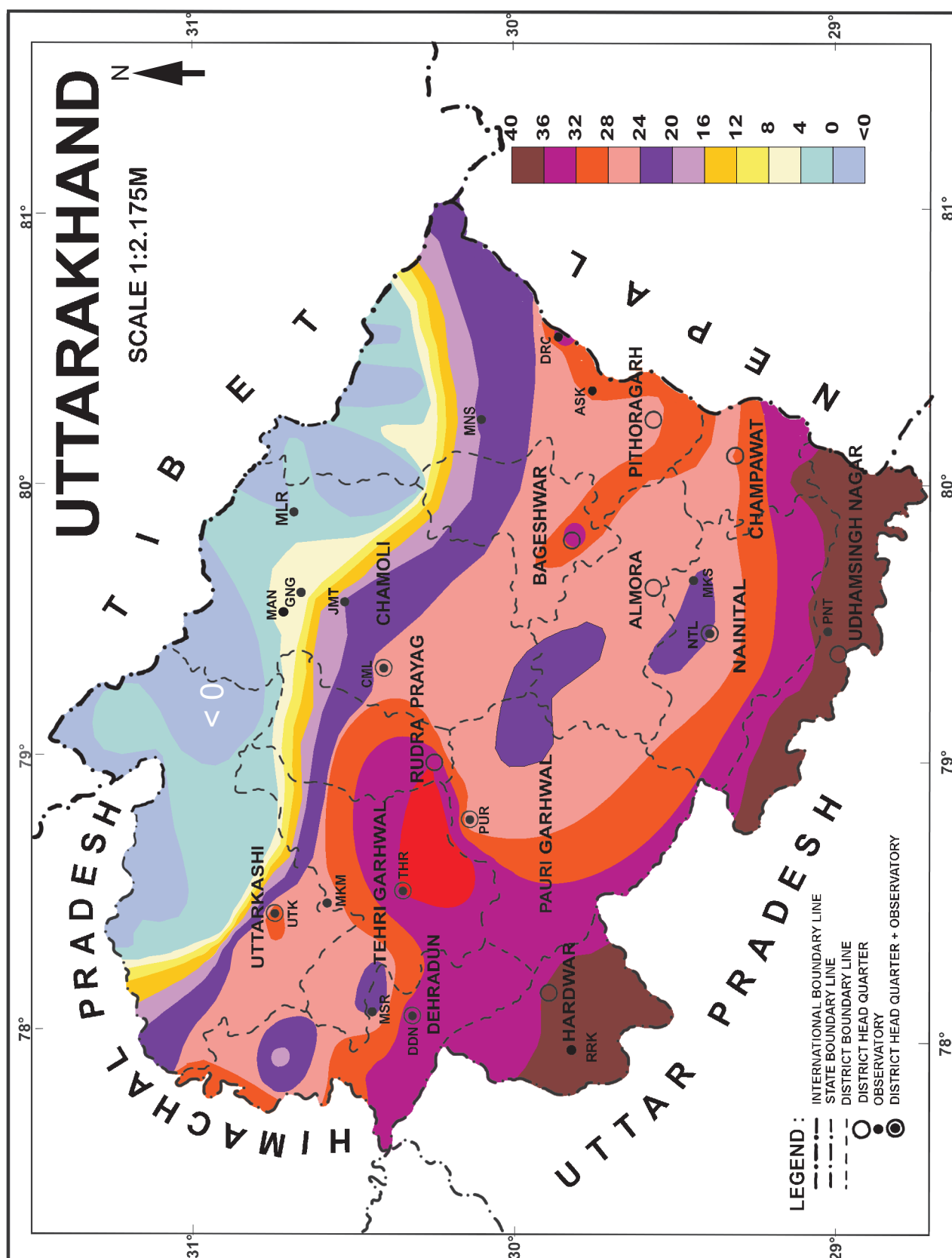
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FIG: 2(a) : MEAN MAXIMUM TEMPERATURE (°C) - MAY



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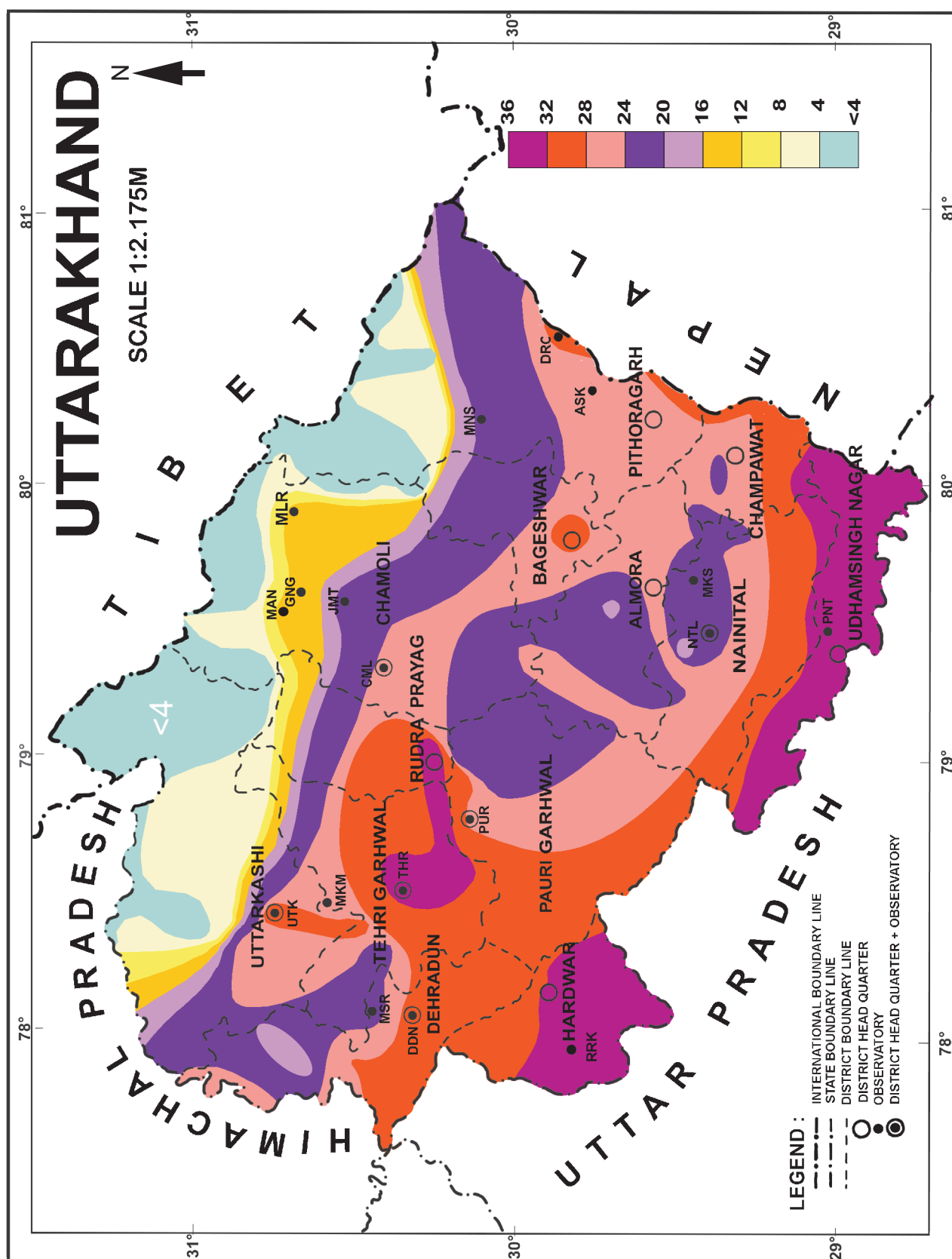
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FIG:2(b) :MEAN MAXIMUM TEMPERATURE (°C) -JULY



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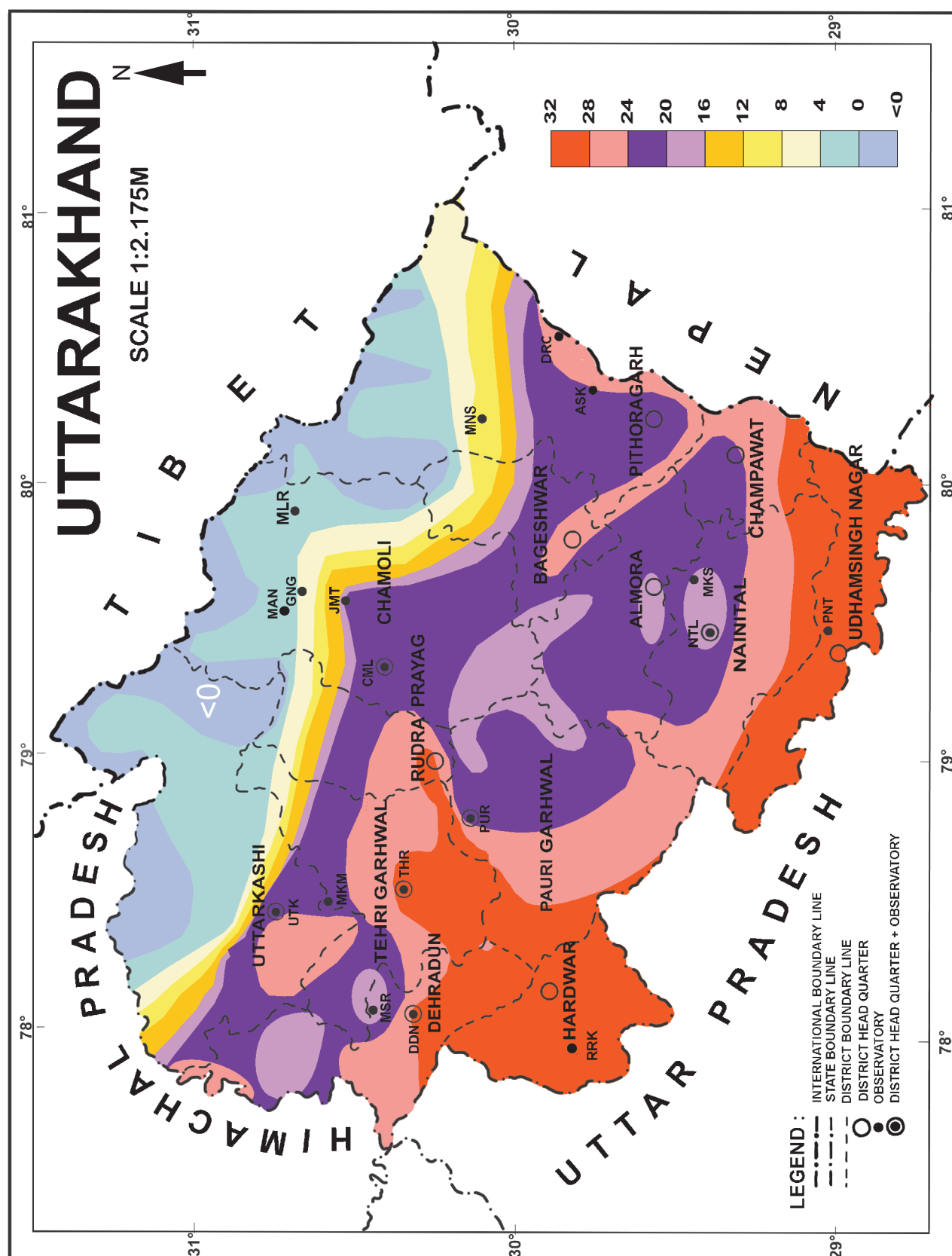
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FIG: 2(c) :MEAN MAXIMUM TEMPERATURE (°C) - OCTOBER



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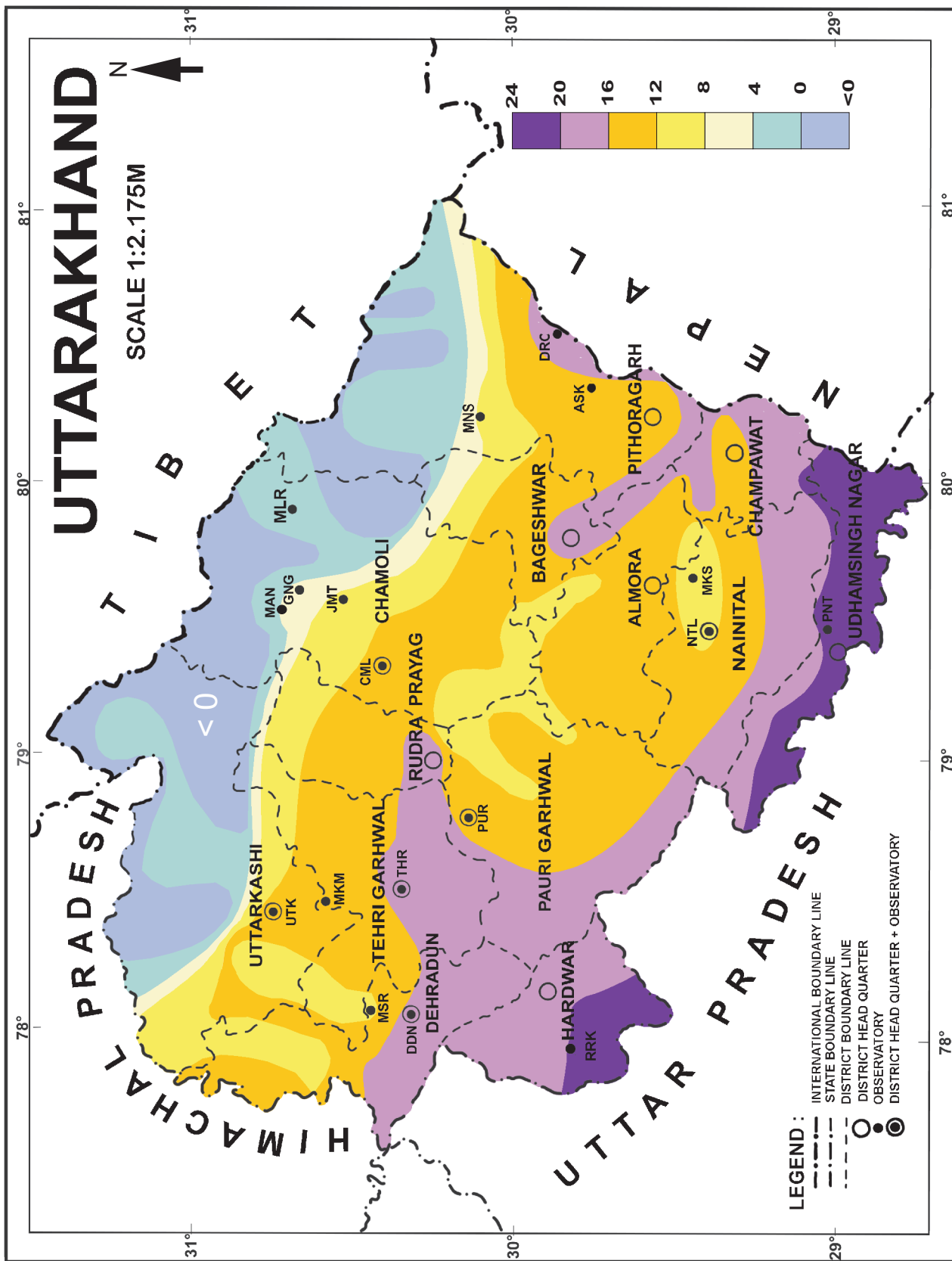
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FIG. 2(d) : MEAN MAXIMUM TEMPERATURE (°C) - JANUARY



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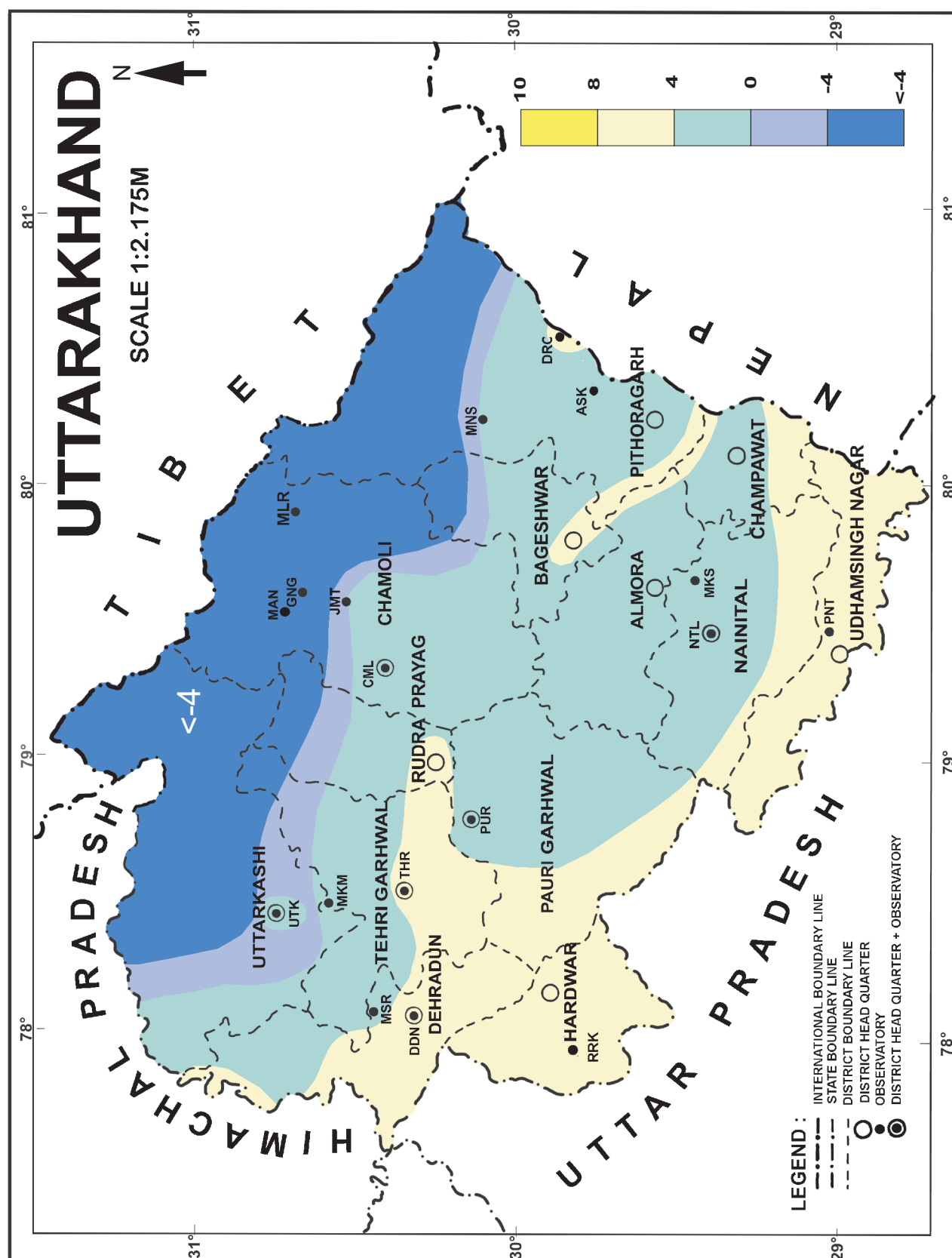
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FIG. 3(a) : MEAN MINIMUM TEMPERATURE (°C) - JANUARY



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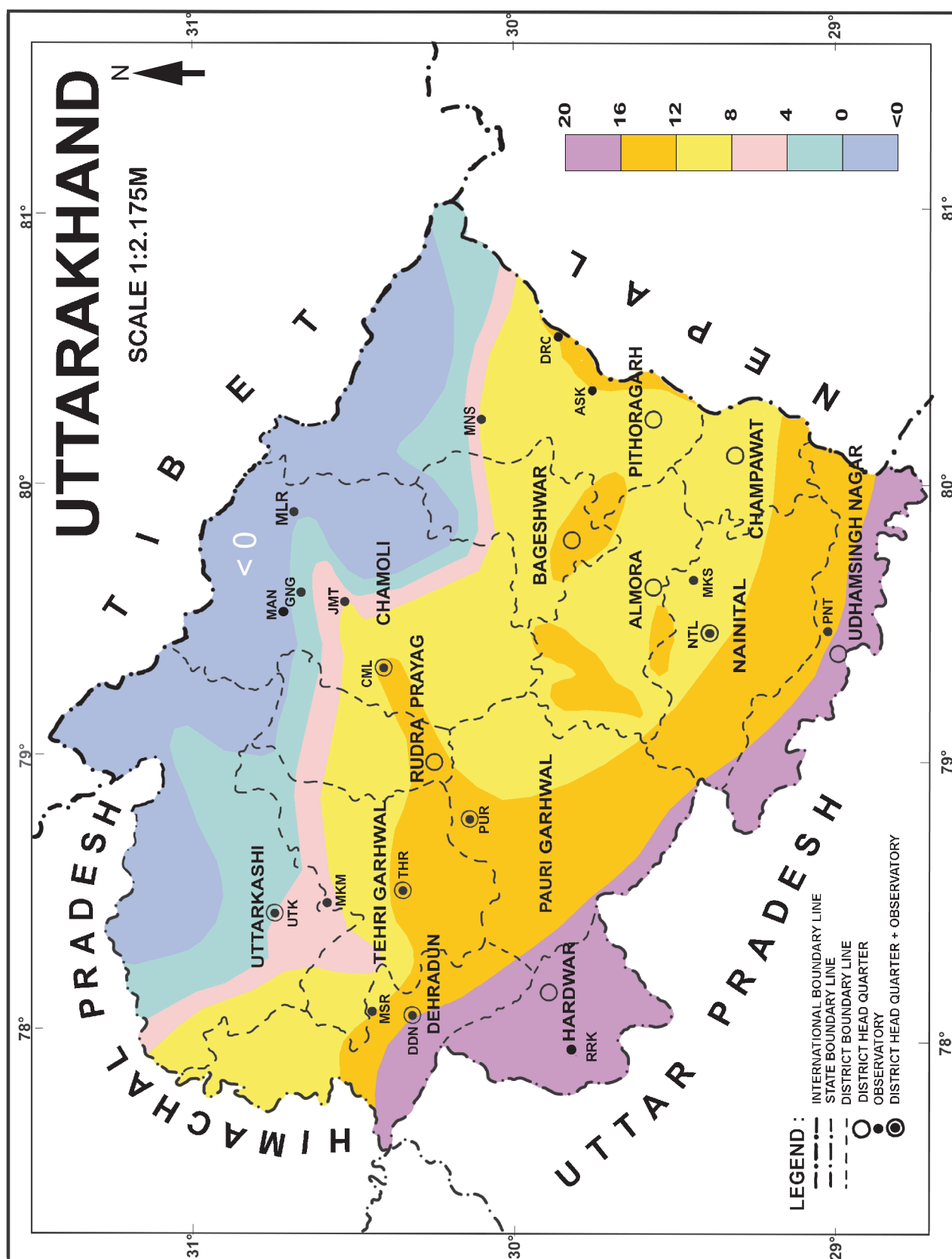
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FIG: 3(b) : MEAN MINIMUM TEMPERATURE (°C) - APRIL



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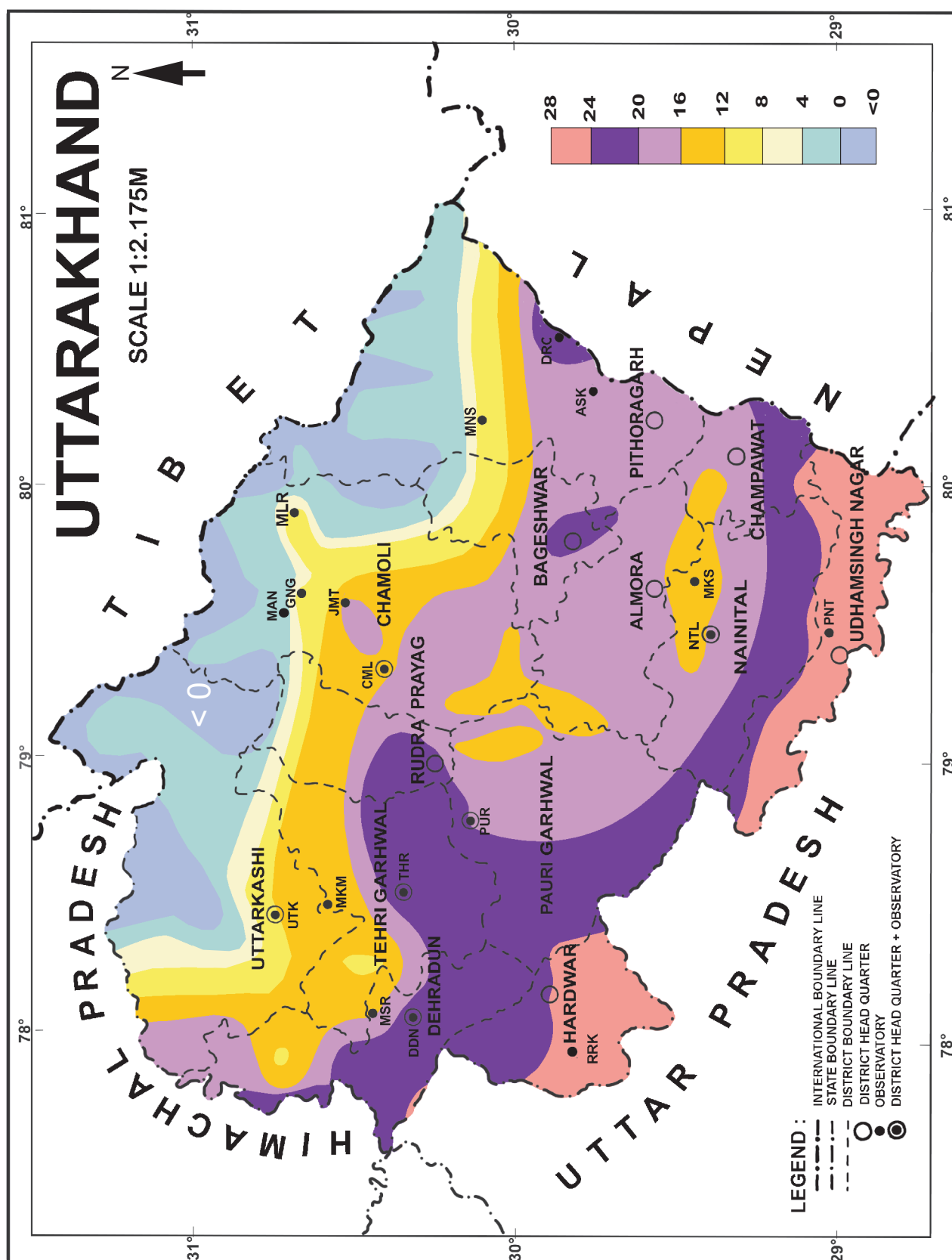
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FIG: 3(c) : MEAN MINIMUM TEMPERATURE (°C) - JULY



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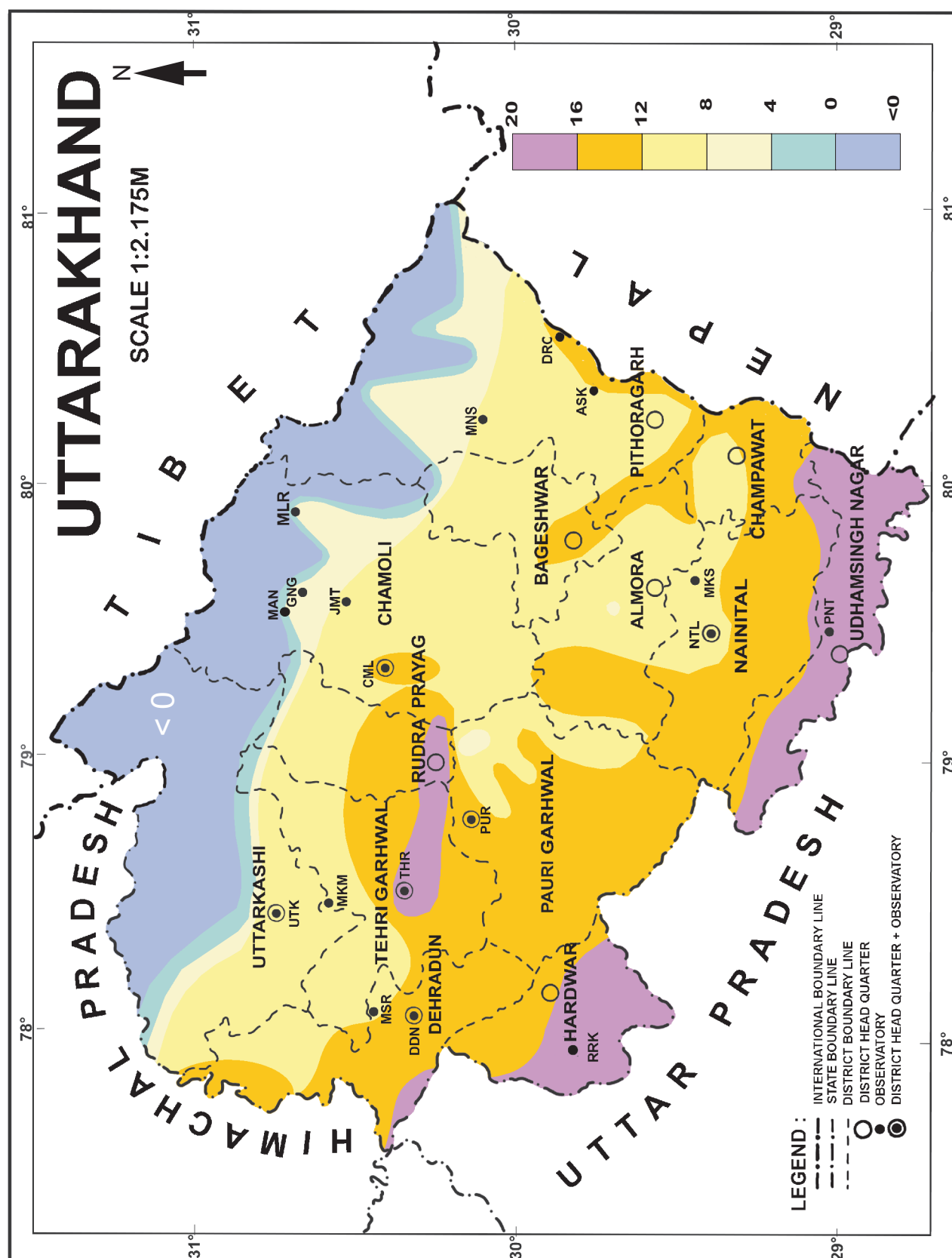
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FIG: 3(d) : MEAN MINIMUM TEMPERATURE (°C) - OCTOBER



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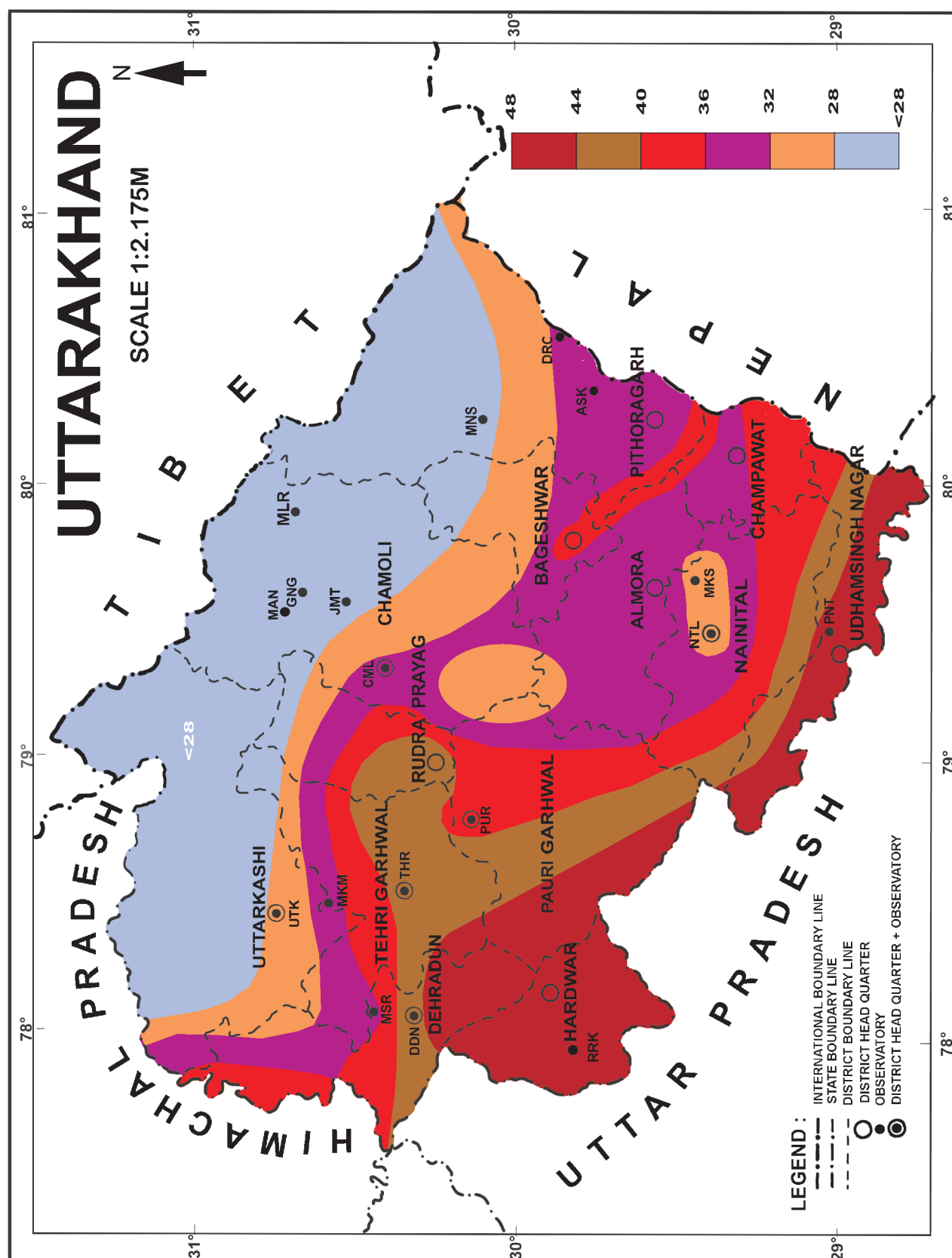
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FIG: 4 : HIGHEST MAXIMUM TEMPERATURE (°C) EVER RECORDED



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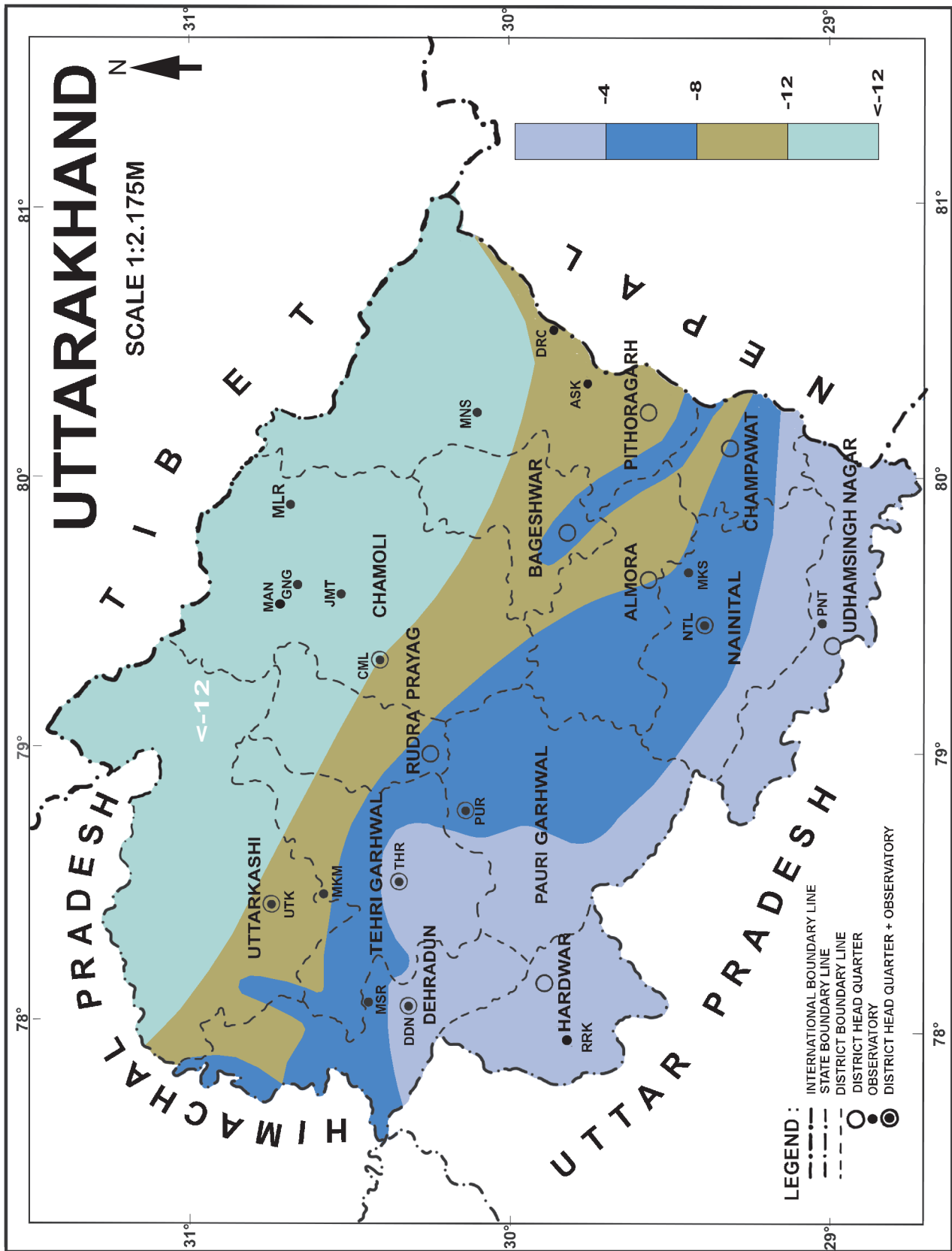
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FIG: 5 :LOWEST MINIMUM TEMPERATURE (°C) EVER RECORDED



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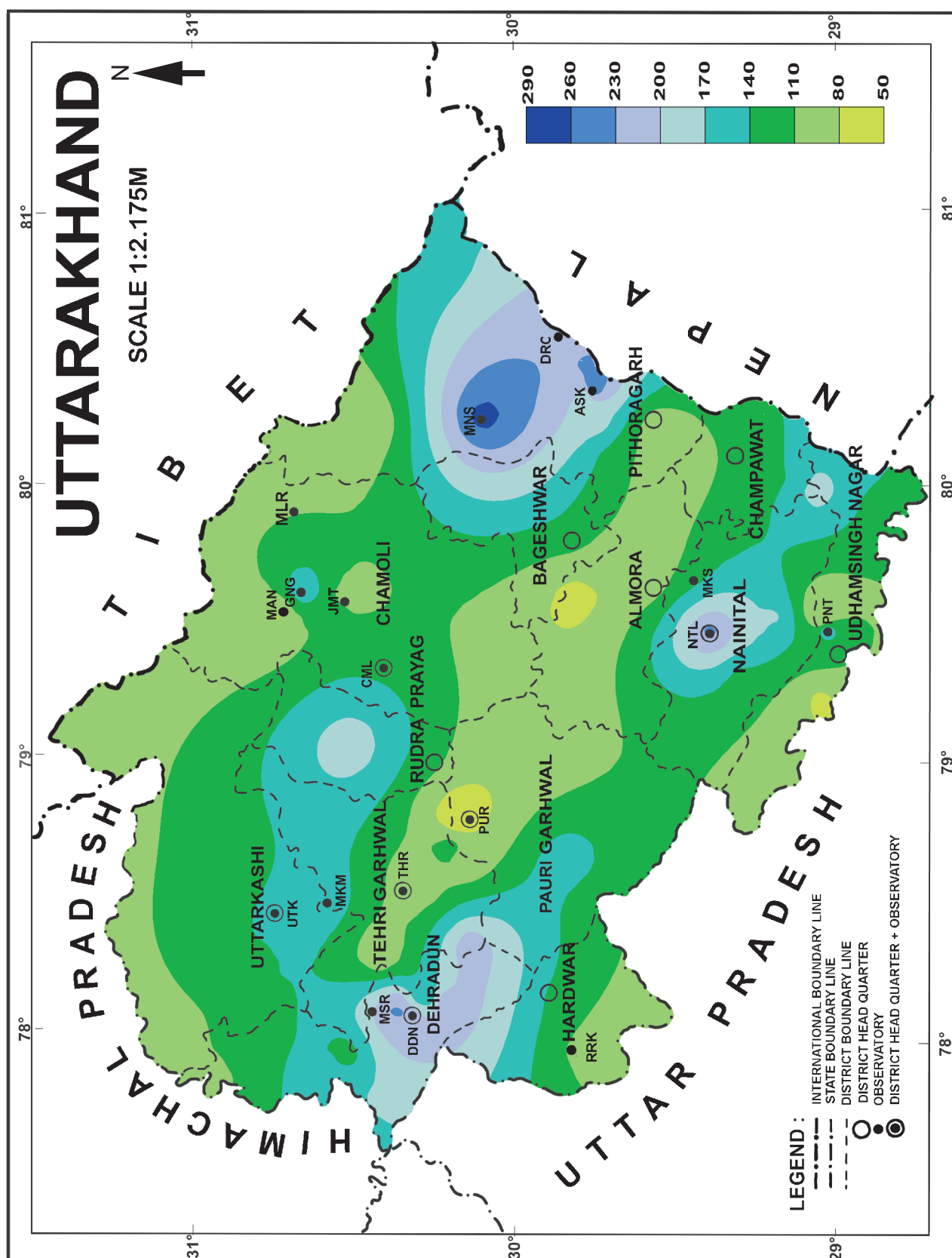
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FIG: 6 : ANNUAL NORMAL RAINFALL (cm)



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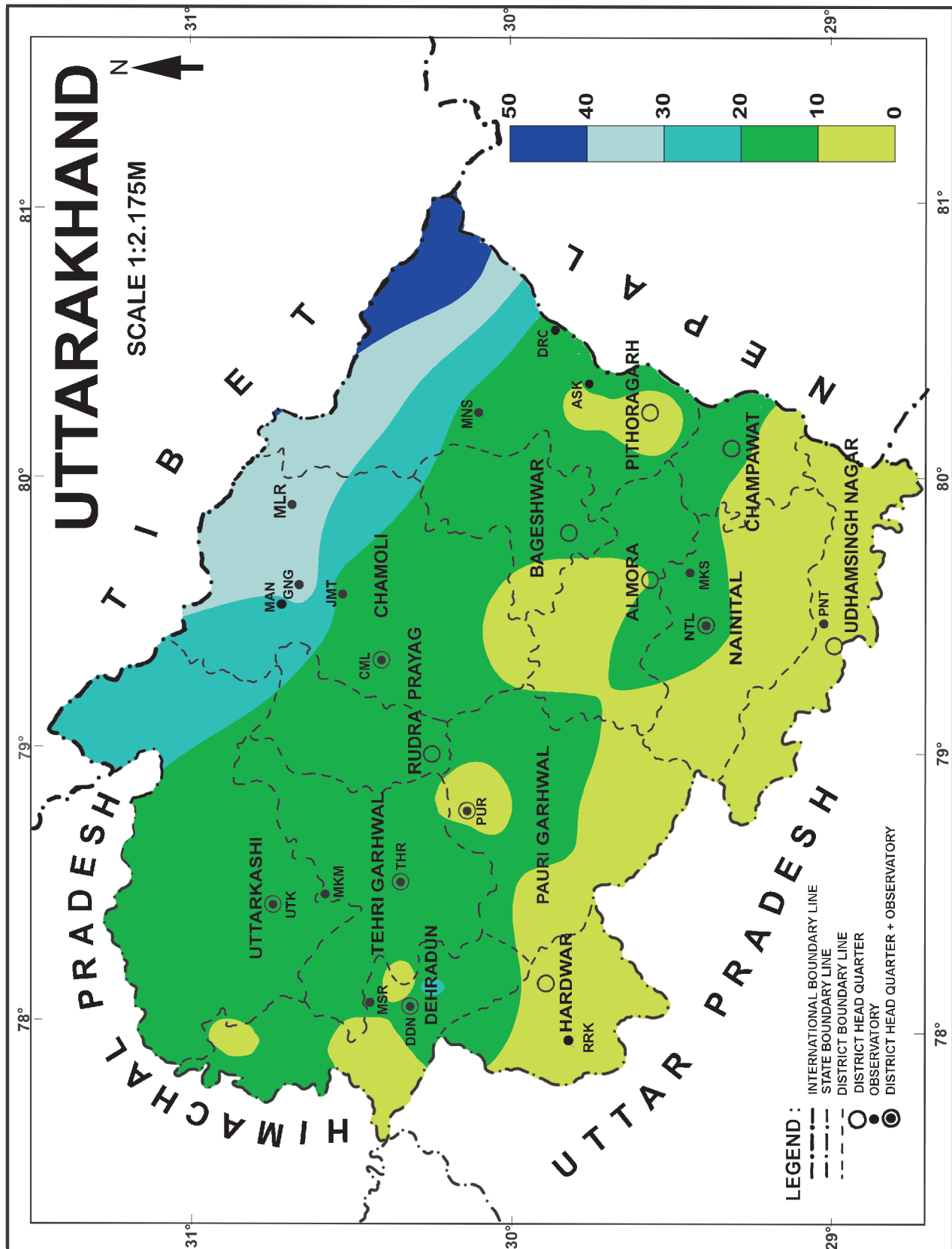
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FIG: 6(a) : SEASONAL RAINFALL (cm) - WINTER (COLD WEATHER) SEASON - DEC-JAN-FEB



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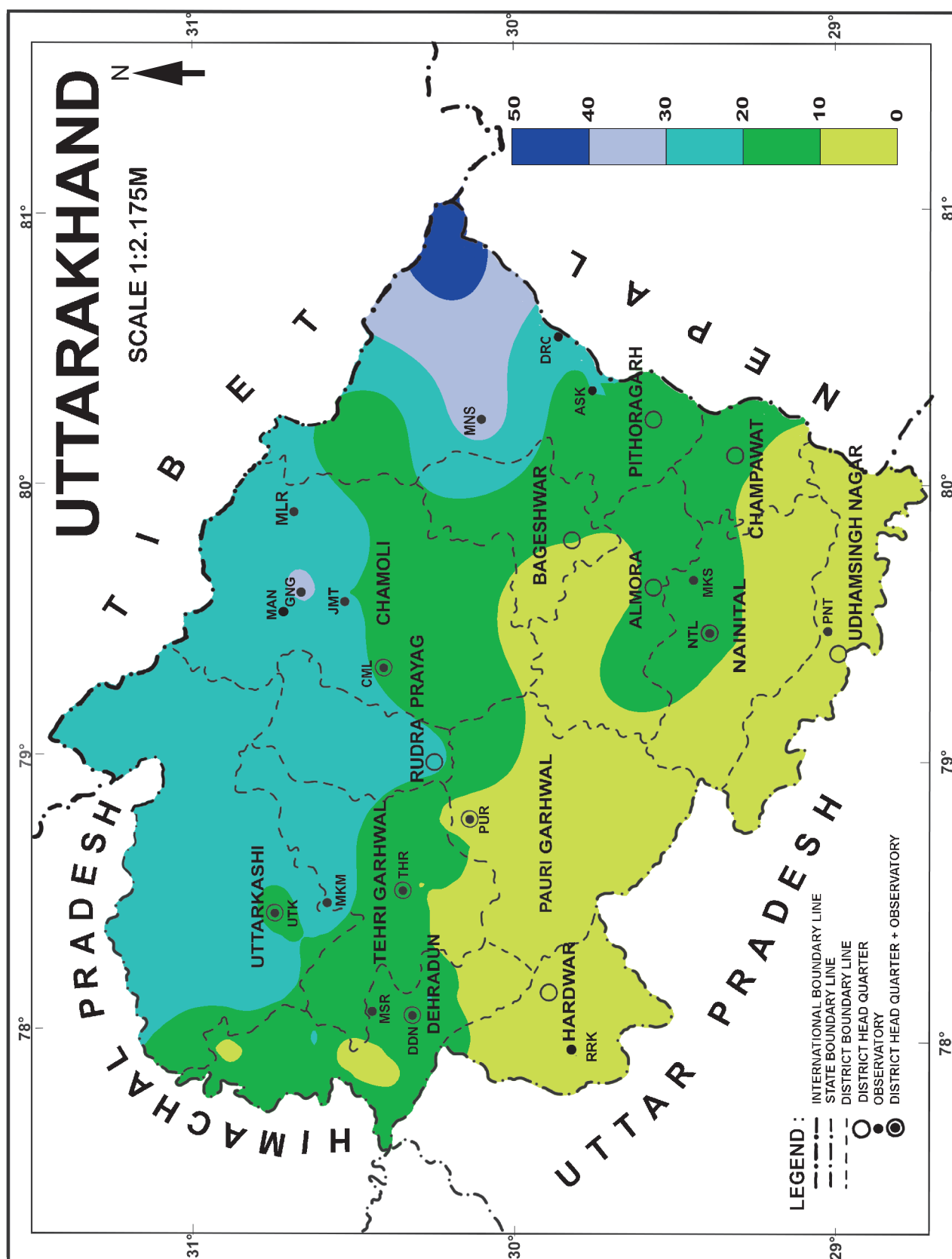
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FIG: 6(b) : SEASONAL RAINFALL (cm)- PRE-MONSOON (HOT WEATHER) SEASON-MARCH-MAY



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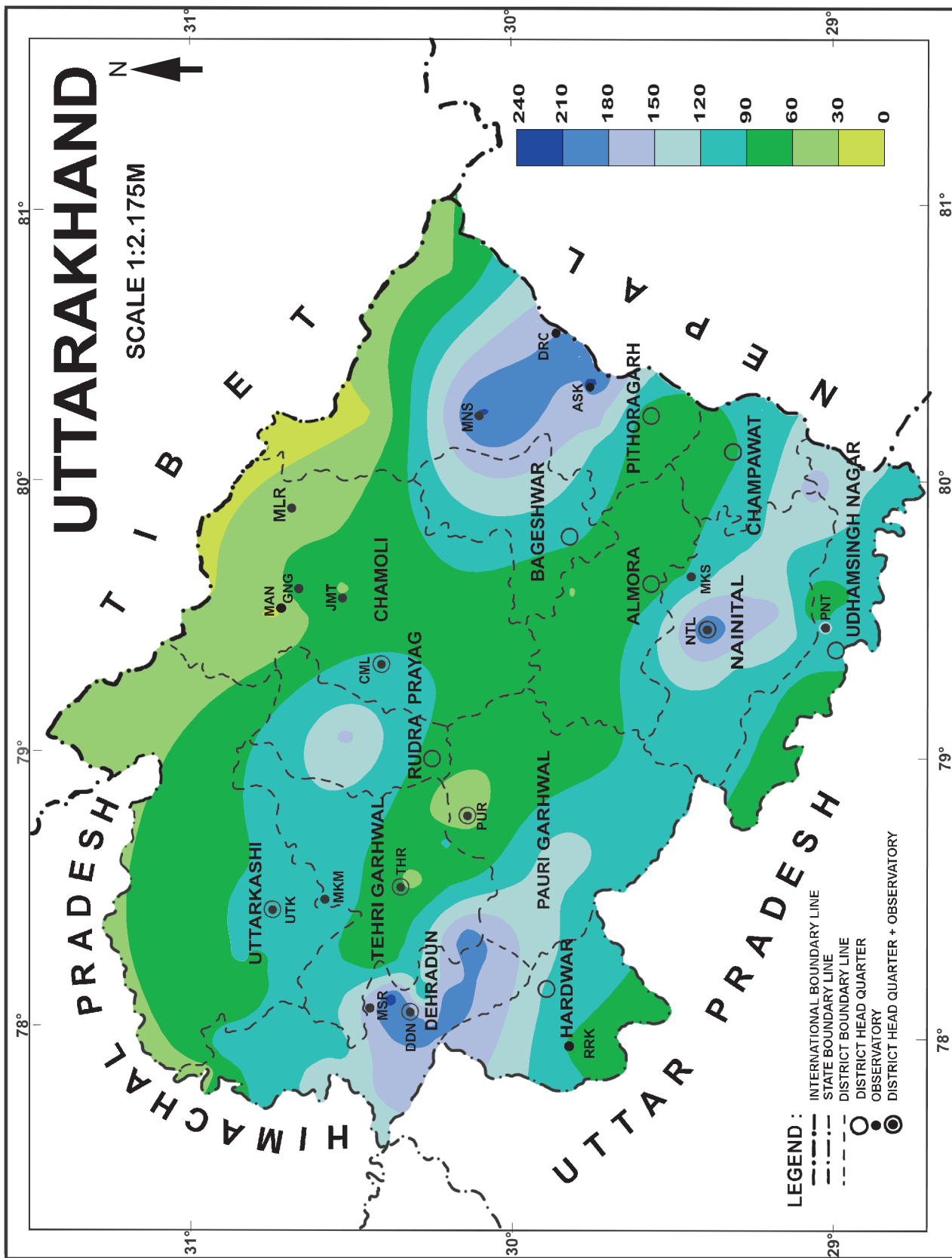
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FIG: 6(c) : SEASONAL RAINFALL (cm) - SOUTHWEST MONSOON SEASON - JUNE - SEPTEMBER



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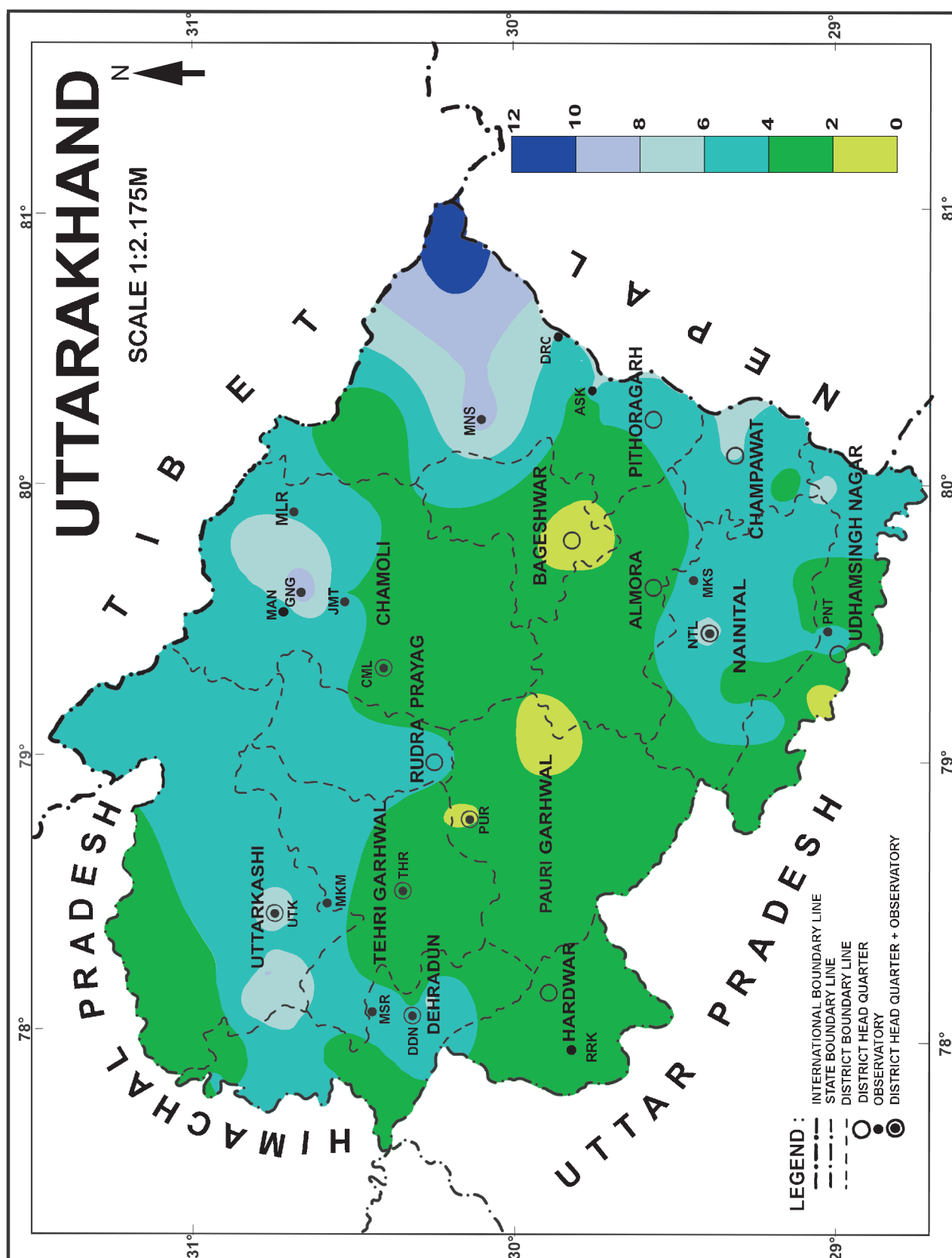
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FIG: 6(d) : SEASONAL RAINFALL (cm) - POST MONSOON SEASON - OCTOBER-NOVEMBER



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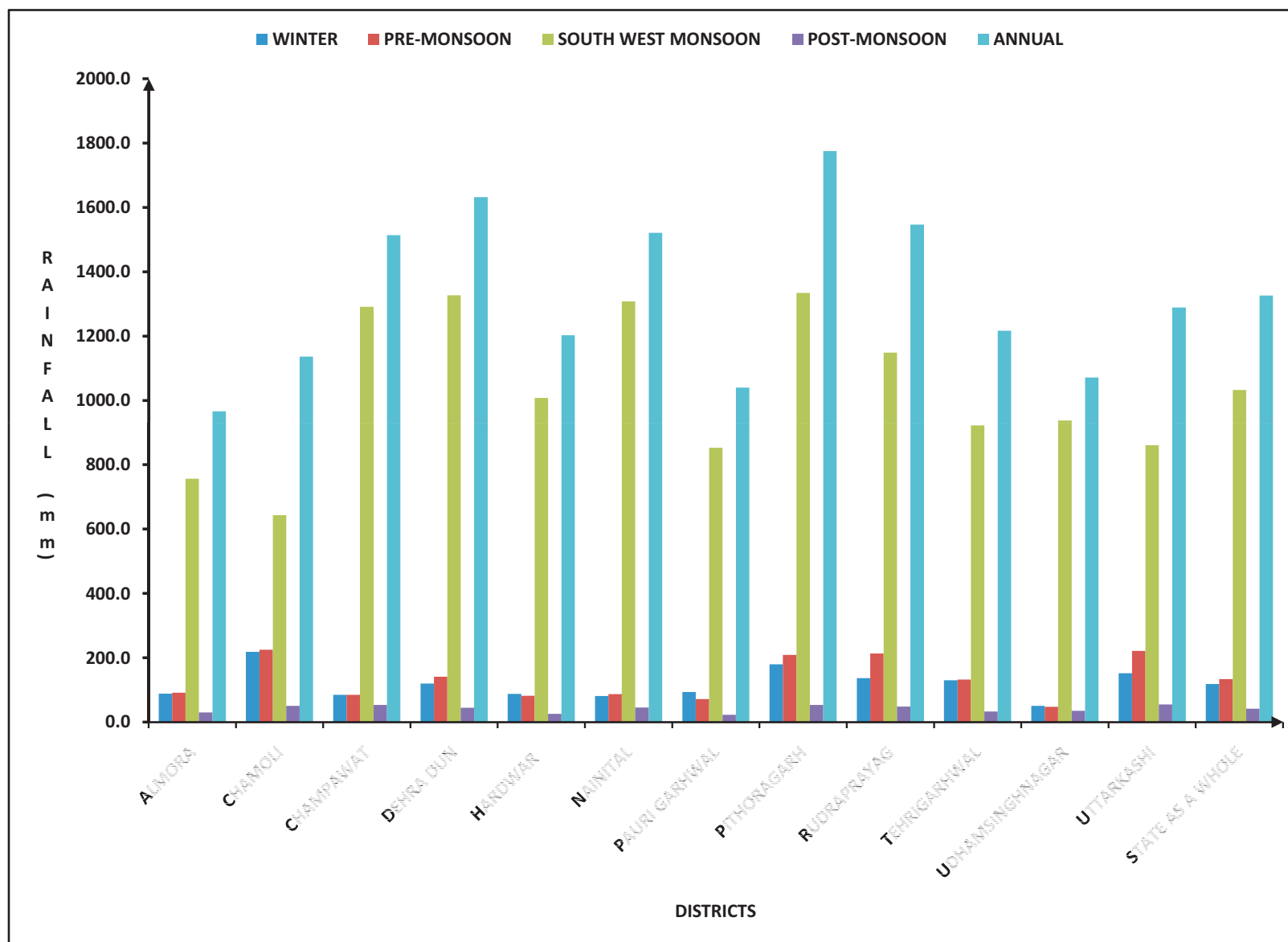
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**FIG: 7 : DISTRICT NORMALS OF SEASONAL AND ANNUAL RAINFALL (mm) (1961-2010)
UTTARAKHAND**



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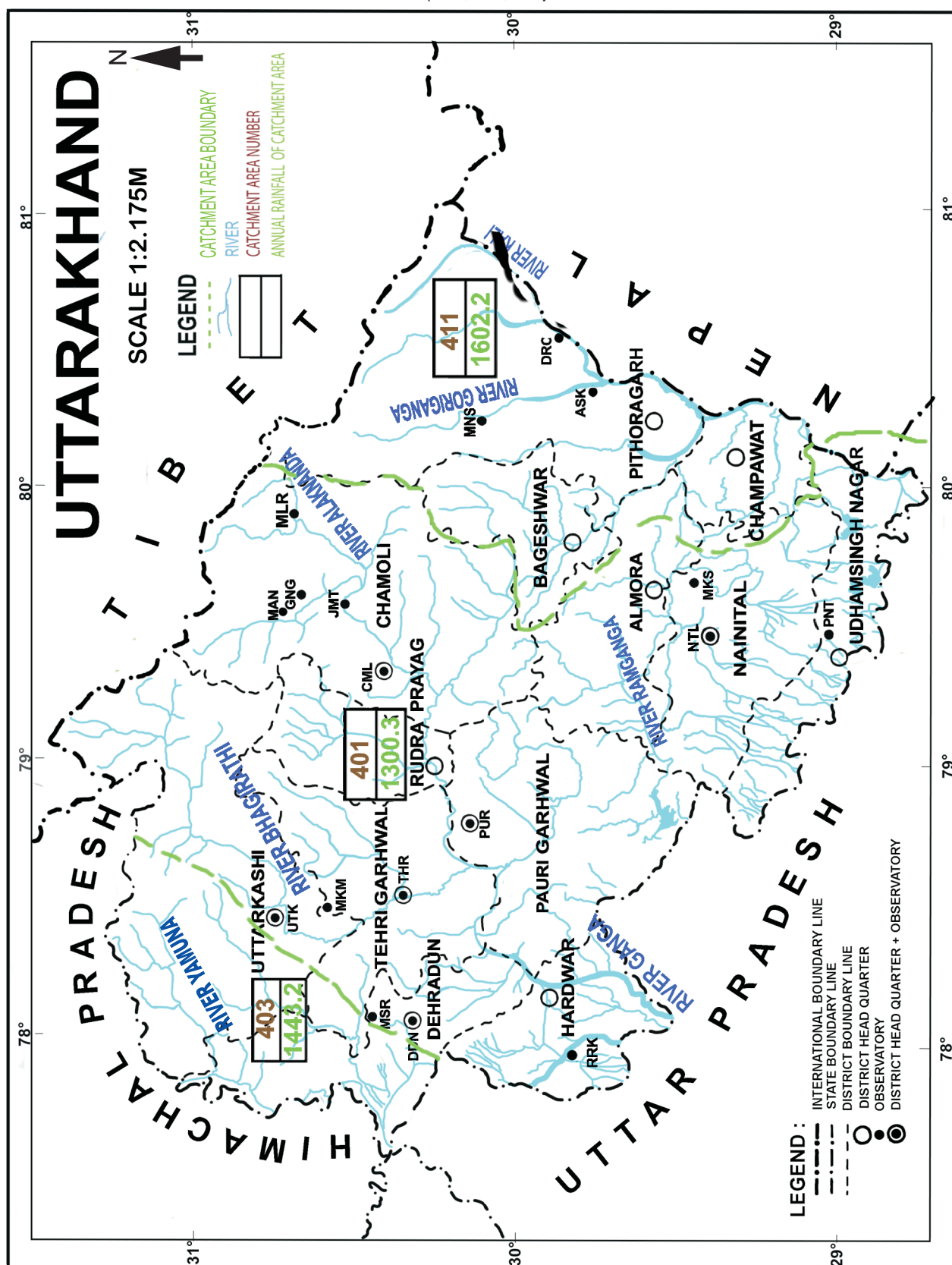
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FIG: 8 : CATCHMENT AREAS WITH ANNUAL RAINFALL (mm)
(401,403,411)



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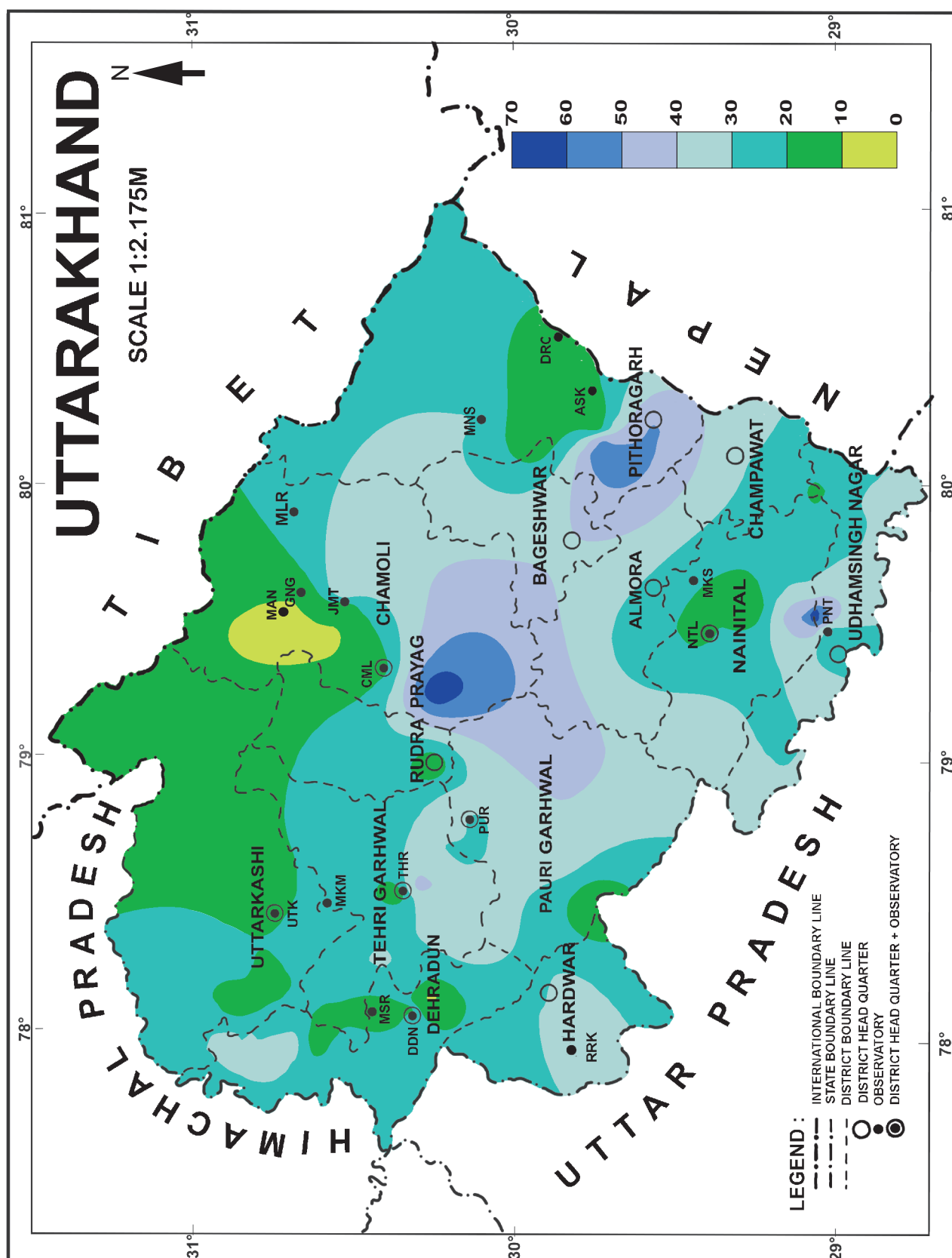
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FIG: 9 : COEFFICIENT OF RAINFALL VARIATION - ANNUAL



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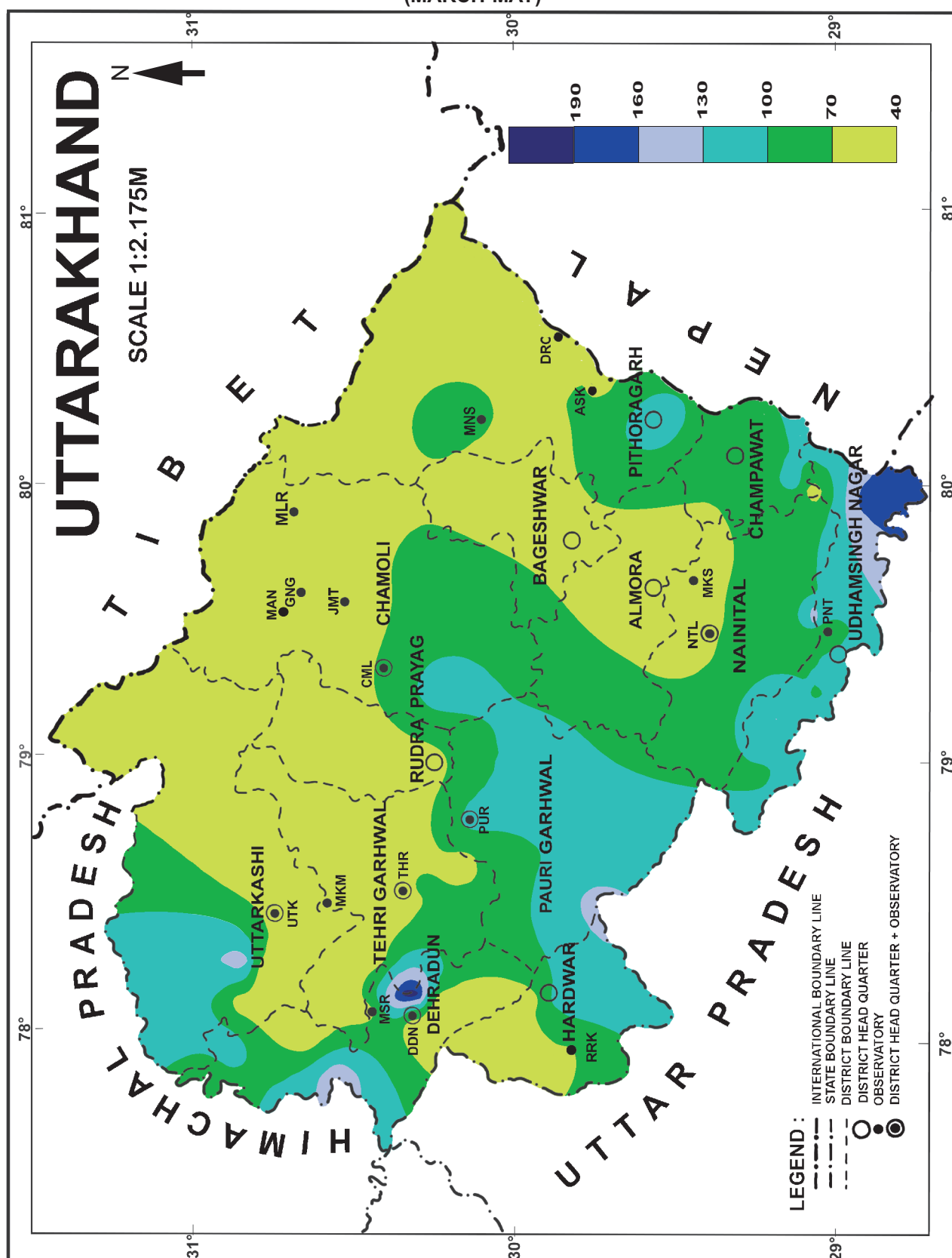
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FIG.9(a) : COEFFICIENT OF RAINFALL VARIATION PRE-MONSOON SEASON
(MARCH-MAY)



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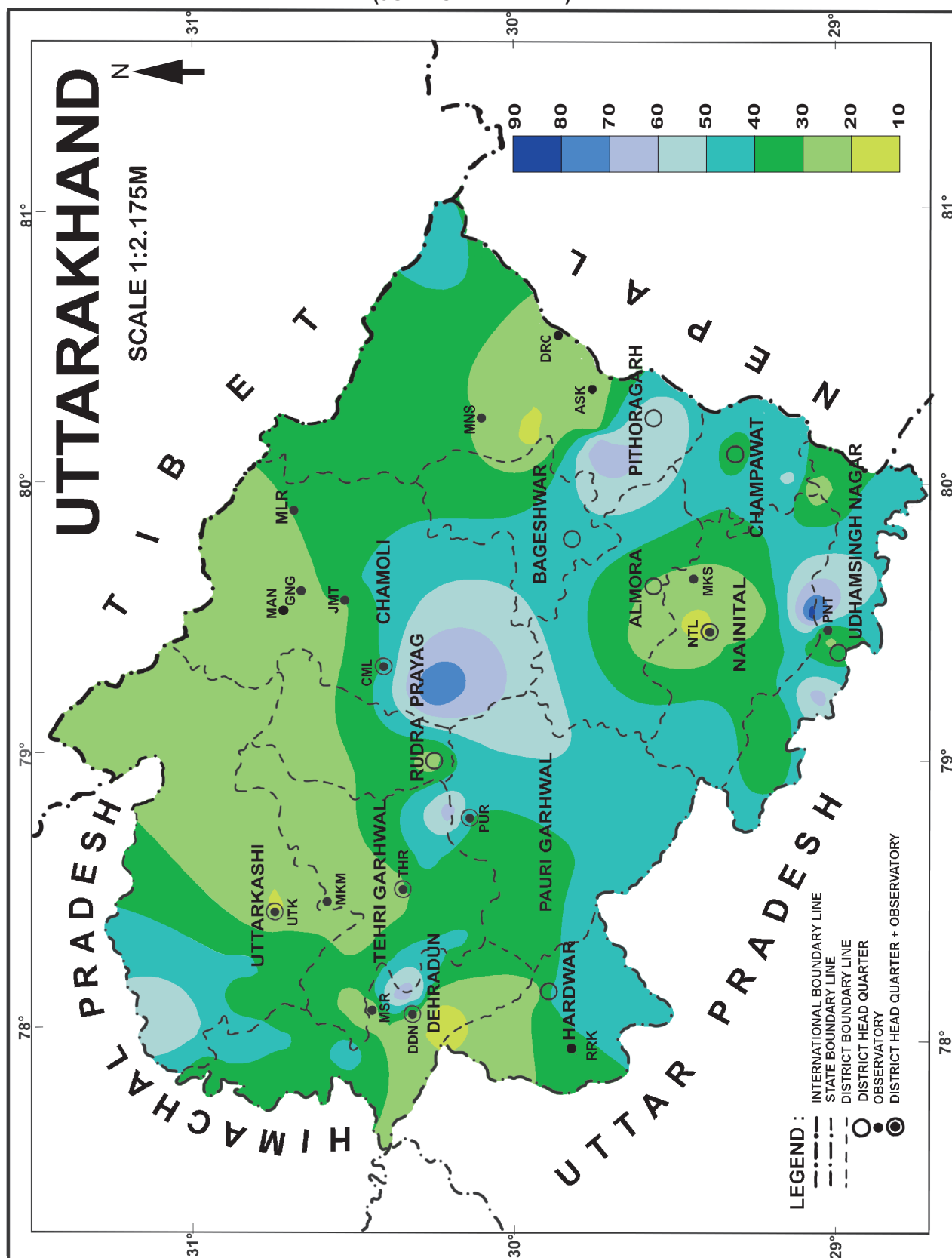
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FIG :9(b) :COEFFICIENT OF RAINFALL VARIATION - SOUTH WEST MONSOON SEASON
(JUNE-SEPTEMBER)



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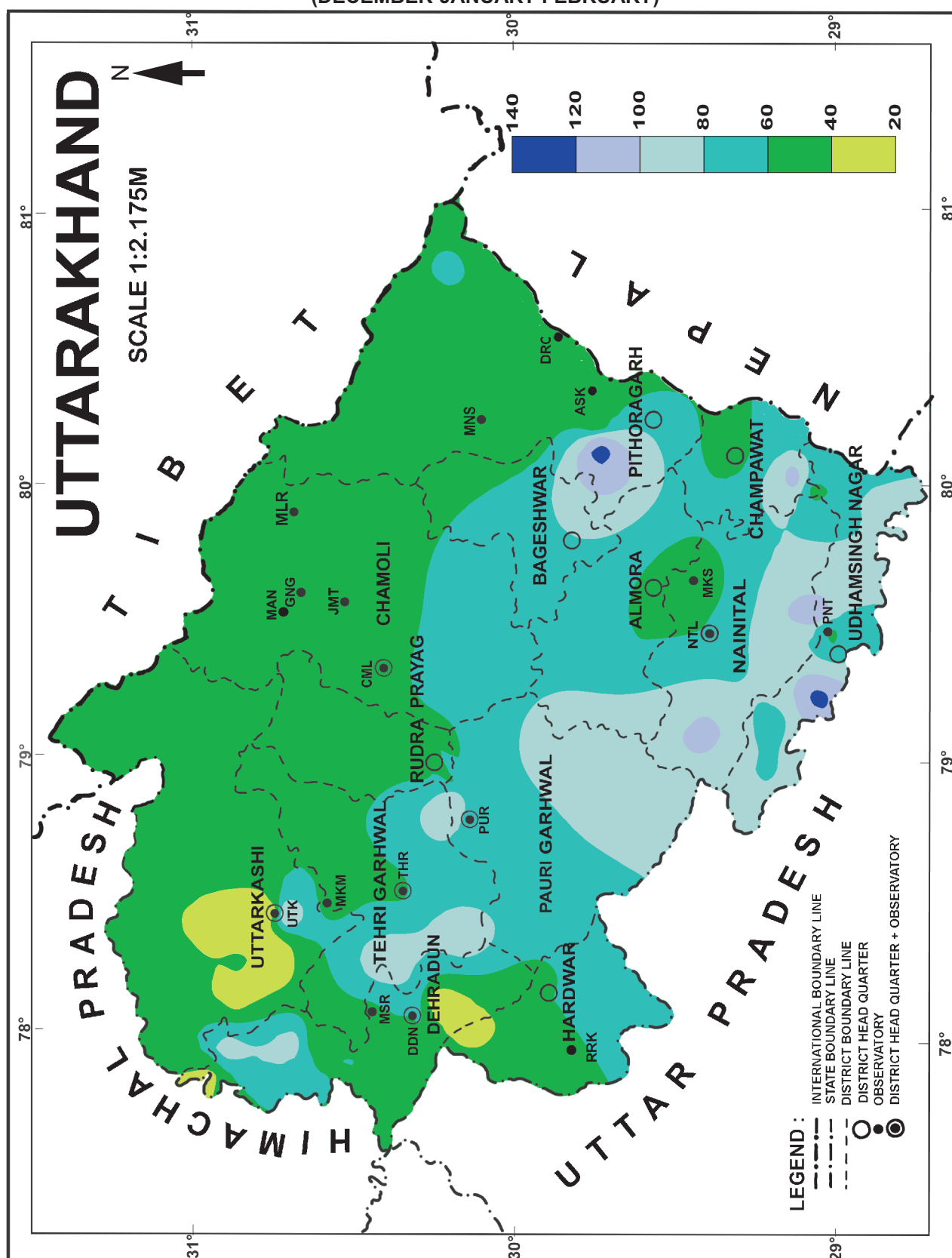
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FIG: 9(d) : COEFFICIENT OF RAINFALL VARIATION - WINTER SEASON
(DECEMBER-JANUARY-FEBRUARY)



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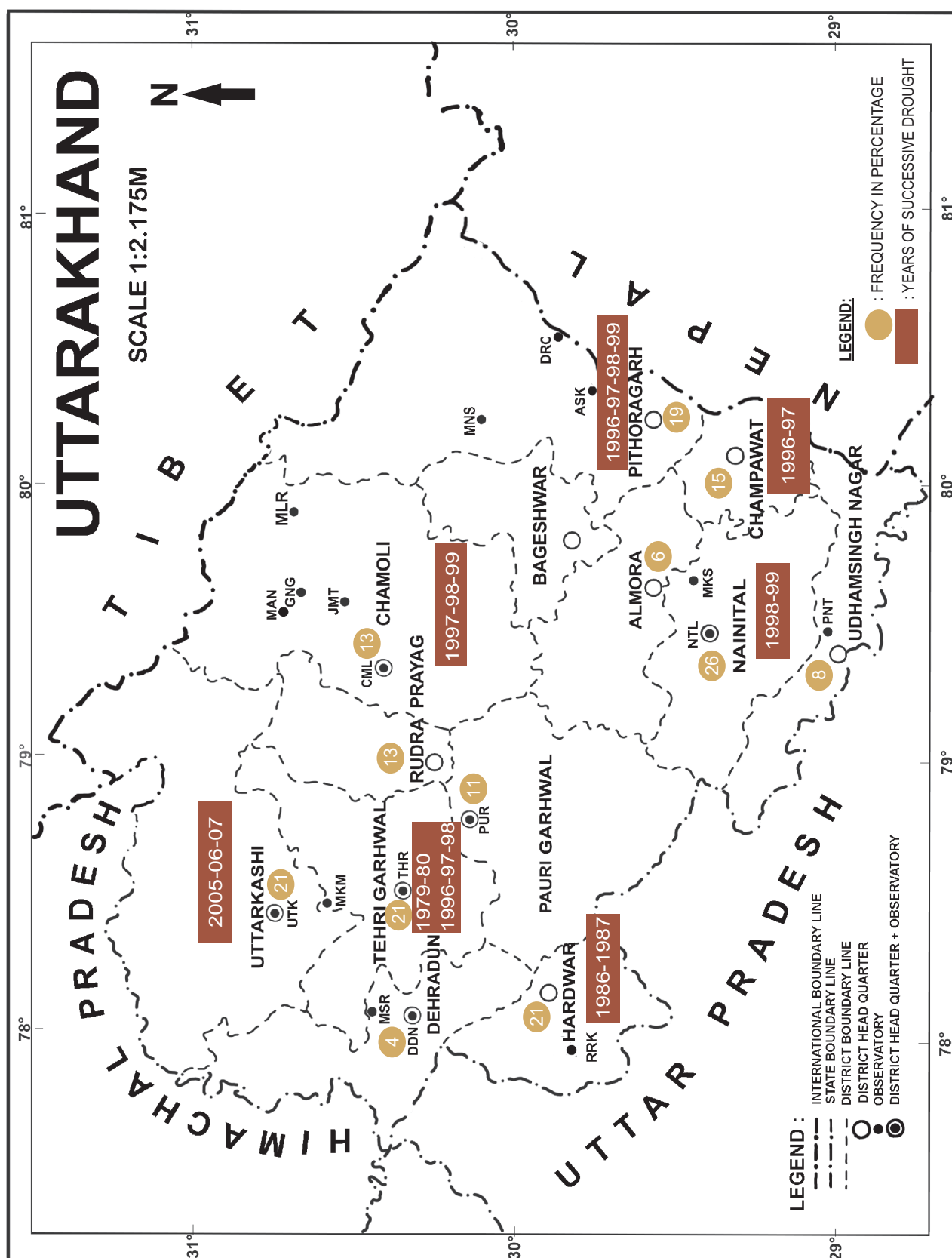
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FIG:10 :AREA AFFECTED BY DROUGHT (1961-2010)



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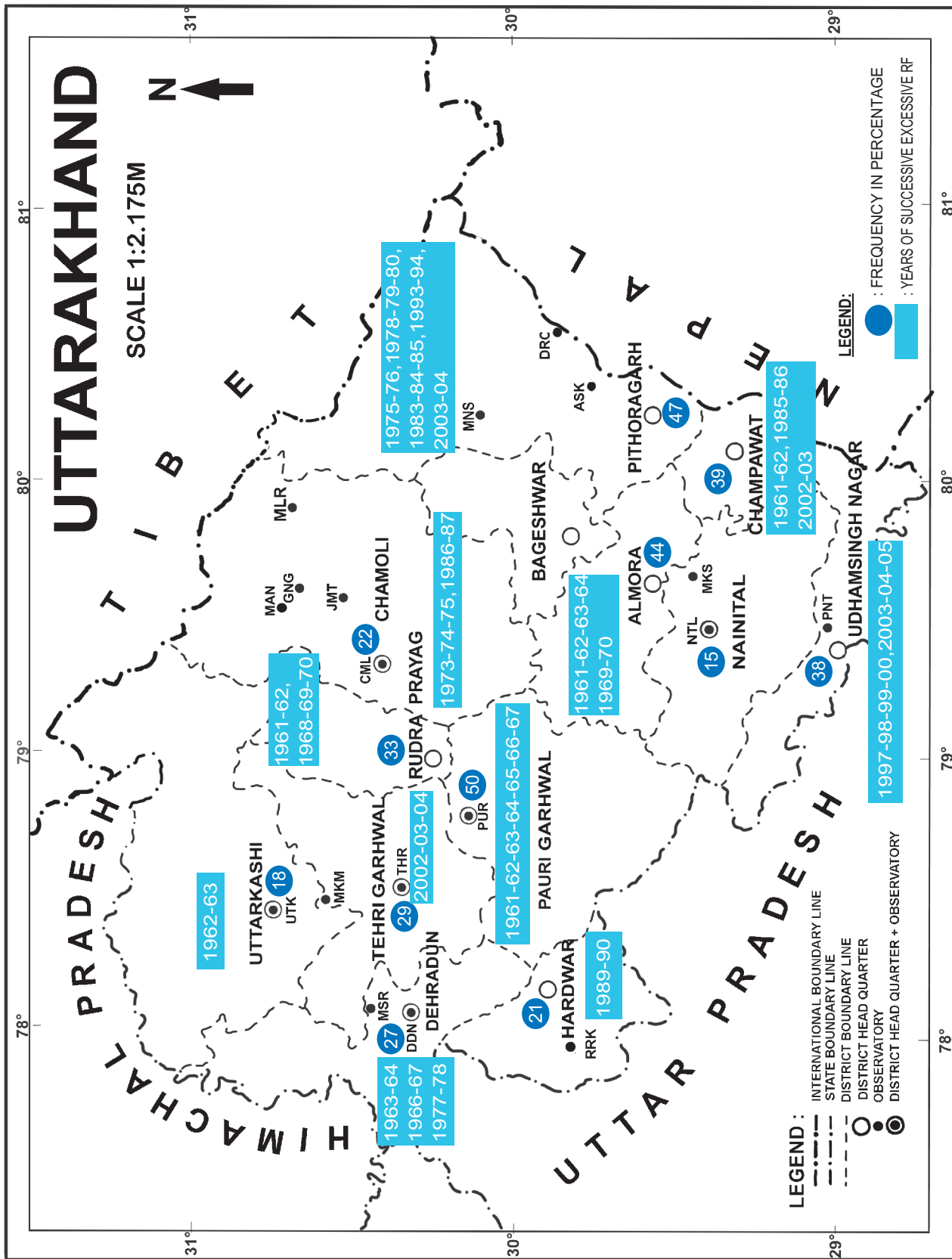
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FIG: 11 :AREA AFFECTED BY EXCESSIVE RAINFALL (1961 - 2010)



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STATE SUMMARY OF UTTARAKHAND

CLIMATE OF UTTARAKHAND

Introduction

Uttarakhand state is located between 28°43' - 31°27' N latitudes and 77°34' - 81°02' E longitudes in the northern part of India. The state is mostly hilly and has international boundary with China (Tibet) in the north and Nepal in the east and state boundary with Himachal Pradesh in the northwest. The state has foothills areas in the south and southwest which are bounded by Uttar Pradesh. Uttarakhand state has total geographical area of 53,485 sq. km, of which 86% is mountainous and 65% is covered by forest. The state is rich in natural resources especially water and forests with many glaciers, perennial rivers, dense forests and snow-capped mountain peaks. The most of the northern parts of state are part of greater Himalaya ranges covered by the high mountain peaks and glaciers. Two of India's mightiest rivers Ganga and Yamuna originate in the glaciers of Uttarakhand.

Uttarakhand lies on the south slope of Himalaya ranges and the climate varies from sub-tropical forests at lower elevation to glaciers at higher elevation. The altitude in the state varies from 200 to 7817 metre above mean sea level. Within this altitudinal variation state comprises five litho tectonically and physiographical distinct sub-divisions namely, Outer Himalaya comprising Tarai and Bhabhar, Sub-Himalayan belt of Siwalik, the Lesser Himalaya, the Great Himalaya and the Trans-Himalaya or Tethys. The highest elevations are covered by ice and snow. The upper Gangetic plains, moist deciduous forests and the drier Tarai savanna and grassland cover the low lands along the border of Uttar Pradesh. The physical features of the state are shown in Fig. 1. The inset Fig. 1(a) indicates its position in the country.

Important mountain peaks in northern part of Uttarakhand are Nanda Devi (7817 m), Mt. Kamet (7756 m), Abi Gamin (7355 m), Mana (7272 m), Mukut Parvat (7242 m), Hardeol (7151 m), Chaukhamba (7140 m), Trishul (7122 m), Dunagiri (7066 m), Kedarmath (6942 m), Gangotri (6674 m), Neelkanth (6597 m), Shivling (6501m), Nilgiri (6474 m),

Bandarpoonch (6320 m). Major Glaciers in Uttarakhand are Maiktoli, Kaphini, Ralam, Sunderdhunga, Chorbani, Gangotri, Khatling and Nandadevi.

Uttarakhand state has a large number of rivers as its northern part is a home of glaciers to melt the ice and flow the water. Hence, there are almost perennial rivers in the state. The state is mostly drained by Ganga, Yamuna, Bhagirathi, Alaknanda, Kosi, Mandakini, Kali, Gori-Ganga, Ramganga and Pindar rivers, and other major rivers with their tributaries.

Yamuna river: It rises from Yamunotri. Its main tributaries are Kamola, Tons and Alghar. Tons river flows along the border of Himachal Pradesh and Uttarakhand for considerable distance. Yamuna river and its tributaries drain western part of Uttarakhand i.e. parts of Dehradun and Uttarkashi districts.

Bhagirathi river: It originates from Gangotri glaciers and joins Alaknanda at Deoprayag to form main channel of Ganga river, so that geographically, Ganga river rises as Bhagirathi. The main tributaries of Bhagirathi river are Janhavi and Bhilangana. Bhagirathi river drains parts of Tehri Garhwal and Uttarkashi districts.

Alaknanda river: It rises from the snow at the confluence of the Satopanth and Bhagirath Kharak glaciers. It flows through Alaknanda valley and merges with Bhagirath river at Deoprayag. Mandakini, Nandakini and Pindar are main tributaries of Alaknanda river. This river drains the parts of Chamoli, Rudraprayag, Pauri Garhwal and Tehri Garhwal districts.

Ganga river: Bhagirathi and Alaknanda rivers meet at Deoprayag and form main channel of Ganga. The tributaries which join main channel of Ganga between Deoprayag and Hardwar, are Nayar, eastern Hiyuni, western Hiyuni, Song and Suswa. The main channel of Ganga river drains the parts of Tehri Garhwal, Dehradun, Pauri Garhwal and Hardwar districts before entering the plain of Bijnor district of Uttar Pradesh.

Pindar river: It emerges from the Pindari Glacier and flows into the Alaknanda river at Karanprayag. The river, in its initial course, flows through sedimentary rocks and further to the south. The Pindar river has cut a gorge in thick glacial deposits up to nearly 10 km, resulting in the formation of spacious glacial terraces spread on both sides of the gorge.

Further down from Phurkia up to Khati, places on route to the Pindari Glacier, there are numerous waterfalls, hanging valleys and tremendous rolls cliffs.

Kali or Kaliganga river: It originates from the Greater Himalayas at Kalapani in Pithoragarh district. It flows considerable distance along the Uttarakhand – Nepal border. It drains through of some parts of Pithoragarh, Almora, Bageshwar, Champawat and Udham Singh Nagar districts.

Ghori Ganga river: It originates from Milam Glacier in the Munsiyari tehsil of the Pithoragarh district. It is also fed by glaciers and streams flowing from the eastern slopes of the east wall of the Nanda Devi Sanctuary, and those flowing west from the high peaks of Panchchuli, Rajramba, and Chaudhara including the Ralam Gad and the Pyunsani Gadhera. The water from Kalabaland-Burfu Kalganga glacier also flows into the Ghori Ganga Valley from the east.

Ramganga river: It rises from Chorarkhal dhar in Gaisain block of Chamoli district. Its main tributaries are Mandal, Palain and Sona. It flows through parts of Chamoli, Almora, Nainital and Pauri Garhwal districts before entering the plain (Kalagarh) of Bijnor district of Uttar Pradesh.

Kosi river: It originates from Kausani in Almora district. Small tributaries and streams meet with this river. It flows through Almora, Nainital and Udham Singhnagar districts and joins Ramganga.

Mandakini river: It originates from Chorabadi glacier of Kedarnath. It flows in Rudraprayag district and joins with Alaknanda river.

The state has one meteorological sub-division- Uttarakhand and it has 13 districts viz: 1 .Almora 2. Bageshwar 3.Chamoli 4. Champawat 5. Dehradun 6. Hardwar 7. Nainital 8. Pauri Garhwal 9. Pithoragarh 10. Rudraprayag 11. Tehri Garhwal 12. Udham Singh Nagar 13. Uttarkashi

Climate

The climatic conditions experienced in Uttarakhand vary from hot and moist sub-tropical in the southern part to cold alpine in the upper reaches of the Himalayan mountain in the northern parts. Warm and cool temperate climate persists over the areas between southern and northern parts of the state. The climate at particular place in the state is influenced by (a) Altitude/ elevation (b) Latitude or location (c) Slope and topography. The climate of Uttarakhand is sharply demarcated in case of two distinct divisions the predominant hilly terrain and the smaller plain region. The areas of high hills even become inaccessible in winter due to extreme cold of climate causing prolonged snowfall. The mountain range itself exerts an appreciable extent of influence on monsoon and rainfall patterns. Cold alpine climate is experienced at higher reaches where summers are cool and winters are harsh. At altitudes over 4800 m, the climate is bitterly cold with temperatures consistently below the freezing point of water and the area is perennially shrouded in snow and ice.

In general the year may be divided into four seasons. The winter season from December to February is followed by pre-monsoon or hot weather season from March to May. June to September constitutes the southwest monsoon season and the period of October and November is of post monsoon season.

The state is divided into two regions viz. western part is known as Garhwal region and eastern part is Kumaun region. Garhwal region consists of Chamoli, Dehradun, Hardwar, Pauri Garhwal, Rudrapur, Tehri Garhwal and Uttarkashi districts. Kumaun region consists of Almora, Bageshwar, Champawat, Nainital, Pithoragarh and Udham Singh Nagar districts.

Areas in the state under each climate pattern based on Koppen's classification are shown in Fig. 2. This broad classification is based on annual and monthly means of precipitation in cm and temperature in °C.

Hardwar and Udham Singh Nagar districts and some parts of Nainital, Bageshwar, Champawat, Almora, Dehradun, Pithoragarh, Tehri Garhwal, Pauri Garhwal, Rudrapur

and Uttarkashi districts come under the climate type-subtropical monsoon, mild and dry winter, hot summer (Cwa). Some parts of Chamoli, Almora, Dehradun, Nainital, Uttarkashi, Pithoragarh, Rudraprayag, Bageshwar, Champawat , Pauri Garhwal and Tehri Garhwal districts come under the climate type- Tropical upland, mild winter, dry winter, short warm summer (Cwb)). High altitudinal areas of Almora, Bageshwar, Chamoli, Dehradun, Pauri Garhwal, Pithoragarh, Rudraprayag, Tehri Garhwal and Uttarkashi districts come under the climate type –Humid continental, severe winter, moist all season, short warm summer (Dfb).

High altitudinal areas (peaks) of Bageshwar, Chamoli, Pithoragarh, Rudraprayag, Tehri Garhwal and Uttarkashi districts come under the climate type –Tundra and very short summer (ET).

Sea Level Pressure and Winds

The seasonal variation in atmospheric pressure over the state occurs in a systematic way with a maximum in the winter and minimum in the southwest monsoon season. The pressure gradient over the state is generally weak except during latter part of summer and south west monsoon season. During winter season pressure is slightly high in northern as compared to southern part. Topography of the state with deep valleys and high ridges does not permit to analyse the variation of atmospheric pressure by usual way of drawing isobars over the state for particular season. Winds are generally variable as the state has mostly hilly terrain with lofty mountains and valleys. Owing to the nature of the terrain, local effects on winds are predominant. When the general prevailing winds are not too strong, there is a tendency for diurnal reversal of winds, blowing down the slopes at night (katabatic). With the progress of the monsoon, southeasterly, easterly and northerly components of the wind appear. October onwards, the changeover of the pressure to winter pattern commences but wind pattern slightly changes as sometimes northwesterly and westerly components are seen.

Winds are generally light of the order of 1 to 4 kmph in the valleys and 5 to 10 kmph at elevations of 2km increasing further with higher altitudes. In the wake of western disturbances and in association with thunderstorms the winds become quite strong.

Table I gives the monthly mean wind speed in kilometer per hour and predominant wind direction in the morning and evening for observatory stations in the state.

Temperature

Table II gives the mean maximum and minimum temperatures at the observatory stations of the sub-division. Fig. 2(a,b,c,d) and 3(a.b.c.d) show the distribution of mean maximum and mean minimum temperatures respectively for the selected months. Fig. 4 and 5 give the extremes of temperatures ever recorded on data up to 2010.

The state lies in the mountainous region except for some plain areas in the districts along the southern boundary of the state. The temperatures in the state therefore, vary considerably from place to place in the state accordingly elevation, location, slope and topography. The temperature starts to rise from March and steadily rises till it reaches its peak in May to the middle of June, when the mean maximum temperature in southern parts and valleys of the state is at about 34⁰C to 38⁰C and mean minimum temperature is at about 20⁰C to 24⁰C. At places at about 2 km altitude mean maximum and mean minimum temperatures are around 23 - 24⁰C and 15⁰C respectively. On individual days maximum temperature rises to 42⁰C in the valleys and southern part of the state and 30⁰C at stations at about 2 km elevation. The highest maximum temperature on record at any individual station was 47.4⁰C at Roorkee observatory on 22nd May 1978.

With the onset of southwest monsoon, the maximum temperatures fall by about 3⁰C to 4⁰C, while the minimum temperatures remain slightly more or same as in end of summer. With the withdrawal of monsoon by about the end of September, both day and night temperatures start to fall and reaching lowest in January and early February. January is the coldest month with mean maximum temperature in southern part and river valleys about 20⁰C and mean minimum temperature about 6⁰C. At places of 2 km elevation mean maximum and mean minimum temperatures are around 10⁰C to 12⁰C and 1⁰C to 3⁰C respectively. A much lower temperature is experienced in the wake of western disturbances during winter. On such occasions minimum temperature falls below the freezing point of water in southern part and less than -10⁰C at high elevated areas in northern part of the state. The lowest minimum temperature on record at any individual station was -15.1⁰C at Joshimath observatory on 15th January 1974.

Humidity

Table III gives the mean relative humidity at 0830 and 1730 hours IST for observatory stations in the state. Summer is generally the driest part of the year when relative humidity in the afternoons generally ranges between 30% and 45% and morning relative humidity ranges between 50% and 70% in southern part (Dehradun, Hardwar and Udham Singh Nagar districts). In these districts during southwest monsoon and winter seasons relative humidity ranges between 80% and 90% in the mornings and it is between 50% and 70% in the afternoons. Generally mornings are more humid than the afternoons for most of the observatories except Mukteshwar, Mussoorie, Nainital and Munsiri Milan where relative humidity is more in afternoons than the mornings.

Cloudiness

Table IV and IV (a) give the mean monthly and total cloud amount and mean number of days with clear and overcast skies at 0830 and 1730 hours IST respectively for observatory stations in the state.

There is cloudiness almost throughout the year. The skies are generally heavily clouded during July and August months. On an average for about 12 days in these months, the skies are heavily clouded. The period from October to November is generally lightly clouded and clear sky. In the rest of the year the skies are generally moderately clouded. Afternoons are however, more clouded than mornings.

Rainfall

Table V gives districtwise and statewise mean monthly and annual rainfall and number of rainy days (i.e. days with rainfall of 2.5 mm or more). Fig. 6 and 6(a) to 6(d) depict the spatial distribution of the annual and seasonal rainfall over the state.

The total annual rainfall for the state as a whole is about 133 cm and total annual number of rainy days are about 63 (Table V). The precipitation in the state occurs in the

form of rain and snow. Snowfall occurs mostly in winter months from December to February associated with western disturbances. January is the month with the heaviest snowfall. The rainfall in the state varies from place to place due to its rugged topography. Pithoragarh district in Kumaon division received the maximum amount of precipitation i.e. at about 177 cm in a year, whereas Almora district in Kumaon division received the minimum amount of precipitation i.e. at about 97 cm in a year.

It is seen from Fig. 6 that the rainfall generally increases in the valley regions towards the hills and decreases beyond the highest range (leeward side).

Fig. 6(a) and 6(b) show rainfall pattern during winter (December to February) and pre-monsoon season (March to May) respectively. The rainfall over the state increases from southwest towards the northeast region of the state during winter and pre-monsoon season. From Fig. 6(d) it is observed that during post monsoon season rainfall increases from west to east direction. From Fig. 6(c), it is observed that rainfall during the southwest monsoon season increases towards the southwest region. Maximum rainfall is observed in some part of easternmost region, some part of western region and some part of southern region. The pattern of spatial distribution of the rainfall during southwest monsoon season viz. Fig.6(c)) generally resembles to that of the spatial distribution of the annual rainfall (Fig. 6). The southwest monsoon season is the main rainy season over the state. Of the total amount of annual rainfall, about 78% is received in the southwest monsoon season (June to September), 9% is received in the winter season (December to February), 10% in pre-monsoon season (March to May) and 3% in post monsoon season (October to November).

The percentage of the seasonal number of rainy days with respect to the annual number of rainy days shows that 70% during the southwest monsoon season, 15% during the pre-monsoon season, 11 % during the winter season and 4% in post monsoon season.

The state receives rainfall mainly due to low pressure areas and monsoon depressions originating in the Bay of Bengal during the southwest monsoon season. During the monsoon season most of the depressions originating in the Bay of Bengal cross inland and move northwestwards or westwards over the state, some of them reach near the hilly districts. Sometimes heavy rain occurs with the interaction of the monsoon system and

extra-tropical system (western disturbances). In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hilly terrain causing floods in the rivers. The rest of the rainfall occurs in winter and early summer in association with the passage of western disturbances across north India. Winter precipitation over the northern parts of the districts is in form of snowfall. July and August are the rainiest months and in these two months nearly 53% of the annual rainfall is received. There are two rainfall minima observed in the state, one in April and other in November. After April, the rainfall gradually increases till June and thereafter sharply increases in July. It decreases rapidly after withdrawal of southwest monsoon from the last week of September. Precipitation during the pre-monsoon months is mostly associated with thunderstorms.

The southwest monsoon sets in over the state by the last week of June. The monsoon starts to withdraw from the state by about third week of September and completely withdraws by 1st October.

The features of rainfall described above are also evident from Fig. 7 which shows the annual and seasonal rainfall for the individual districts as well as for the state and provides a measure for comparison of seasonal rainfall with the annual for both district wise and state wise rainfall.

Table VI gives the monthly and annual rainfall for various river catchments (No. 401, 403 and 411) in the state. The annual rainfall of these river catchments is shown in Fig. 8. However, table VI shows the districts/parts of districts of Uttarakhand state covered by these catchments. Catchment No. 401 formed by Ganga up to and Ramganga river which covers Chamoli , Hardwar, Pauri Garhwal, Tehri Garhwal, Udhamasinghnagar and Rudraprayag districts, and some area of Almora, Dehradun, Nainital and Uttarkashi districts receives the annual rainfall of 1300.3 mm with 62 rainy days. Catchment No. 403 formed by river Yamuna up to its confluence with river Chambal (excluding Chambal) which covers the parts of districts Dehradun and Uttarkashi receives an annual rainfall of 1443.2 mm with 66 rainy days. Catchment No. 411 formed by river Gogra (including river Sarada) up to its confluence with river Ganga which covers the districts of Bageshwar,

Champawat, Pithoragarh and parts of Almora and Nainital districts receives an annual rainfall of 1602.2 mm with 75 rainy days.

Rainfall Variability

The spatial distribution of variation of annual rainfall over Uttarakhand is depicted in Fig. 9. Coefficient of Variation (CV) which is expressed as percentage is defined as:

$$C.V. = \frac{\text{Standard deviation } (\sigma)}{\text{Normal } (N)} \times 100$$

It is observed from Fig. 9 that values of CV of annual rainfall range between 8% and 70% over the entire state of Uttarakhand.

The spatial distribution of CV of seasonal rainfall over Uttarakhand is shown in Fig. 9(a), 9(b), 9(c) and 9(d) for the seasons: pre-monsoon season (March to May), southwest monsoon season (June to September), post monsoon season (October and November) and winter season (December to February) respectively.

During the pre-monsoon season it is observed that values of CV range between 40% and 200% (Fig. 9(a)). Extreme southeastern part and some portion in western part of the state exhibits the highest variability with values of CV ranging between 130% and 200%. Northern region and smaller portion of southwest region of the state exhibit the least variability with the values of CV less than 70%. The remaining portion of the state shows the CV values ranging between 70% and 130%.

During the southwest monsoon season it is observed that values of rainfall variability CV range between 15% and 90% (Fig. 9(b)). The rainfall variability is the highest in small part along Udham Singh Nagar and Nainital districts with values of CV ranging between 80% and 90%. Some part of Chamoli district in the central region and some part along the border of Udham Singh Nagar and Nainital districts in the southern region exhibit CV ranging between 60% and 80%. Large portion of northern region (some part of Uttarkashi, Rudra Prayag, Chamoli and Tehri Garhwal districts) and some parts of western region,

eastern region and southern region exhibit the least variability with the values of CV ranging from 10% to 30%. The remaining portion of the state shows range of CV values between 30% and 60%.

During the post monsoon season the values of CV range between 78% and 280% (Fig. 9(c)). The rainfall variability is the highest in small part of Udham Singh Nagar Champawat and Nainital districts with values of CV ranging between 250% and 280%. The southeastern portion of the state exhibits the variability with values of CV ranging between 160% and 250%. Northeast region of the state and small pockets in Tehri Garhwal and Dehradun districts exhibit the least variability with values of CV less than 100%. Remaining portion of the state shows range of CV values between 100% and 160%.

During the winter season the values of CV range between 20% and 140% (Fig. 9(d)). The smaller portion of southernmost Udham Singh Nagar and eastern Pithoragarh districts exhibits the highest variability with values of CV ranging from 100% to 140%. Some portion of Uttarkashi district in northwest sector and small portion of west sector exhibits the least variability with values of CV ranging between 20% and 40%. Remaining parts of the state exhibit the values of CV ranging from 40% to 100%.

The variability of annual rainfall over the state ranges between 8% and 70% (Fig. 9). As the variability of annual and southwest monsoon rainfall over the state is relatively low and the variability of rainfall during the other three seasons are very high with CV values exceeding 100% over some parts of the state, in general the contribution of southwest monsoon rainfall to the annual rainfall is a maximum over the state.

Droughts:

Meteorological drought over an area or a place may be defined as a situation when the annual rainfall over the area or place is less than 75% of the normal. It is classified as "Moderate drought" if the rainfall deficit is between 25% and 50% and "Severe drought" when it is more than 50%. Areas where frequency of drought as defined above is more than 20% of the years examined, such areas are classified as "drought areas" and areas having drought condition for more than 40% of the years under consideration represent "chronically

drought affected areas”. Nainital and Hardwar districts in the state experienced 10 and 6 years of drought respectively out of 39 and 28 years of consideration during the period 1961-2010, satisfying the criteria for “drought areas”.

Following districts of the state were affected by drought during the period 1961-2010. The details of year wise occurrence of drought over each district during the 50 year period (1961-2010) are given below. The figures within the brackets against each district indicate the number of occasions during the 50 year period when these districts were affected by drought.

Almora (1), Chamoli (4), Champawat (5), Dehradun (2), Hardwar (6), Nainital (10), Pauri Garhwal (2), Pithoragarh (7), Rudraprayag (3), Tehri Garhwal (7), Udham Singh Nagar (2) and Uttarkashi (7).

Occurrence of drought conditions in successive years is not frequent in the state. However, individual district have had successive years of drought. Severity of drought not only depends upon the order of the rainfall deficiency in a single year, but also on the continued occurrence of deficient rain in successive years, even though the deficiency in each successive year may not be as high as in a single year.

The following table (i) depicts district wise years of successive drought during the period under consideration 50 year period 1961-2010.

Table (i)

S.No.	Name of districts affected	Years of drought	Years of successive drought
1	Almora	1997	NIL.
2	Chamoli	1964, 1997, 1998, 1999.	1997 - 1998 - 1999.
3	Champawat	1970, 1972, 1989, 1996, 1997.	1996 - 1997.
4	Dehra Dun	1991, 2009.	NIL.
5	Hardwar	1968, 1979, 1986, 1987, 2004, 2006.	1986 - 1987.
6	Nainital	1974, 1979, 1991, 1994, 1996, 1998, 1999, 2001, 2004, 2006.	1998 - 1999.

Table (i)

S.No.	Name of districts affected	Years of drought	Years of successive drought
7	Pauri Garhwal	1972, 1997.	NIL.
8	Pithoragarh	1972, 1989, 1991, 1996, 1997, 1998, 1999.	1996 - 1997 - 1998 - 1999.
9	Rudraprayag	1977, 2002, 2007.	NIL.
10	Tehri Garhwal	1972, 1974, 1979, 1980, 1996, 1997, 1998.	1979 - 1980, 1996 - 1997 - 1998.
11	Udham Singh Nagar	1965, 1991.	NIL.
12	Uttarkashi	1976, 1984, 1991, 2005, 2006, 2007, 2009.	2005 - 2006 - 2007.

Fig. 10 shows the percentage frequency of drought and years of successive drought in the districts during the period 1961-2010.

The following table (ii) shows the years of severe drought for various districts, with the actual rainfall expressed as percentage of normal rainfall given in brackets, against each district.

Table (ii)

S.No.	Name of Districts Affected	Years of severe drought
1	Chamoli	1997, 1998 (29%).
2	Champawat	1972 (24%)
3	Nainital	1991 (33%)
4	Pauri Garhwal	1997(24%)
5	Pithoragarh	1989, 1996, 1997 (29%).
6	Tehri Garhwal	1974, 1997 (38%).
7	Uttarkashi	1976 (14%), 2009.

It is observed that the lowest annual rainfall was in Uttarkashi district (14% of the normal rainfall) in the year 1976.

It is observed that in year 1997 six districts and in year 1991 five districts out of 12 districts of which sufficient rainfall data is available, experienced drought.

There were no drought conditions in the state in the following 23 years: 1961 to 1963, 1966, 1967, 1969, 1971, 1973, 1975, 1978, 1981 to 1983, 1985, 1988, 1990, 1992, 1993, 1995, 2000, 2003, 2008 and 2010.

Excessive Rainfall:

Rainfall sufficiently in excess of the normal is a predominant factor for occurrence of floods, particularly in high rainfall regions. An annual rainfall of 125% or more of the normal is considered as excessive rainfall.

Fig. 11 shows the percentage frequency of excessive rainfall years and successive years of excessive rainfall during the period 1961- 2010. The following table (iii) gives the district wise excessive rainfall years and the highest annual rainfall (expressed as percentage of normal) with the years of occurrence.

Table (iii)

District	Years of excessive rainfall	Highest amount of Annual Rainfall in cm (expressed as % of normal with year)			Annual rainfall in cm.
Almora	1961, 1962, 1963, 1964, 1969, 1970, 1998.	147.8	153	1963	96.6
Chamoli	1969, 1971, 1973, 1974, 1975, 1986, 1987.	195.4	172	1969	113.6
Champawat	1961, 1962, 1981, 1983, 1985, 1986, 1990, 1993, 1998, 2000, 2002, 2003, 2007.	261.9	173	1993	151.4
Dehra dun	1961, 1963, 1964, 1966, 1967, 1971, 1973, 1977, 1978, 1999, 2001, 2010.	313.4	192	1971	163.2
Hardwar	1978, 1989, 1990, 1998, 2000, 2010.	196.1	163	1998	120.3
Nainital	1961, 1963, 1967, 1969, 1971, 1980.	238.8	157	1971	152.1
Pauri Garhwal	1961, 1962, 1963, 1964, 1965, 1966, 1967, 1989, 1999.	203.9	196	1989	104.0
Pithoragarh	1961, 1964, 1967, 1975, 1976, 1978, 1979, 1980, 1983, 1984, 1985, 1993, 1994, 2000, 2003, 2004, 2007.	412.6	223	2007	177.5
Rudraprayag	1961, 1962, 1964, 1966, 1968, 1969, 1970, 1989.	292.2	189	1970	154.6
Tehri garhwal	1961, 1966, 1970, 1978, 1981, 1993, 2002, 2003, 2004, 2007.	189.9	156	2007	121.7
Udhamnagar	1961, 1969, 1997, 1998, 1999, 2000, 2003, 2004, 2005, 2007.	203.5	190	2003	107.1
Uttarkashi	1962, 1963, 1969, 1988, 1994, 1998.	243.6	189	1969	128.9

From the above table, it is seen that during the period under consideration, there were 41 years in which some districts or the other in the state recorded excessive rainfall. In the year 2007, Pithoragarh district received the highest excessive rainfall (412.6 cm), i.e. 223% of the annual normal rainfall. In the year 1961, maximum number of districts i.e. 9 out of 12, of the state experienced excessive rainfall. Pithoragarh district experienced maximum number (17) of excessive rainfall year while Hardwar, Nainital and Uttarkashi districts experienced minimum number (6) of excessive rainfall year. The successive years of excessive rainfall against each district are listed below:

Successive years of Excessive Rainfall (Districtwise)

S.No.	District	Years of excessive rainfall	Successive years of excessive rainfall
1	Almora	1961, 1962, 1963, 1964, 1969, 1970, 1998.	1961 - 1962 - 1963 - 1964 , 1969 - 1970
2	Chamoli	1969 1971 1973 1974 1975 1986 1987	1973 - 1974 - 1975 , 1986 -1987.
3	Champawat	1961, 1962, 1981, 1983, 1985, 1986, 1990 ,1993, 1998, 2000, 2002, 2003, 2007.	1961 - 1962, 1985 - 1986, 2002- 2003.
4	Dehra dun	1961, 1963, 1964, 1966, 1967, 1971, 1973, 1977, 1978, 1999, 2001, 2010.	1963 - 1964, 1966 - 1967, 1977 - 1978.
5	Hardwar	1978, 1989, 1990, 1998, 2000, 2010.	1989 - 1990.
6	Nainital	1961, 1963, 1967, 1969, 1971, 1980.	NIL
7	Pauri garhwal	1961, 1962, 1963, 1964, 1965, 1966, 1967, 1989, 1999.	1961 - 1962 - 1963 - 1964 - 1965 - 1966 - 1967.
8	Pithoragarh	1961, 1964, 1967, 1975, 1976, 1978, 1979, 1980, 1983, 1984, 1985, 1993, 1994, 2000, 2003, 2004, 2007.	1975 - 1976, 1978 - 1979 - 1980, 1983 - 1984 - 1985, 1993 - 1994, 2003 - 2004.
9	Rudraprayag	1961, 1962, 1964, 1966, 1968, 1969, 1970, 1989.	1961 - 1962, 1968 - 1969 - 1970.
10	Tehrigarhwal	1961, 1966, 1970, 1978, 1981, 1993, 2002, 2003, 2004, 2007.	2002 - 2003 - 2004.
11	Udhamsignagar	1961, 1969, 1997, 1998, 1999, 2000, 2003, 2004, 2005, 2007.	1997 - 1998 - 1999 - 2000, 2003 - 2004 - 2005.
12	Uttarkashi	1962, 1963, 1969, 1988, 1994, 1998.	1962 - 1963.

The heaviest one day rainfall on record at any station in the state was 495.3 mm on 18 September 1880 at Hardwar (Hydro) in Hardwar district. The second highest one day rainfall recorded at Raipur station in Dehradun district was 487.5 mm on 02 August 1959.

Cyclonic storms and depressions

Table VII depicts the number of storms/depressions which affected the state during the period 1891- 2013. The cyclonic storms and depressions which affect India mostly originate and/or intensify over the Bay of Bengal, mostly during the months of May to November. They usually travel northwestwards or westwards and cross the east coast of India. Occasionally some storms or depressions originating over Arabian Sea also affect the western and northwestern parts of the country during the above period. They affect the state and produce the rain. In general, storm does not reach towards the state and even though depressions become very weak as they rarely reach on the land of Uttarakhand state is about 1300 km away from the east coast of India. The state therefore does not experience the full fury of depressions like the coastal regions. However, in association with these systems, heavy rainfall occurs over the affected districts. During the course of movement, the disturbances sometimes turn or recurve towards north or northeast under the influence of deep westerly system moving across Pakistan and Northwest India. The point of recurvature progressively shifts westward till September. The systems in May recurve while still out in Bay of Bengal. As such exceptionally a few of them cross the coast and travel inland, thereafter they become weak far away from the state and therefore cannot affect it.

In the months November to May, the state has not been affected by the storms and depressions for a single occasion. The maximum number of storms / depressions originating from the Bay of Bengal affects the state during August and September. The monsoon disturbances during June to September generally form over the head Bay of Bengal and travelling west or northwestwards, they move across Orissa, Chattisgarh, Madhya Pradesh, Uttar Pradesh and move towards Uttarakhand. During the period 1891-2013, there are 34 storms/depressions affected the Uttarakhand state.

Other Weather Phenomena

(a) Western Disturbances

Western disturbance (WD) is a synoptic system in mid latitude which moves from west to east across north India. It can be seen as a low pressure area over north Pakistan and neighbourhood which is extended at least up to 0.9 km as a cyclonic circulation in the lower troposphere. The WDs develop over Mediterranean sea, Black sea and Caspian sea. Life period of sequence of WD is 2 to 4 days. The disturbances mostly affect Indian subcontinent to the north of Latitude 25°N.

The state is strongly affected by WDs in winter. On an average 3 to 6 WDs per month move across the state in winter months. They are less frequent in post monsoon season. Its frequency is 2 in November and about 4 in March and April, and 2 to 3 in May. The weather associated with western disturbances over the state are of precipitation, cold wave condition (severe cold) and fog.

Due to movement of WDs precipitation occurs over the state. Precipitation in the form of rain and snowfall generally occurs in the forward sector of a WD as a thundershower. The high elevated areas of the state often get heavy snowfall during the winter season. Hails also occur over the state in association with the WDs.

The chilly weather in the state is experienced with the movement of WDs. Cold wave conditions generally prevail during November to March along with WDs in the state. Cold waves occur in the rear sector of western disturbances. The lowest temperature in cold wave generally reaches on the second night of the cold spell, when the minimum temperature in cold waves drops as much as 5°C to 8°C below normal. A spell of cold wave usually lasts for about 4 to 5 days. The state is most affected by severe cold wave approximately 4 spells per year. Fog is generally experienced with the movement of western disturbances over the state.

(b) Thunderstorms, Hail storms and Dust storms

Convective activity is responsible for the occurrence of thunderstorms, hailstorms and dust storms in Uttarakhand state. With the advance of the summer, thunderstorm activity becomes pronounced due to unequal heating of the land. When the moisture in the atmosphere is sufficient, thunderstorms or hail storms occur with association of convective clouds. The maximum number of thunderstorms occurs with availability of moisture in large scale and monsoon current, so its frequency reaches maximum in May or June or July in the state. While dust storms are mainly confined in the plain areas of southern part during summer months when atmosphere is dry.

Thunderstorms occur throughout the year in the state but its frequency is more during the period from March to September. The areas of high thunderstorm activity are also the areas of hailstorms and squalls. Thunderstorm activity is more in the districts viz. Tehri Garhwal, Pithoragarh, Nainital, Dehradun and Hardwar. In other districts its frequency is less. During the winter season, the state occasionally experiences thunderstorm activity. Thunderstorm activity is the least and minimum in the month of December. Squalls occasionally occur in the state, mainly during the pre-monsoon and early southwest monsoon months.

(c) Fog

Fog is experienced during the post monsoon and winter months when the air is still moist and is easily cooled below the dew point while rising over high elevations. Favourable conditions for formation of fog such as light to calm wind, sufficient humidity, clear skies, low temperatures etc., do exist after the withdrawal of the monsoon till March, maximum frequency of fog occurrence being during the months of December and January. Fog generally occurs throughout the year at Myunsiari Milan (Pithoragarh district), Pantnagar (Udham Singh Nagar district), Joshimath (Chamoli district), Mussoorie (Dehradun district), Mukhim (Tehri Garhwal district) and its frequency is maximum at Myunsiari and it is about 75 in a year. In the hilly terrain of the state frequency of fog is maximum in monsoon season and in the plain terrain it is maximum in winter. Generally the fog occurs in the early morning and prevails till late forenoon.

During winter fog is generally experienced along with western disturbances particularly, after passing the WDs. In association with WDs, conditions become favourable for occurrence of fog over large areas mainly in its rear sector and sometimes ahead of it. The low level moisture content, stability and light wind conditions become favourable for its formation. In the rear sector of the western disturbance radiation fog occurs one or two days after the cessations of rainfall.

Earthquakes

Uttarakhand state is prone to seismic activity and comes under seismic zone IV and V. Details of earthquakes of intensity of 5.0 or more at Richter scale having epicenter of the highest intensity earthquake month wise in the state are given in Table VIII. The state has experienced 67 earthquakes under moderate and high intensity during the period 1862-2013. Moderate to heavy damage in property and human life occurred due to these events of the earthquakes in the state as well as its neighboring regions. The state has maximum number (10) of earthquakes experienced in the month of June. The highest intensity of earthquake was experienced of 7.5 Richter scale having epicenter at 30° 00' N latitude and 81° 00' E longitude in August 1916.

TABLE - I
Mean Wind Speed (kmph) and Predominant Wind Direction
UTTARAKHAND

STATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Dehradun	a	2.4	2.9	3.3	3.6	3.6	3.2	2.6	2.4	2.6	3	2.7	2.3	2.9
	m	C/NE/NW	C/NE/NW	C/NE/NW	C/NW/NE	C/SW/NW	C/NE/SE	C/SE/NE	C/NE/SE	C/NE/SE	C/NE/NW	C/NE/NW	C/NE/NW	
	e	C/NW/SW	NW/SW/W	SW/NW/W	SW/NW/W	SW/NW/W	SW/NW/W	NW/SE/C	NW/C/NE	NW/C/W	C/NW/W	C/NW/W	C/NW/W	
Mukhim	a													
	m	W/S/NW	NW/W/S	NW/W/S	W/NW/S	W/NW/S	NW/W/C	W/NW/C	NW/W/C	NW/W/S	W/SW/NW	W/NW/S	W/S/NW	
	e	S/W/N	S/NW/W	W/NW/N	NW/N/S	NW/S/N	S/NW/N	S/NW/W	NW/N/S	S/W/N	S/W/NW	W/S/NW	W/S/NW	
Mukteshwar (Kumaun)	a	5.4	6.8	7.8	8.5	5.2	5.5	4.7	4.3	3.6	3.7	3.9	4.9	5.4
	m	C/NE/W	C/NE/W	C/W/NE	W/C/SW	W/C/SW	W/C/SW	C/NE/W	C/NE/W	C/NE/W	C/NE/E	C/NE/W	C/NE/W	
	e	C/W/SW	W/SW/C	W/SW/C	W/SW/NE	W/SW/C	W/SW/C	W/SW/C	W/C/SW	W/SW/C	C/W/SW	C/W/SW	C/W/NE	
Mussoorie	a	8.0	8.8	9.7	9.4	9.1	7.2	6.2	5.5	6.0	6.9	7.2	7.4	7.6
	m	C/N/S/SE/NE	C/N/S/SE	C/N/S/SE	C/S/N/SE	C/S/NSE	C/S/SE	C/S/SE	C/S/SE	C/S/SE	C/S/SE	C/S/SE	C/N/S/SE	
	e	S/N/SE	S/SE/SW/N	S/SE/N	S	S/SE	S/C/SE	C/S/SE	C/S/SE	C/S/SE	S/SE/C	S/SE/C	S/C/SE	
Pantnagar	a	1.7	2.1	2.6	2.9	3.5	3.1	2.8	2.3	1.9	1.1	0.9	1.2	2.2
	m	C/W/V	C/W/E	C/W/V	C/E/W	E/C/W	E/C/V	E/C/V	E/C/V	C/E/V	C/E/V	C/E/W	C/W/E	
	e	C/W/V	W/C/V	W/C/V	W/C/V	W/C/E	W/C/E	E/C/W	C/E/W	C/W/E	C	C	C	
Joshimath	a	5.5	6.2	7.4	6.2	5.5	3.8	2.8	2.6	2.8	3.8	4.2	5.3	4.7
	m	E/SE/C	E/SE/C	E	E	E	C/E/NE	C/E/NE	C/E	C/E	E	E/C	E/SE	
	e	SW/C	SW/C	E/SE/C	C/E	C/E	C/E/SW	C/SW	C/SW	C/SW	C/SW	C/SW/S	SW/S/C	
Nainital	a	7.2	7.7	7.8	7.7	7.8	7.0	7.8	7.9	6.8	6.6	6.6	6.5	7.3
	m	C/W	C/W/N	C/N/E	C/E/N	E/C/W	E	E	E	C/E	C/E	C/E	C/W	
	e	W	W	W	W/N/E	W/N/E	W/E/N	E/SE	E/SE/W	W/E/SE	W	W	W	

TABLE - I
Mean Wind Speed (kmph) and Predominant Wind Direction
UTTARAKHAND

STATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Tehri	a	1.0	1.6	2.1	2.9	3.6	3.8	2.8	2.2	2.0	1.8	1.2	0.7	2.1
	m	C	C	C	C	C/NE/N	C	C	C	C	C	C	C	
	e	C/SE	C/S	C/SE/SW/S	C/W/NW/SW	C/W/NW/SW	C/W/S	C/SW/S/SE	C/SE/S/SW	C/SE/S/SW	C/SE/S/SW	C/SE	C/SE	
Ascote	a	1.3	1.6	2.2	2.9	2.7	2.0	1.6	1.3	1.2	1.3	1.1	1.0	1.7
	m	C	C/NE	C/E/NE	C/NE/E	C/NE/E	C/NE/E	C	C	C	C/E/NE	C	C	
	e	C	C/W/SW	C/W/SW	C/SW/NE	C/NE/SW	C/NE/SW	C/SW/W	C	C/SW/W	C/W	C/W	C/W/SW	
Dharchula	a	1.6	2.4	3.5	4.6	4.8	3.2	2.0	1.2	1.5	2.0	1.7	1.2	2.5
	m	C	C	C	C	C	C	C	C	C	C	C	C	
	e	C	C	C/NW/SW	C/SW	C/SW/NE/NW	C	C	C	C	C	C/NE	C	
Roorkee	a	2.5	3.2	4.1	4.6	5.4	4.9	4.7	3.7	3.4	2.3	1.7	2.2	3.6
	m	C	C/NW	C/NW	C/NW/SE	C/SE	C/SE	C/SE	C/SE	C	C	C	C	
	e	C	C/NW	C/NW	C/NW	C/NW	C/SE/NW	C/SE	C/SE	C/NW	C	C	C	
State Mean	a	3.7	4.3	5.1	5.9	5.1	4.4	3.8	3.3	3.2	3.3	3.1	3.3	4.0

- a Mean wind speed in kms per hour.
m Predominant wind direction in the morning.
e Predominant wind direction in the evening.

TABLE - II
MEAN MAXIMUM AND MINIMUM TEMPERATURE (°C)
UTTARAKHAND

OBSERVATORY	TEMP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Dehradun	MAX	19.8	22.1	26.8	32.3	34.8	34.2	30.7	30.0	29.9	28.8	25.3	21.5	28.0
	MIN	6.2	8.4	12.5	16.8	20.6	22.7	23.1	22.6	20.8	15.6	10.8	7.2	15.6
Mukhim	MAX	14.3	15.2	18.4	22.9	26.3	26.7	25.4	25	24.8	23.2	20.7	17.7	21.7
	MIN	2.7	3.1	5	7.5	10.5	12.3	12.2	12.3	11.9	9.3	6.4	4.4	8.1
Mukteshwar	MAX	12.3	13.4	17.4	22.2	23.7	23.6	21.5	20.8	20.7	19.8	17	14.2	18.9
	MIN	1.7	2.4	5.4	9.5	11.7	13.4	13.8	13.6	12.2	9.1	5.6	3.3	8.5
Mussoorie	MAX	10.5	11.6	16.0	20.8	23.4	23.5	20.9	20.3	19.8	18.8	15.4	12.8	17.8
	MIN	2.6	3.4	7.2	11.6	14.3	15.8	15.2	14.9	13.7	10.9	7.2	4.3	10.1
Pantnagar	MAX	20.3	23.8	29	35.2	36.7	36	33.2	32.7	32.3	30.8	27.3	22.7	30.0
	MIN	5.4	7.4	11.3	15.7	20.9	24	24.9	24.6	22.8	16.7	10.4	6.3	15.9
Joshimath	MAX	11.4	12.2	17.6	21.7	24.4	25.8	24.0	23.5	22.8	20.6	16.8	13.4	19.5
	MIN	2.1	3.2	6.6	10.8	13.8	16.5	16.8	16.8	14.7	10.4	6.3	3.8	10.2
Nainital	MAX	10.7	12.3	16.3	20.8	23.5	23.5	21.6	21.0	20.7	18.7	15.4	12.9	18.1
	MIN	1.7	3.5	7.5	11.9	14.6	16.4	16.5	16.0	14.1	9.7	5.7	3.1	10.1
Tehri	MAX	19.9	22.4	27.9	33.3	36.3	36.5	33.2	32.5	32.4	30.2	26.1	21.6	29.4
	MIN	4.5	7.1	11.0	15.6	18.9	22.9	23.5	23.2	20.9	15.3	9.3	4.7	14.7
Roorkee	MAX	20.1	23.5	28.8	35.2	37.7	37.6	33.8	32.7	32.7	31.5	27.4	22.5	30.3
	MIN	6.2	8.4	13.1	18.3	22.5	24.4	25	24.6	22.9	17	11.3	7.3	16.8
State Mean	MAX	15.5	17.4	22.0	27.2	29.6	29.7	27.1	26.5	26.2	24.7	21.3	17.7	23.7
	MIN	3.7	5.2	8.8	13.1	16.4	18.7	19.0	18.7	17.1	12.7	8.1	4.9	12.2

TABLE - III
MEAN RELATIVE HUMIDITY (%)
UTTARAKHAND

OBSERVATORY		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Dehradun	M	85	77	64	51	51	65	86	89	84	71	76	83	73
	E	65	55	45	34	37	53	78	82	76	65	67	69	61
Mukhim	M	64	64	61	53	53	62	81	84	78	60	54	56	64
	E	61	61	57	50	48	54	71	74	69	54	50	54	59
Mukteshwar (Kumaun)	M	53	55	50	42	57	71	91	92	82	60	51	46	63
	E	63	63	60	46	59	69	88	90	86	74	69	62	69
Mussoorie	M	64	64	57	51	52	70	89	90	82	63	59	57	67
	E	77	73	63	52	51	67	88	91	88	78	75	74	73
Pantnagar	M	90	85	72	52	55	69	83	85	84	75	79	87	76
	E	68	57	45	31	39	53	73	77	74	68	70	71	60
Joshimath	M	57	58	53	55	56	72	89	90	82	64	52	55	65
	E	53	52	51	47	50	61	77	79	73	58	49	52	59
Nainital	M	63	54	47	44	46	67	84	85	77	57	53	55	61
	E	67	61	54	45	46	65	84	85	81	68	65	63	65
Tehri	M	91	84	74	57	48	63	81	85	81	77	80	91	76
	E	48	40	33	26	25	40	61	64	55	45	42	48	44
Roorkee	M	87	81	70	52	50	60	81	85	84	75	79	85	74
	E	61	53	44	35	37	47	69	74	68	57	59	60	55
Ascote	M	74	73	74	69	70	77	88	89	84	76	72	74	77
	E	68	67	65	61	66	72	84	85	81	70	66	68	71
Munsyari Milan	M	60	58	54	54	56	73	89	90	84	72	62	50	67
	E	66	62	56	57	57	71	87	89	86	76	67	61	70
Dharchula	M	81	79	70	60	60	73	87	87	84	80	76	78	76
	E	51	43	37	31	38	50	72	73	68	53	45	47	51
State Mean	M	72	69	62	53	55	69	86	88	82	69	66	68	70
	E	62	57	51	43	46	59	78	80	75	64	60	61	61

M : MORNING

E : EVENING

TABLE – IV
MEAN CLOUD AMOUNT ** (OKTA OF THE SKY) AND NUMBER OF DAYS OF CLEAR AND OVERCAST
SKIES AT 0830 HRS. IST

UTTARAKHAND

OBSERVATORY		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Dehradun	a	13	11	12	14	15	10	3	2	6	21	20	15	141
	b	3	3	2	2	1	4	10	11	5	1	0	2	44
	c	2.6	2.7	2.7	2	2.1	3.5	5.6	5.7	4	1	1.1	2	2.9
Mukhim	a	12	8	11	12	12	6	0	0	2	12	16	13	104
	b	5	4	4	2	2	3	9	10	5	1	1	3	48
	c	2.9	3.2	3	2.4	2.2	3.6	6.2	6.4	4.8	1.7	1.4	2.4	3.3
Mukteshwar (Kumaun)	a	11	9	11	13	11	6	1	0	3	15	17	13	110
	b	3	3	3	2	2	6	12	12	7	1	1	2	54
	c	2.7	3	2.8	2.4	2.5	4.1	6.3	6.4	4.5	1.5	1.3	2.2	3.3
Mussoorie	a	13	12	11	13	17	11	1	1	5	18	19	15	136
	b	6	5	5	3	3	6	19	18	10	2	1	3	81
	c	3.1	3.4	3.2	2.7	2.1	4	6.5	6.8	4.6	1.6	1.5	2.5	3.5
Pantnagar	a	10	12	15	17	15	9	1	1	6	22	22	16	147
	b	9	4	3	1	3	7	13	13	8	1	1	5	68
	c	3.5	2.5	2.1	1.6	2	3.7	6	5.9	4.2	1.1	0.9	2.2	3
Joshimath	a	19	16	20	19	19	14	3	2	12	23	24	20	191
	b	5	6	5	4	3	4	14	13	5	1	2	4	66
	c	2.5	2.5	2.4	1.9	1.6	3.0	5.1	5.3	3.2	0.8	1.0	1.8	2.6
Nainital	a	16	17	18	18	20	10	2	3	7	21	23	20	175
	b	7	5	4	3	3	11	19	18	10	4	2	3	89
	c	2.8	2.4	2.2	1.9	1.8	4.4	6.6	6.2	4.3	1.4	1.2	1.7	3.1
Tehri	a	14	10	12	17	16	10	1	0	5	19	21	19	144
	b	5	4	4	2	2	3	10	9	4	1	1	2	47
	c	3.1	3.2	2.5	2.0	1.8	3.3	5.6	5.7	3.6	1.2	1.3	1.9	2.9
Roorkee	a	13	10	12	14	14	9	2	0	5	20	21	14	134
	b	3	2	1	0	0	1	3	2	1	0	0	2	15
	c	2.4	2.2	2.5	1.7	1.7	2.6	4	4.2	3.2	0.9	0.7	1.9	2.3
Ascote	a	17	15	19	17	19	8	2	1	4	18	21	21	162
	b	6	5	4	4	3	9	17	19	10	2	2	3	84
	c	2.8	2.5	2.3	2.1	1.7	4.5	6.7	6.8	4.9	1.7	1.2	1.8	3.3
Munsyari Milan	a	15	15	17	17	17	5	3	2	8	16	21	19	155
	b	8	7	7	3	3	9	17	17	11	3	2	5	92
	c	3.6	3.1	2.4	2.0	2.4	5.0	6.5	6.6	4.4	2.1	1.4	2.2	3.5
Dharchula	a	18	17	20	19	20	8	2	2	8	22	24	22	182
	b	5	4	3	2	3	6	14	12	7	2	1	3	62
	c	2.7	2.4	2.0	1.5	1.7	3.8	5.9	5.9	4.0	1.4	1.0	1.7	2.8

OBSERVATORY		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	a	14	13	15	16	16	9	2	1	6	19	21	17	149
	b	5	4	4	2	2	6	13	13	7	2	1	3	62
	c	2.9	2.8	2.5	2.0	2.0	3.8	5.9	6.0	4.1	1.4	1.2	2.0	3.1

a :- DAYS WITH CLEAR SKY.

b :- DAYS WITH SKY OVERCAST

c :- MEAN CLOUD AMOUNT

** OKTA=UNIT,EQUAL TO AREA OF ONE EIGHTH OF THE SKY USED IN SPECIFYING CLOUD AMOUNT

FOR EXAMPLE :- 1 OKTA MEANS 1/8 TH OF THE SKY COVERED.

TABLE - IV (a)

MEAN CLOUD AMOUNT ** (OKTA OF THE SKY) AND NUMBER OF DAYS OF CLEAR AND OVERCAST
SKIES AT 1730 HRS. IST

UTTARAKHAND

OBSERVATORY		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Dehradun	a	8	5	5	6	6	4	1	1	2	11	14	12	75
	b	3	3	3	1	2	2	6	7	3	1	0	2	33
	c	3.3	3.6	3.5	3.1	3.1	3.9	6	6.2	4.9	2.1	1.6	2.5	3.7
Mukhim	a	7	4	4	3	3	1	0	0	1	6	13	11	53
	b	5	5	6	6	8	8	9	9	6	2	1	2	67
	c	3.2	3.9	4.1	4.4	4.6	5.3	6.2	6.2	5	2.4	1.6	2.3	4.1
Mukteshwar (Kumaun)	a	6	3	4	5	4	2	0	0	0	6	11	9	50
	b	3	3	3	2	2	3	8	10	5	1	1	2	43
	c	3.2	3.8	3.8	3.6	3.4	4.4	6.2	6.5	4.9	2.3	1.7	2.5	3.9
Mussoorie	a	6	4	4	3	5	3	0	0	1	6	16	13	61
	b	10	6	5	3	4	5	19	21	10	4	2	4	93
	c	4.2	4.5	4.6	4.5	3.8	4.9	6.9	7.3	6	3.3	2.4	2.9	4.6
Pantnagar	a	12	10	11	12	13	8	1	0	4	18	20	16	125
	b	4	2	3	1	2	3	6	7	4	1	1	2	36
	c	2.8	2.4	2.3	2	1.9	3	5	5.2	3.5	1	1	1.8	2.7
Joshimath	a	14	8	7	6	5	5	1	1	5	13	18	18	101
	b	7	9	12	11	9	7	14	13	9	4	3	4	102
	c	3.4	4.0	4.4	4.6	4.6	4.9	6.0	6.1	4.6	2.7	1.9	2.3	4.1
Nainital	a	15	14	17	15	18	10	4	3	6	16	17	18	153
	b	6	5	4	3	3	6	15	15	10	4	3	3	77
	c	3.1	2.7	2.5	2.2	1.9	3.8	6.1	6.4	4.6	1.7	1.8	2.3	3.3
Tehri	a	11	9	9	7	8	4	1	1	3	14	17	18	102
	b	4	3	3	3	4	2	6	6	3	1	1	1	37
	c	2.9	3.3	3.3	3.2	3.3	3.7	5.3	5.2	3.4	1.6	1.3	1.7	3.2

OBSERVATORY		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Roorkee	a	14	9	12	12	14	9	1	0	4	20	21	14	130
	b	1	1	1	0	0	0	1	1	0	0	0	1	6
	c	2.1	2.3	2.6	1.9	1.7	2.3	3.9	4	3.1	0.9	0.7	1.8	2.3
Ascote	a	16	10	10	5	6	2	2	1	3	13	19	20	107
	b	5	5	5	6	7	8	12	13	8	3	1	2	75
	c	2.8	3.2	3.7	4.4	4.3	5.2	6.1	6.2	4.6	2.4	1.5	1.6	3.8
Munsyari Milan	a	8	5	5	2	4	0	1	1	1	3	10	13	53
	b	11	11	13	8	10	12	21	21	15	7	4	6	139
	c	4.9	5.3	5.4	5.6	5.9	6.2	7.2	7.3	6.1	5.2	2.9	2.9	5.4
Dharchula	a	13	12	9	8	5	1	1	2	3	10	17	20	101
	b	5	4	5	5	6	6	11	11	7	3	1	2	66
	c	3.0	3.3	3.7	4.0	4.2	5.0	6.0	6.0	4.8	2.8	1.7	1.8	3.9
State Mean	a	11	8	8	7	8	4	1	1	3	11	16	15	93
	b	5	5	5	4	5	5	11	11	7	3	2	3	66
	c	3.2	3.5	3.7	3.6	3.6	4.4	5.9	6.1	4.6	2.4	1.7	2.2	3.7

a :- DAYS WITH CLEAR SKY.

b :- DAYS WITH SKY OVERCAST

c :- MEAN CLOUD AMOUNT

** OKTA=UNIT,EQUAL TO AREA OF ONE EIGHTH OF THE SKY USED IN SPECIFYING CLOUD AMOUNT
FOR EXAMPLE :- 1 OKTA MEANS 1/8 TH OF THE SKY COVERED.

TABLE V
MEAN RAINFALL (mm) AND NUMBER OF RAINY DAYS
UTTARAKHAND

DISTRICT		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Almora	a	32.2	39.0	29.8	20.3	40.9	112.4	292.8	234.4	116.9	25.7	4.2	17.3	965.9
	b	2.1	3.0	2.2	1.3	3.3	6.3	13.8	12.4	6.4	1.5	0.3	1.0	53.6
Chamoli	a	75.6	104.2	100.6	51.0	73.0	93.3	217.5	224.0	108.5	40.2	10.0	38.5	1136.4
	b	4.2	5.7	6.2	4.4	5.4	7.4	14.6	15.0	8.4	3.1	0.9	2.0	77.3
Champawat	a	33.2	35.9	23.5	21.2	40.1	187.9	418.3	430.9	253.8	49.0	4.6	15.5	1513.9
	b	2.1	2.3	1.8	1.9	3.1	8.6	14.4	14.7	8.7	1.7	0.4	1.0	60.7
Dehra dun	a	41.5	57.0	55.0	35.2	50.5	162.2	489.6	457.9	217.3	34.7	9.8	21.4	1632.1
	b	2.7	3.3	3.2	2.2	3.3	6.9	15.0	15.6	9.1	1.7	0.6	1.2	64.8
Hardwar	a	29.1	41.5	34.2	17.5	30.0	131.5	335.3	367.5	173.7	21.1	4.8	16.7	1202.9
	b	2.3	2.4	2.5	1.4	2.5	6.1	12.3	13.8	6.8	1.2	0.5	1.2	53.0
Nainital	a	32.5	36.2	27.6	17.3	42.0	199.0	453.9	415.6	239.4	41.1	4.5	12.1	1521.2
	b	2.0	2.3	2.0	1.4	2.8	8.1	14.5	14.9	8.4	1.8	0.4	0.9	59.5
Pauri Garhwal	a	35.7	37.8	25.7	14.1	31.4	112.2	306.2	285.7	148.7	18.2	4.3	20.1	1040.1
	b	1.8	2.2	1.5	0.9	2.0	5.1	10.7	11.6	5.7	1.0	0.3	1.0	43.8
Pithoragarh	a	67.5	76.6	86.4	46.0	76.2	223.8	455.8	407.0	247.7	39.4	13.8	35.2	1775.4
	b	3.6	4.6	4.1	3.5	5.5	10.9	18.3	17.0	11.7	2.7	0.9	1.4	84.2
Rudraprayag	a	46.9	65.3	63.6	53.3	96.1	179.2	393.5	403.8	171.9	39.3	8.6	24.7	1546.2
	b	3.4	4.2	4.7	4.6	7.3	11.3	18.1	17.6	9.6	2.5	0.9	1.7	85.9
Tehri Garhwal	a	46.7	58.7	49.4	31.9	50.6	128.3	321.0	326.1	146.5	25.2	7.9	24.4	1216.7
	b	2.7	3.6	3.2	2.6	3.9	7.2	13.6	13.6	6.6	1.5	0.5	1.3	60.3
Udham Singh Nagar	a	20.7	21.4	10.2	8.5	29.1	128.8	324.2	306.8	177.6	33.2	2.2	8.4	1071.1
	b	1.4	1.6	1.0	0.7	1.8	5.4	10.9	11.1	6.1	1.3	0.2	0.7	42.2
Uttarkashi	a	48.1	71.7	86.8	50.8	84.0	132.7	312.0	277.9	138.4	44.2	10.4	31.8	1288.8
	b	3.5	4.5	5.2	3.9	5.8	8.8	15.7	14.6	8.3	2.3	0.8	1.8	75.2
State mean	a	42.5	53.8	49.4	30.6	53.7	149.3	360.0	344.8	178.4	34.3	7.1	22.2	1326..1
	b	2.7	3.3	3.1	2.4	3.9	7.7	14.3	14.3	8.0	1.9	0.6	1.3	63.5

a : NORMAL RAINFALL IN mm.

b: AVERAGE NUMBER OF RAINY DAYS (i.e.days with rainfall of 2.5mm or more)

TABLE VI
MEAN RAINFALL(mm) OVER DIFFERENT RIVER CATCHMENTS OF UTTARAKHAND STATE
UTTARAKHAND

Sr.No	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1	Ganga upto and including River Ramganga. (Catchment.No.401)												
	<u>Districts/Parts of districts within this catchment:-</u> CHAMOLI,HARDWAR,PAURI GARHWAL,TEHRI GARHWAL,UDHAMSINGH NAGAR,RUDRA PRAYAG / ALMORA,DEHRADUN,NAINITAL,UTTARKASHI.												
A	40.8	52.3	47.7	30.8	49.6	144.1	358.5	343.5	171.9	33.7	6.4	21.0	1300.3
B	2.6	3.3	3.1	2.3	3.6	7.3	14.0	14.2	7.8	1.8	0.5	1.3	61.8
2	Yamuna upto its confluence with River Chambal (excluding Chambal). (Catchment.No.403)												
	<u>Parts of districts within this catchment:-</u> DEHRADUN,UTTARKASHI.												
A	46.4	67.9	72.3	35.6	75.7	140.5	387.7	353.8	185.7	37.4	12.6	27.6	1443.2
B	3.0	3.8	4.2	2.8	4.4	7.3	14.5	14.4	7.9	1.7	0.7	1.5	66.2
3	Rest of Gogra (including River Sarada) upto its confluence with River Ganga. (Catchment.No.411)												
	<u>Districts/Parts of districts within this catchment:-</u> BAGESHWAR, CHAMPAWAT,PITHORAGARH / ALMORA, NAINITAL												
A	55.0	63.4	62.5	36.6	61.7	201.6	426.5	392.9	224.7	38.5	9.9	28.9	1602.2
B	4.5	3.8	3.2	2.9	4.6	9.7	16.7	15.7	10.1	2.2	0.7	1.2	75.3

TABLE – VII
STORMS AND DEPRESSIONS AFFECTING UTTARAKHAND STATE
DURING 1891 – 2013
UTTARAKHAND

MONTHS	NO. OF STORMS/ DEPRESSIONS
JANUARY	NIL
FEBRUARY	NIL
MARCH	NIL
APRIL	NIL
MAY	NIL
JUNE	2
JULY	5
AUGUST	11
SEPTEMBER	14
OCTOBER	2
NOVEMBER	NIL
DECEMBER	NIL
TOTAL	34

TABLE VIII
DETAILS OF EARTHQUAKE OF INTENSITY OF 5.0 OR MORE AT RICHTER SCALE HAVING EPICENTRE
WITHIN UTTARAKHAND STATE DURING YEARS 1862-2013

UTTARAKHAND

MONTHS	YEARS	FREQUENCY	EARTHQUAKE OF HIGHEST INTENSITY			EPICENTRE			
			INTENSITY AT RICHTER SCALE	DEPTH IN km	YEAR	LATI-TUDE-N		LONGI-TUDE-E	
						DEG	MIN	DEG	MIN
JANUARY	1963 1968 1997	3	5.6	33.0	1997	29	50	80	32
FEBRUARY	1949 1984 2006 2012	4	5.5	0.0	1949	31	12	79	54
MARCH	1844 1935 1935 1965 1969 1981 1996 1999 1999	9	6.8	21.0	1999	30	25	79	25
APRIL	1843 1999 1999 2011	4	5.5	9.0	2011	29	35	80	53
MAY	1816 1883 1968 1979 2006	5	6.5	0.0	1816	30	0	80	0
JUNE	1902 1906 1945 1966 1966 1966 1966 1966 1966 1966	10	6.5	0.0	1945	30	18	80	0
JULY	1926 1962 1962 1980 1986 2007	6	6.1	0.0	1980	29	38	81	5
AUGUST	1916 1947 1966 1972	4	7.5	0.0	1916	30	0	81	0
SEPTEMBER	1964 1990 2008 2009	4	5.8	50.0	1964	29	58	80	28
OCTOBER	1927 1937 1964 1991 2004	5	6.6	13.0	1991	30	45	78	52
NOVEMBER	1963	1	5.1	33.0	1963	30	48	79	6
DECEMBER	1908 1958 1958 1961 1964 1964 1966 1966 1979	9	6.3	0.0	1958	30	1	79	56
OTHER	1803 1809 1809	3	6.5	0.0	1803	30	0	80	0
TOTAL		67	7.5	0	1916	30	0	81	0

**DISTRICT SUMMARIES OF
UTTARAKHAND**

ALMORA DISTRICT

Almora district is situated in Kumaon division of the state. This district has highly rugged hilly terrain marked with steep and high ridges, deep narrow valleys and perennial rivers. Almora town is the district headquarters which is situated at an elevation of 1585 metres above mean sea level. Peak height of the district is about 2770 m. The elevation is high ranging from about 1500 to 2700 m towards the north. The valleys are generally lying in the south where elevation is low about 300 m. The climate of the district largely depends on its physiographic features. Severe cold in winter is the chief climatic feature of the district.

During the winter season which starts from December and lasts till early March a considerable precipitation occurs in the form of rain and often little snow in association with western disturbances passing across north India and affecting the district. The district is situated on the southern slopes of the Himalayas and it gets more rainfall from the monsoon current which penetrates through the valleys in the last week of June and monsoon lasts till September. October and November months constitute the post monsoon season. The period of March to the third week of June is of pre-monsoon season.

RAINFALL

Records of rainfall in the district are available for three rain gauge stations for period ranging from 17 to 34 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district is 965.9 mm. The annual rainfall in the district varies over a moderate range. The rainfall in the southwest monsoon season (June to September) is about 78% of the annual normal rainfall. With the onset of the summer monsoon, rainfall increases sharply from the end of June and continues to increase till August. July being the month with the highest rainfall with an average of 292.8 mm and August is the second rainiest month. These two months together amounted for about 55% of annual precipitation. The rainfall in the pre-monsoon months (March to May) mostly associated with thunderstorms and occasional hailstorms is about 9% of the annual

rainfall. The winter months of December to February account for about 9% of the annual normal rainfall. Winter precipitation which is associated with the passage of western disturbances and is mostly in the form of rain and snow over higher elevations. The snow accumulation at high elevated areas is a considerable. In the fifty-year period 1961 to 2010, the highest annual rainfall of 153% of the normal was recorded in year 1963, while the lowest was 72% of the normal recorded in 1997. During this period there were 2 years in which the rainfall was less than 80% of the normal and they were not consecutive. It is seen from Table 2 that the annual rainfall was between 701 mm and 1200 mm in 8 years out of 16.

In the monsoon season the depressions or low pressure system from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

On an average there are 54 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 29 at Kausani to 70 at Ranikhet.

The heaviest rainfall recorded in 24 hours at any station in the district was 350.5 mm at Ranikhet on 16th June 1970.

TEMPERATURE

There is no meteorological observatory in the district. Almora town is the district headquarters situated at an altitude of 1585 m. Hence, the description of the climate for this district which follows is based on the records of the neighbouring observatory Mukteshwar at an altitude of 2311 m in Nainital district. Temperature variations from place to place are considerable and depend on topography of the district. The temperature decreases rapidly from November and weather becomes cool and oppressive till February. January is the coldest month with mean maximum

temperature of about 15°C and mean minimum temperature of about 3°C at Almora town. In the wake of western disturbances often make the weather conditions more rigorous, when the temperatures below the freezing point of water are recorded. The lowest temperatures of the order of -8°C can be expected to be reached at higher altitudes.

Both day and night temperatures begin to rise rapidly from mid-February. June is the warmest month when mean maximum temperature is of about 28°C and mean minimum temperature of about 17°C at Almora town. On individual days during summer, maximum temperature may reach up to 36°C. With the onset of the monsoon, day temperature falls slightly in July and remains more or less steady at about 27°C till August, while the night temperatures continue to be steady at about 16°C. The temperatures continue fall further but after October the fall in both day and night temperatures is rapid till January when winter is fully established. During pre-monsoon and post monsoon months the weather becomes pleasant. The temperatures may be 3° to 5°C lower at high altitudinal areas and 4° - 6°C higher at low elevated areas with reference to Almora town.

HUMIDITY

The atmosphere over the district is much humid during the southwest monsoon season. The values of relative humidity are at about 80% to 90% during this period. It is slightly less humid during winter months when its values are at about 60%. The summer season is the driest part of the year when values of relative humidity's are between 40% and 60%. In general values of humidity in the evenings are slightly more than mornings especially in the hilly region.

CLOUDINESS

The skies are heavily clouded to overcast on many days in the southwest monsoon season. The skies are generally clear or lightly clouded in the rest of the year except for few days when the skies become mostly cloudy in passage of

western disturbances. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are generally light to moderate throughout the year. In the district winds mainly blow from west or southwest direction. In winter and southwest monsoon seasons, northeasterly wind also blows particularly in the mornings while westerly and southwesterly winds blow in the evenings. In the rest of year westerly wind especially in the evenings prevails.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year especially in the district. Its frequency is more in the period latter part of pre-monsoon and early period of southwest monsoon season i.e. April to July and least in months November and December. Winter and early pre-monsoon season thunderstorms are occasionally accompanied with hail. Fog is common almost throughout the year especially in the northern portion of the district. Fog is generally observed over hills during monsoon months where its frequency is a maximum. In the winter months fog generally occurs in the wake of western disturbances. In the valleys fog is frequent in the morning during winter.

TABLE - 1
NORMALS AND EXTREMES OF RAINFALL
ALMORA

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Almora	34	a b	35.9 2.7	41.6 3.6	38.3 3.2	21.0 1.7	49.5 4.4	129.9 8.3	224.4 13.5	223.5 13.8	129.6 7.5	21.6 1.4	5.6 0.4	20.1 1.3	941.0 61.8	154 (1971)	50 (1997)	222.5	29 Sep 1924
Kausani	17	a b	21.6 1.0	21.8 1.5	0.3 0.0	0.0 0.0	16.1 0.9	26.1 1.8	326.7 11.7	174.8 7.3	55.4 3.0	28.4 1.3	0.0 0.0	10.2 0.4	681.4 28.9	213 (1963)	209 (1962)	200.1	03 Oct 1910
Ranikhet	34	a b	39.0 2.5	53.5 3.8	50.9 3.5	40.0 2.3	57.0 4.7	181.2 8.9	327.4 16.2	305.0 16.0	165.6 8.8	27.2 1.7	7.1 0.4	21.6 1.2	1275.5 70.0	139 (1970)	67 (1972)	350.5	16 Jun 1970
Almora (District)		a b	32.2 2.1	39.0 3.0	29.8 2.2	20.3 1.3	40.9 3.3	112.4 6.3	292.8 13.8	234.4 12.4	116.9 6.4	25.7 1.5	4.2 0.3	17.3 1.0	965.9 53.6	153 (1963)	72 (1997)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data up to 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
ALMORA
(Data 1961-2000)

Range in mm	No. of years	Range in mm	No. of years
601 – 700	1	1101 – 1200	1
701 – 800	2	1201 – 1300	2
801 – 900	0	1301 – 1400	3
901 – 1000	4	1401 – 1500	2
1001 – 1100	1		

(Data available for 16 years)

BAGESHWAR DISTRICT

Bageshwar district is mostly hilly and is situated in Kumaon division of the state. It has an average elevation of about 1004 metre above mean sea level. Bageshwar town is the district headquarters situated on the bank of Gomati river at an elevation of 895 metre. Peak height of the district is at about 6500 m. The district has topographic variation from north to south viz high hills and low elevated areas with valleys and perennial rivers. The area shows an extremely rugged topography characterized by hills and deep gorges. In the northern parts, the elevation of land surface ranges from about 3000 m to 6500 m whereas in the valleys of southern part, the altitude is low as 795 m.

The northern part of the district experiences sub-zero temperature during winter whereas the central and southern parts are comparatively warm and humid. Severe cold in winter is the chief climatic feature of the district. In general the district experiences tropical to sub-tropical and sub-humid climate except for the northern part where cold temperate climate prevails and the upper-reaches of the district receive snowfall in winter season. Winter starts from the end of November and lasts till early March, and is followed by summer (pre-monsoon) season till the third week of June. Thereafter southwest monsoon season begins and lasts till September. October and November months constitute transition period (post monsoon season) between monsoon season and winter.

RAINFALL

Records of rainfall in the district are available for only one rain gauge station i.e. Bageshwar for all available data for the short period. The details of rainfall at this station is given in Table- 1. The average annual rainfall in the district is 1229.0 mm and average annual rainy days in district are about 84. Generally the rainfall increases from south to north direction. The rainfall in the southwest monsoon season (June to September) is about 79% of the annual normal rainfall. August is the rainiest month with an average value of 369.4 mm while July being the second highest rainfall month. The winter months of December to February account for

about 12% of the annual normal rainfall. In winter months the district receives precipitation in the form of rain and snow at higher altitudinal areas. In association with western disturbances precipitation occurs which is mostly in the form of snow at higher elevations. During winter months the district especially at higher reaches receives about 30 cm or more precipitation in the form of snow.

In the monsoon season the depressions or low pressure systems from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

The heaviest rainfall in 24 hours recorded at Bageshwar was 170.6 mm on 13th August 1990.

TEMPERATURE

There is no meteorological observatory in Bageshwar district. Bageshwar town is the headquarters of the district situated at an elevation of 895 m. Hence, the meteorological parameters recorded at Mukteshwar observatory at an altitude of 2311 m in neighbouring district Nainital may be taken as representative of the climatic conditions in the district. Temperature and other meteorological conditions vary depending much on the topography of the place. Day and night temperatures decrease rapidly from November. January is the coldest month with mean maximum temperature of about 18°C and mean minimum temperature about 4°C at Bageshwar town. On individual days during winter season minimum temperature may drop below freezing point of water. Cold waves in the wake of western disturbances often make the winter conditions more rigorous.

Both day and night temperatures begin to rise from the middle of February and rapidly increase from March to June. June is the warmest month with mean maximum temperature of about 33°C and mean minimum temperature of about 21°C at Bageshwar town. With the onset of the monsoon day temperature falls slightly in

July and remain more or less steady at 31°C till August while the night temperatures continue to be steady at about 21°C. On individual days during summer, maximum temperature may reach up to 40°C at Bageshwar town. The temperatures begin to fall after withdrawal of the monsoon, the fall in day and night temperatures is rapid till January when winter is fully established. In general weather is pleasant during pre-monsoon and post monsoon seasons. These temperatures may be 10- 30°C lower at high altitudinal areas with reference to Bageshwar town.

HUMIDITY

The atmosphere over the district is humid during the southwest monsoon season. The values of relative humidity are about 80% to 90% during this period. It is slightly less humid during winter months, when its values are about 60%. The summer season is the driest part of the year with values of relative humidity's are between 40% and 60%. In general values of humidity in the evenings are slightly more than mornings especially in the hilly region.

CLOUDINESS

The skies are heavily clouded to overcast on many days in the southwest monsoon season. The skies are generally clear or lightly clouded in the rest of the year except for few days each time in association of western disturbances the skies become cloudy. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are generally light to moderate throughout the year. In the district winds mainly blow from west or southwest direction. In winter and southwest monsoon seasons, northeasterly wind also blows particularly in the mornings while westerly and southwesterly winds blow in the evening. In the rest of year westerly wind especially in the evenings is predominant.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year especially in the district. Its frequency is more in the period latter part of pre-monsoon and early period of south-west monsoon season i.e. April to July and least in months of November and December. During winter and early pre-monsoon season thunderstorms are occasionally accompanied with hail. Fog is common almost throughout the year especially in the northern portion of the district. Fog is generally observed at hills during monsoon months where its frequency is a maximum. In the winter months fog generally occurs in the wake of western disturbances. In the valleys fog is frequent in the morning during winter.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
BAGESHWAR

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Bageshwar	09	a b	41.8 23.0	68.3 3.8	26.8 2.5	35.8 2.5	41.0 4.0	218.2 10.7	286.9 13.8	369.4 15.4	99.5 6.4	9.1 0.6	0.8 0.1	31.4 0.9	1229.0 83.7	-	-	170.6	13 Aug 1990
Bageshwar (District)		a b	41.8 23.0	68.3 3.8	26.8 2.5	35.8 2.5	41.0 4.0	218.2 10.7	286.9 13.8	369.4 15.4	99.5 6.4	9.1 0.6	0.8 0.1	31.4 0.9	1229.0 83.7	-	-		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

** Years of occurrence given in brackets.

CHAMOLI DISTRICT

Chamoli is hilly district situated in the northern part of Uttarakhand state. The district shares its northern boundary with Tibet. It is situated in Garhwal division of the state. The district headquarters is Gopeshwar town situated at an elevation of 1466 metre above mean sea level. Peak height in the district is about 7817 m. It contains within its limits lofty snowbound peaks of Himalayas where in the glaciers, the Alaknanda and its tributaries originated. The elevation is mostly high, ranging from 2500 m to 7817 m. The terrain is marked with deep and narrow valleys, perennial rivers and steep high ridges. The land slopes down towards the south, where in the valleys elevation at places comes down to 800 m. The climate therefore depends largely on physiographic features. The northern part of the district is mostly covered by snow throughout the year.

As most of the region is situated on the southern slopes of the Himalayas, the monsoon current penetrates through the trenched valleys and rainfall is maximum in the southwest monsoon season from the end of June to September. Severe cold in winter is the chief climatic feature of the district. Winter starts from about mid-November and lasts till mid-March. In higher mountains winter is very cold and there is snowfall. The winter is followed by pre-monsoon (summer) season till the third week of June, and it is mild warm and pleasant. The period of October to mid-November constitutes the post monsoon season.

RAINFALL

Records of rainfall in the district are available for five raingauge stations for the period ranging from 15 to 47 years. The details of rainfall at these stations which may be taken as representative for the district as a whole are given in Tables 1 and 2. Rainfall generally increases from southeast to northwest reaching the maximum in the higher elevated area. The average annual rainfall in the district is 1136.4 mm. The

annual rainfall in the district varies over a large range due to topographic variation. The rainfall in the southwest monsoon season (June to September) is about 57% of the annual normal rainfall. July and August are the rainiest months with an average value of 220.7 mm. The rainfall in the pre-monsoon months (March to May) is about 20% of the annual. The rainfall in pre-monsoon months is mostly associated with thunderstorms. The winter months (December to February) account for about 19% rainfall of the annual normal and precipitation is associated with the passage of western disturbances and is mostly in the form of snow. In the period of 1961 to 2008 years, the highest annual rainfall was recorded 172% of the normal in year 1969, while the lowest was 29% of the normal recorded in 1998. During this period, there were 4 years in which the rainfall was less than 80% of the normal and there was one occasion of three consecutive years of such low rainfall. It is seen from Table 2 that the annual rainfall was between 901 mm and 1400 mm in 21 years out of 32.

In the district especially in higher mountains considerable amount of precipitation is received in the form of snow. During the months of November to February the precipitation is in association with the passage of western disturbances and is mostly in the form of snow. In monsoon season the depressions from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hilly terrain causing floods in the rivers.

On an average there are 77 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 51 at Mana obsy to 126 at Ghangaria obsy.

The heaviest rainfall recorded in 24 hours at Joshimath was 300.0 mm on 22nd June 1973.

TEMPERATURE

There is one meteorological observatory in the district at Joshimath at an altitude 1875 metre. The records of this observatory may be taken as representative of the meteorological conditions for almost areas of the district. Much lower temperatures may be prevailed at higher elevations. The district being hilly temperature variations with elevation and place to place are considerable. Temperature begins to increase from March. June is the hottest months with mean maximum temperature of about 28°C and mean minimum temperature about 18°C at district headquarters- Gopeshwar (Alt 1466 m), and these temperatures are about 25°C and 16°C respectively at places having altitude of 2 km. With the onset of the southwest monsoon by about the end of June, the day temperature decreases slightly while night temperature remains as or slightly more in the summer season. After withdrawal of southwest monsoon both the day and night temperatures begin to decrease steadily and weather becomes cool and pleasant in October and November. January is the coldest month with the mean minimum temperature of about 3°C and mean maximum temperature about 13°C at Gopeshwar, and these temperatures are about 2°C and 11°C respectively at places having altitude of 2 km. During the winter season in association with passing western disturbances, cold weather conditions prevail over the district, the minimum temperature occasionally dropping down to about 10 degree below the freezing point of water. These temperatures may be 10 - 25°C lower at high altitudinal areas and 2 - 4°C higher in valleys of low elevation with reference to Joshimath observatory.

The highest maximum temperature ever recorded at Joshimath observatory was 34.2°C on 14th June 1974 and the lowest minimum temperature was -15.1°C on 15th January 1974.

HUMIDITY

The atmosphere over the district is humid during the southwest monsoon season particularly in the rainiest months July and August, when values of relative humidity are about 90% in the mornings and about 79% in the afternoons. The driest part of the year is from November to April months, when humidity may become as low as 47% during the afternoons.

CLOUDINESS

The skies are clouded to overcast on many days in southwest monsoon season particularly in the rainiest months July and August. During winter months skies are heavily clouded to overcast for short spells when the district is affected by western disturbances. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day. In the rest of the year skies are mostly clear or lightly clouded. In general evenings are much cloudier than mornings.

WINDS

Owing to the nature of the terrain, local effects are pronounced and when the general prevailing winds are not strong because there is a tendency for diurnal reversal of winds, blowing up the slopes during the day (anabatic flow) and down the slopes at night (Katabatic flow). At Joshimath winds are light to moderate throughout the year except winter when it becomes strong. Easterly or southeasterly/northeasterly winds blow in the mornings throughout the year. In the afternoons wind mainly blows from southwest / south direction in winter, east in summer and southwest / west direction in southwest monsoon season. Sometimes wind is calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year except January which is practically free. Its frequency is more in April month. Some thunderstorms of the latter part of winter and pre-monsoon are associated with hail or dust storms. Fog is common over hilly terrain during the monsoon. Fog occurs occasionally .Its frequency is more in monsoon months and cold season in the wake of western disturbances. In the valleys, fog frequently occurs in morning during winter.

Table 3, 4,5 and 6 give the temperature and humidity, cloudiness, mean wind direction and speed, and frequency of special weather phenomena respectively for Joshimath observatory.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
CHAMOLI

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Ghangaria (Obsy)	15	a b	157.7 8.5	160.7 8.7	138.4 10.1	82.9 7.2	124.6 10.1	155.4 13.7	300.5 22.2	258.3 21.2	150.3 12.3	81.6 6.3	18.5 1.9	79.8 3.5	1708.7 125.7	122 (1972)	84 (1970)	136.0	25 Dec 1985
Joshimath	34	a b	40.1 3.7	75.1 4.5	80.6 5.3	50.6 4.1	63.8 4.5	94.9 6.9	196.3 15.0	188.5 15.6	76.7 7.6	25.2 2.4	11.6 0.9	22.1 1.6	925.5 72.5	156 (1991)	30 (1998)	300.0	21 Jun 1973
Joshimath (Obsy)	47	a b	54.4 3.8	91.6 5.7	106.0 6.7	51.5 4.3	62.1 5.5	85.7 7.2	232.0 15.6	203.2 15.9	112.1 9.1	37.0 2.8	12.3 1.2	28.1 1.9	1076.0 79.7	140 (1961)	82 (1965)	273.0	21 Jul 1970
Mana (Obsy)	17	a b	84.8 2.9	136.7 5.7	134.7 6.0	35.4 3.7	31.6 3.0	21.1 2.7	72.7 7.1	83.9 9.1	66.6 6.2	39.9 2.5	2.3 0.3	40.5 1.9	750.2 51.1	180 (1971)	18 (1970)	120.0	20 Feb 1971
Karnaprayag	34	a b	41.0 2.0	57.1 3.4	43.4 3.1	34.5 2.7	82.8 4.0	109.2 6.4	285.9 13.3	386.1 13.3	136.6 6.9	17.3 1.3	5.3 0.4	21.8 1.3	1221.0 58.1	321 (1969)	08 (1972)	198.1	23 Jun 1942
Chamoli (District)		a b	75.6 4.2	104.2 5.7	100.6 6.2	51.0 4.4	73.0 5.4	93.3 7.4	217.5 14.6	224.0 15.0	108.5 8.4	40.2 3.1	10.0 0.9	38.5 2.0	1136.4 77.3	172 (1969)	29 (1998)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
CHAMOLI
(Data 1961-2008)

Range in mm	No. of years	Range in mm	No. of years
301 – 400	1	1201 – 1300	3
401 – 500	1	1301 – 1400	4
501 – 600	1	1401 – 1500	0
601 – 700	0	1501 – 1600	5
701 – 800	1	1601 – 1700	0
801 – 900	0	1701 – 1800	0
901 - 1000	3	1801 – 1900	0
1001 – 1100	6	1901 – 2000	2
1101 – 1200	5		

(Data available for 32 years)

TABLE – 3
Normals of Temperature and Relative Humidity
(JOSHIMATH)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	11.4	2.1	21.6	01-01-1972	-15.1	15-01-1974	57	53
February	12.2	3.2	21.1	25-02-1962	-4.3	05-02-1977	58	52
March	17.6	6.6	28.6	21-03-1974	-4.0	09-03-1979	53	51
April	21.7	10.8	30.6	20-04-1968	0.0	05-04-1976	55	47
May	24.4	13.8	31.9	30-05-1972	4.9	04-05-1977	56	50
June	25.8	16.5	34.2	14-06-1974	6.0	10-06-1983	72	61
July	24.0	16.8	30.2	01-07-1987	10.0	27-07-1969	89	77
August	23.5	16.8	29.9	01-08-1978	12.6	15-08-1972	90	79
September	22.8	14.7	30.0	03-09-1974	8.0	13-09-1979	82	73
October	20.6	10.4	28.0	26-10-1971	1.8	31-10-1961	64	58
November	16.8	6.3	25.1	17-11-1962	0.1	23-11-1978	52	49
December	13.4	3.8	21.2	31-12-1971	-3.1	29-12-1977	55	52
Annual	19.5	10.2	34.2	14-06-1974	-15.1	15-01-1974	65	59

TABLE – 4
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(JOSHIMATH)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	19	16	20	19	19	14	3	2	12	23	24	20	191
b	5	6	5	4	3	4	14	13	5	1	2	4	66
c	2.5	2.5	2.4	1.9	1.6	3.0	5.1	5.3	3.2	0.8	1.0	1.8	2.6
1730 HOURS IST													
a	14	8	7	6	5	5	1	1	5	13	18	18	101
b	7	9	12	11	9	7	14	13	9	4	3	4	102
c	3.4	4.0	4.4	4.6	4.6	4.9	6.0	6.1	4.6	2.7	1.9	2.3	4.1

a: Days with clear sky.
b: Days with sky overcast.
c: Mean cloud amount in Okta.
** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE - 5
Mean Wind Speed and Predominant Wind Direction
(JOSHIMATH)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind Speed in Km/hr	5.5	6.2	7.4	6.2	5.5	3.8	2.8	2.6	2.8	3.8	4.2	5.3	4.7
Direction in morning	E/SE/C	E/SE/C	E	E	E	C/E/NE	C/E/NE	C/E	C/E	E	E/C	E/SE	
Direction in evening	SW/C	SW/C	E/SE/C	C/E	C/E	C/E/SW	C/SW	C/SW	C/SW	C/SW	C/SW/S	SW/S/C	

TABLE - 6
Special Weather Phenomena
(JOSHIMATH)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	0.0	0.1	0.9	1.5	0.9	0.8	0.6	0.5	0.3	0.4	0.1	0.1	6.2
Hail	0.0	0.1	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Dust storm	0.4	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Squall	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Fog	0.4	0.8	0.9	0.1	0.0	1.5	5.4	4.7	3.0	0.4	0.1	0.0	17.3

CHAMPAWAT DISTRICT

Champawat district is situated in the Kumaon division and southeastern part of the state. It shares its international boundary with Nepal on the east. It mainly consists of mountain ranges, large valleys, uneven landscapes, perennial rivers and rivulets. The district headquarters is Champawat town situated at an elevation of 1638 metre above mean sea level. Peak height of the district is about 2000 m. The district divides into three main regions. First one is Tarai region of an average height of 200 m to 250 m. It is a plain and hot area in summer. Second region is Shivalik which is situated at 250 m to 1200 m. It is area of a sloping and uneven topographic land consisting of dense forests. Third region is hilly area with an average height of 1500 m and it is a cold region in winter.

The climate, therefore largely depends on altitude. Northern and central parts of the state are experienced more cold than other parts. The southern most part is hot in summer. The district receives abundant rainfall during the monsoon season. The year may be divided into four seasons. Winter season is from December to early March followed by summer season till the third week of June. Thereafter southwest monsoon season starts and continues till September. The period of October to November is of post monsoon season. Larger part of the district is situated on the southern slopes of the Himalayas, monsoon current can penetrate through trenched valleys, and rainfall reaches its maxima in the monsoon season. Summers are mild hot at high altitudinal areas and winters are too cold and foggy. In summers the hilly terrain of the district is pleasant.

RAINFALL

Records of rainfall in the district are available for three raingauge stations for period ranging from 18 to 35 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district

is 1513.9 mm. The annual rainfall in the district varies over a large range. Owing to the nature of terrain, precipitation is highly variable spatially and is determined by elevation and exposure to rain bearing winds. The rainfall in the southwest monsoon season (June to September) is about 85% of the annual normal rainfall. July and August are the rainiest months with an average of 424.6 mm. With the onset of the summer monsoon (March to May), rainfall increases sharply from the end of June and continues to increase till August and thereafter it decreases. In the monsoon season the depressions or low pressure systems from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. There are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers. Rainfall in the pre-monsoon months of March to May account for 6% of the annual. The winter months of December to February account for about 6 % of the annual normal rainfall. In the fifty-year period 1961 to 2010, the highest annual rainfall of 173% of the normal was recorded in 1990, while the lowest was 24% of the normal in 1972. During this period, there were 6 years in which the rainfall was less than 80% of the normal and there was one occasion of two consecutive years. It is seen from Table 2 that annual rainfall was between 1201 mm and 1900 mm in 14 years out of 33.

On an average there are 61 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 46 at Tanakpur to 71 at Bambasa Hydro.

The heaviest rainfall recorded in 24 hours at any station in the district was 389.9 mm at Champawat on 27th September 1897.

TEMPERATURE

There is no meteorological observatory in the district so, the description which follows is based on the meteorological records of Mukteshwar observatory at an altitude of 2311 m in the neighbouring Nainital district. Champawat town is the headquarters of

the district having an altitude of 1638 m. Temperature variations from place to place are considerable and depend upon elevation as well as location. In the valleys, pool of cold stagnant air causes diurnal range of temperatures to be considerable. January is the coldest month with the mean maximum temperature of about 14°C and mean minimum temperature of about 3°C at Champawat town. At higher altitudes, temperatures may be lowered by 2 - 3°C with reference to Champawat town. Cold waves in the wake of western disturbances often make the conditions more rigorous, when the temperatures below the freezing point of water may be recorded. Fog also prevails over the district. Both day and night temperatures begin to rise from the middle of February. Weather becomes mild warm and pleasant over hilly terrain. June is the warmest month with mean maximum temperature of about 27°C and mean minimum temperature of about 16°C at Champawat town. At higher altitudes temperatures may be lowered by about 2 to 3°C. With onset of the monsoon, day temperature falls slightly in July and is about 25°C till August. The temperatures fall rapidly after withdrawal of monsoon and weather becomes gradually cool and pleasant during post monsoon season. Both day and night temperatures rapidly fall till January when winter is fully established. The temperatures may be high by 6 - 8°C in low elevated areas with reference to Champawat town.

HUMIDITY

The atmosphere over the district is humid during the southwest monsoon season. The values of relative humidity are about 80% to 90% during this period. It is slightly less humid during winter months, when its values are about 60%. The summer season is the driest part of the year with values of relative humidity's are between 40% and 60%. In general values of humidity in the evenings are slightly more than mornings especially in the hilly region.

CLOUDINESS

The skies are heavily clouded to overcast on many days in the southwest monsoon season. The skies are generally clear or lightly clouded in the rest of the year except for few days when the skies become mostly cloudy in passage of western disturbances. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are generally light to moderate throughout the year. In the district winds mainly blow from west or southwest direction. In winter and southwest monsoon seasons northeasterly wind also blow especially in the mornings while westerly and southwesterly winds blow in the evenings. In the rest of year westerly wind especially in the evenings prevails. Sometimes wind is calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year especially in the district. Its frequency is more in the period latter part of pre-monsoon and early period of southwest monsoon season i.e. from April to July and least in months of November and December. During winter and early pre-monsoon season thunderstorms are occasionally accompanied with hail. Fog is common almost throughout the year especially in the northern portion of the district. Fog is generally observed in hilly terrain during monsoon months where its frequency is a maximum. In the winter months fog generally occurs in the wake of western disturbances. In the valleys fog is frequent in morning during winter.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL

CHAMPAWAT

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Bambasa (Hydro)	35	a b	27.6 2.1	38.9 2.3	21.0 1.7	22.1 1.7	50.6 3.5	281.0 10.4	579.3 18.4	501.3 17.0	313.1 10.3	62.4 1.9	7.0 0.4	16.8 1.2	1921.1 70.9	136 (1990)	78 (1999)	340.0	10 Jul 1990
Champawat	29	a b	47.2 3.0	50.0 3.1	33.8 2.7	34.4 3.1	62.0 4.9	134.2 10.5	283.3 14.1	275.0 13.6	166.0 6.6	58.2 2.0	4.7 0.4	19.8 1.0	1168.6 65.0	164 (1971)	31 (1972)	389.9	27 Sep 1897
Tanakpur	18	a b	24.8 1.2	18.9 1.5	15.6 1.0	7.0 0.8	7.8 1.0	148.4 4.9	392.4 10.8	516.4 13.6	282.2 9.2	26.4 1.1	2.1 0.3	9.9 0.7	1451.9 46.1	183 (1961)	82 (1967)	305.1	20 Aug 1961
Champawat (District)		a b	33.2 2.1	35.9 2.3	23.5 1.8	21.2 1.9	40.1 3.1	187.9 8.6	418.3 14.4	430.9 14.7	253.8 8.7	49.0 1.7	4.6 0.4	15.5 1.0	1513.9 60.7	173 (1990)	24 (1972)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data up to 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
CHAMPAWAT
(Data 1961-2010)

Range in mm	No. of years	Range in mm	No. of years
301 – 400	1	1501 – 1600	5
401 – 500	0	1601 – 1700	2
501 – 600	0	1701 – 1800	4
601 – 700	0	1801 – 1900	0
701 – 800	0	1901 – 2000	2
801 – 900	1	2001 – 2100	2
901 – 1000	0	2101 – 2200	2
1001 – 1100	2	2201 – 2300	1
1101 – 1200	2	2301 – 2400	2
1201 – 1300	1	2401 – 2500	3
1301 – 1400	2	2501 – 2600	0
1401 – 1500	0	2601 – 2700	1

(Data available for 33 years)

DEHRADUN DISTRICT

Dehradun district is located in the northwestern part of the state and it comes under the Garhwal region. Southern and southwestern parts of the district are of low elevation, whereas other parts have high elevated areas. Average altitude of the district is about 640 metre above mean sea level. Dehradun town is the headquarters of the district situated at an altitude of 683 m. Peak height of the district is about 2910 m. The district has mainly highland areas and vast forests with cool temperate. Topographically, the region can be divided into two distinct tracts namely the montane tract and the submontane tract. The montane tract consists entirely of a succession of mountains and gorges. The mountains are very rough with steep slopes. The most important features of the tract are ridge which separate the drainage areas of the river on the west from that of Yamuna river on the east. Below the montane tract follows the submontane tract, which is the famous Dune valley bounded by Shivalik hills in the south and outer scraps of Himalaya on the north.

The climate of the district varies from tropical to severe cold towards the north depending upon the altitude of the area. The climate of the district is mainly characterized by hot in summer, cold in winter and abundant rainfall in the monsoon period. The district being hilly has much temperature variation due to topographic variations. In general the year may be divided in to four seasons. The summer season starts from March and lasts up to the third week of June, thereafter southwest monsoon sets in and it continues up to September. The period of October and mid-November is of post monsoon season followed by winter till early March.

RAINFALL

Records of rainfall in the district are available for twelve raingauge stations for period ranging from 10 to 50 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district is 1632.1 mm. The annual rainfall in the district varies over a large range. In general the rainfall increases from the southwest towards the

northeast. The rainfall in the southwest monsoon season (June to September) is about 81% of the annual normal rainfall, July being the rainiest month with the highest rainfall with an average of 489.6 mm and August is the second highest rainfall (457.9 mm) month. The pre-monsoon season (March to May) accounts for 9% of the annual rainfall while the winter season from December to February account for about 7% of the annual normal rainfall. In the period 1961 to 2010, the highest annual rainfall of 192% of the normal was recorded in year 1971, while the lowest was 54% of the normal recorded in 1991. During this period, there were 2 years in which the rainfall was less than 80% of the normal and they were not consecutive. It is seen from Table 2 that the annual rainfall was between 1301 mm and 2000 mm in 31 years out of 45.

In the district especially in higher mountains considerable amount (about 10 to 15 cm) of precipitation is received in the form of snow associated with the passage of western disturbances during the winter months. In the monsoon season the depressions or low pressure systems from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

On an average there are 65 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. It varies from 44 at Ambari to 88 at Mussoorie observatory. The heaviest rainfall recorded in 24 hours at any station in the district was 487.5 mm at Raipur on 02 August 1959.

TEMPERATURE

There are two meteorological observatories in the district, at Dehradun having an altitude of 683 m and Mussoorie at an altitude of 2042 m. The temperature drops below the freezing point of water during the winter in the district, when the higher peaks are under snow. The district being hilly, temperatures varies due to physiographic features. Hence, the records of Dehradun may be taken as

representative of the conditions in the Dune i.e. areas of low elevation (southwestern part), and those of Mussoorie, broadly representative of the hilly regions. After February both day and night temperatures begin to increase rapidly. May and June are generally the hottest part of the year with mean maximum temperature at Dehradun was about 35 °C and that of Mussoorie was 23 °C. On individual days during summer, the maximum temperature rises up to over 42 °C at Dehradun, while at Mussoorie the maximum temperature goes up to over 32°C. In the hilly region, the summer is pleasant, but in the southwestern part of the district the heat is often intense, although not to such a degree as in the plains of adjoining districts. Afternoon thundershowers which occur on some days and bring some relief from the heat, and weather becomes cool and pleasant. With the onset of the southwest monsoon over the district by the end of June there is an appreciable drop in the day temperatures but nights are slightly warm during summer. With the withdrawal of the monsoon by about the last week of September temperatures begin to decrease, the drop in night temperatures being more rapid. January is the coldest month with the mean maximum temperature of 19.8°C and mean minimum temperature of 6.2°C at Dehradun and that of 10.5°C and 2.6°C respectively for Mussoorie. During winter season cold waves affect the district in the rear of passing the western disturbances the minimum temperature sometimes falling down to about a degree below the freezing point of water at places like Dehradun and about –5°C to –6°C in the hilly region and frosts occasionally occur. The temperatures may be 2 - 4°C lower at high altitudinal areas than those of Mussoorie. The temperatures may be 1 - 2°C higher in southern part (low elevated areas) of district than those Dehradun. In winter higher peaks are under snow.

The highest maximum temperature ever recorded at Dehradun observatory was 43.9 °C on 04 June 1902 and that at Mussoorie was 34.4°C on 24.05.1949. The lowest minimum temperature ever recorded at Dehradun was – 1.1°C on 1 February 1905 and on 11 January 1945. While at Mussoorie it was - 6.7°C on 10 February 1950.

HUMIDITY

The atmosphere over the district is mostly humid throughout the year. The relative humidity at Dehradun (southwestern part) is high in mornings whereas it is generally high at Mussoorie (hilly terrain) in evenings. The relative humidity is high during the southwest monsoon season and it is generally above 80% in the mornings at Dehradun and Mussoorie. It is comparatively less humid in the rest of the year. The driest part of the year is the summer season, when the humidity in the afternoons is less than 55% at both places.

CLOUDINESS

The skies are heavily clouded or overcast during southwest monsoon season. It is heavily clouded for short spells of 2 to 3 days at Dehradun and 3 to 10 days at Mussoorie in association with passing western disturbances during winter season. It is usually lightly clouded in the rest of the year. Cloudiness is the least in the post monsoon months; October and November. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are generally light and calm throughout the year in Dun valley. But winds are stronger in the hilly region at Mussoorie observatory. Northeasterly and Northwesterly winds are observed throughout the year in the mornings. Southeasterly winds are also observed at Dehradun during the monsoon season. In the evening generally northwesterly and westerly winds are common throughout the year and in the monsoon season southeasterly and southwesterly components are also observed. In the hilly region southeasterly and southerly winds are observed in mornings throughout the year. Along with these components northerly and northeasterly winds are observed during the winter and summer season. In the afternoons southerly and southwesterly components are observed throughout the year and along with these components northerly winds are seen during winter and early summer season. Sometimes winds are calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Its frequency is more in the southwestern part of the district during the monsoon season. It reduces thereafter with the activity being least in November and December months. During the cold season, western disturbances affect the weather over the district causing occasional thunderstorms some of which are associated with hail. Also thunderstorms occurring in summer are sometimes associated with hail. Dust storms are sometimes observed in summer and monsoon season. Fog is common over hilly areas almost throughout the year. In southwestern part of the district fog is observed in winter months and sometimes during monsoon season.

Table 3, 4, 5 and 6 and 3(a), 4(a), 5(a) and 6(a) give the temperature and humidity, cloudiness, mean wind speed and predominant wind directions, special weather phenomena respectively for Dehradun Observatory and Mussoorie Observatory.

TABLE - 1
NORMALS AND EXTREMES OF RAINFALL
DEHRADUN

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Ambari	16	a b	10.7 0.6	11.5 1.3	31.3 0.9	15.7 0.8	14.1 1.1	167.4 4.8	292.8 10.5	384.7 13.5	217.8 8.4	21.7 1.0	1.6 0.2	20.1 0.8	1189.4 43.9	196 (1966)	55 (1961)	317.5	02 Aug 1907
Bhogpur	16	a b	4.5 0.6	12.2 1.3	13.4 0.5	8.0 0.3	12.5 1.0	192.4 5.3	353.3 10.2	325.0 12.8	208.1 10.9	21.4 1.4	0.5 0.1	11.0 0.7	1162.3 45.1	217 (1961)	88 (1969)	307.3	17 Aug 1921
Chakrata (Hydro)	30	a b	76.0 3.9	81.6 4.4	96.4 6.0	60.9 3.7	78.6 5.7	160.2 9.0	351.2 16.5	316.9 14.6	165.5 7.4	33.9 1.4	14.1 0.7	36.6 1.8	1471.9 75.1	168 (2010)	46 (2009)	246.4	29 Jul 1871
Chakrata Kalsi	33	a b	36.4 2.6	64.7 3.6	55.6 3.5	29.6 2.5	57.1 4.4	137.0 7.2	421.5 15.6	369.6 15.4	168.2 8.0	39.9 1.2	16.8 0.9	18.7 1.2	1415.1 66.1	160 (1961)	38 (1997)	215.9	14 Aug 1903
Dakpathar (Hydro)	30	a b	38.3 2.8	46.3 2.7	61.5 3.0	27.0 2.1	69.9 3.3	147.7 7.4	528.8 16.6	504.1 16.7	249.5 9.1	34.0 1.7	7.9 0.4	20.7 1.2	1735.7 67.0	183 (2010)	44 (2009)	188.8	03 Aug 2012
Dehradun (Obsy)	50	a b	42.0 3.1	58.4 3.8	52.6 3.4	28.0 2.3	51.9 3.9	241.5 9.8	677.9 20.8	694.7 21.5	320.1 12.2	37.0 2.3	9.0 0.7	25.2 1.7	2238.3 85.5	143 (1966)	70 (2002)	487.0	25 Jul 1966
Haripur (Hydro)	20	a b	42.8 2.9	77.6 4.4	46.2 3.2	28.0 2.6	34.1 3.5	183.7 8.0	681.0 19.3	649.6 18.7	375.2 11.6	39.0 1.7	7.5 0.5	12.1 0.8	2176.8 77.2	129 (1998)	77 (2009)	264.8	03 Aug 2001
Koti (Hydro)	10	a b	79.4 4.1	94.0 4.7	102.2 5.9	45.4 3.3	92.8 4.6	114.5 6.6	455.4 14.6	239.5 11.0	87.7 5.0	55.7 2.1	24.5 1.1	46.1 1.9	1437.2 64.9	123 (1982)	74 (1984)	215.3	20 Jul 1982
Mussoorie (Obsy)	28	a b	43.5 3.7	62.9 4.9	63.5 4.5	44.3 3.3	66.7 4.6	189.0 9.1	611.8 21.5	602.2 21.1	264.8 10.7	42.8 2.4	15.3 1.0	14.8 1.4	2021.6 88.2	143 (1971)	67 (1976)	439.4	19 Aug 1890
Raipur	16	a b	25.7 1.8	49.8 1.4	12.0 0.6	71.7 0.8	25.0 1.2	131.3 3.9	383.3 8.8	428.8 13.7	227.0 11.0	20.0 1.4	0.3 0.0	5.0 0.4	1379.9 45.0	239 (1966)	31 (1972)	487.5	02 Aug 1959
Rajpur	25	a b	39.0 2.4	36.7 2.5	54.2 2.0	20.6 1.0	50.9 1.9	215.2 7.0	930.0 15.7	809.9 18.4	209.7 8.2	38.3 1.3	11.0 0.6	10.6 0.7	2426.1 61.7	369 (1965)	67 (1972)	440.4	25 Aug 1954
Tuini (Hydro)	28	a b	59.2 3.6	87.7 5.0	71.0 4.6	43.1 3.4	52.9 4.3	66.2 4.9	188.4 10.3	170.3 10.2	114.3 6.8	32.5 2.0	9.0 0.9	36.1 2.2	930.7 58.2	136 (2005)	64 (1991)	121.8	27 Jun 2001
Dehradun (District)		a b	41.5 2.7	57.0 3.3	55.0 3.2	35.2 2.2	50.5 3.3	162.2 6.9	489.6 15.0	457.9 15.6	217.3 9.1	34.7 1.7	9.8 0.6	21.4 1.2	1632.1 64.8	192 (1971)	54 (1991)		

a: Normal rainfall in mm.

* Based on all available data upto 2010.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
DEHRADUN
(Data 1961-2010)

Range in mm	No. of years	Range in mm	No. of years
801 – 900	1	2001 – 2100	1
901 - 1000	1	2101 - 2200	2
1001 – 1100	0	2201 - 2300	1
1101 - 1200	0	2301 - 2400	2
1201 - 1300	0	2401 - 2500	1
1301 – 1400	3	2501 - 2600	3
1401 – 1500	3	2601 - 2700	0
1501 – 1600	7	2701 - 2800	1
1601 – 1700	3	2801 - 2900	0
1701 – 1800	7	2901 - 3000	0
1801 – 1900	3	3001 - 3100	0
1901 - 2000	5	3101 – 3200	1

(Data available for 45 years)

TABLE – 3
Normals of Temperature and Relative Humidity
(DEHRADUN)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	19.8	6.2	28.6	24-01-2009	-1.1	11-01-1945	85	65
February	22.1	8.4	31.2	25-02-2006	-1.1	01-02-1905	77	55
March	26.8	12.5	37.2	28-03-1892	2.2	06-03-1945	64	45
April	32.3	16.8	40.8	30-04-2009	7.2	23-04-1981	51	34
May	34.8	20.6	43.1	30-05-2012	11.3	15-05-1982	51	37
June	34.2	22.7	43.9	04-06-1902	13.1	01-06-1986	65	53
July	30.7	23.1	40.6	01-07-1931	13.2	17-07-1978	86	78
August	30.0	22.6	37.2	05-08-1949	18.0	04-08-1986	89	82
September	29.9	20.8	36.6	04-09-1974	14.3	30-09-1982	84	76
October	28.8	15.6	36.1	02-10-1901	8.4	24-10-1983	71	65
November	25.3	10.8	30.6	01-11-1952	2.8	30-11-1938	76	67
December	21.5	7.2	27.4	10-12-2008	0.0	31-12-1954	83	69
Annual	28.0	15.6	43.9	04-06-1902	-1.1	11-01-1945	73	61

TABLE – 4
Mean Cloud Amount ^{}(Okta of the Sky) and Mean Number**
of days of Clear and Overcast Skies
(DEHRADUN)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	13	11	12	14	15	10	3	2	6	21	20	15	141
b	3	3	2	2	1	4	10	11	5	1	0	2	44
c	2.6	2.7	2.7	2.0	2.1	3.5	5.6	5.7	4.0	1.0	1.1	2.0	2.9
1730 HOURS IST													
a	8	5	5	6	6	4	1	1	2	11	14	12	75
b	3	3	3	1	2	2	6	7	3	1	0	2	33
c	3.3	3.6	3.5	3.1	3.1	3.9	6.0	6.2	4.9	2.1	1.6	2.5	3.7

a: Days with clear sky.
b: Days with sky overcast.
c: Mean cloud amount in Okta.
^{**} Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE - 5
Mean Wind Speed and Predominant Wind Direction
(DEHRADUN)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	2.4	2.9	3.3	3.6	3.6	3.2	2.6	2.4	2.6	3.0	2.7	2.3	2.9
Direction in morning	C/NE/ NW	C/NE/N W	C/NE/ NW	C/NW/ NE	C/SW/ NW	C/NE/S E	C/SE/ NE	C/NE/ SE	C/NE/ SE	C/NE/ NW	C/NE/ /NW	C/NE/ NW	
Direction in evening	C/NW/ SW	NW/S W/W	SW/N W/W	SW/N W/W	SW/N W/W	SW/N W/W	NW/S E/C	NW/C/ NE	NW/C/ W	C/NW /W	C/N W/W	C/NW/ W	

TABLE - 6
Special Weather Phenomena
(DEHRADUN)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	1.8	3.6	4.8	4.8	9.4	12.7	16.4	15.3	11.7	2.6	0.6	0.9	84.6
Hail	0.1	0.3	0.2	0.1	0.5	0.1	0.0	0.1	0.0	0.2	0.0	0.0	1.7
Dust storm	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.6
Fog	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.7	2.1
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0

TABLE – 3(a)
Normals of Temperature and Relative Humidity
(MUSSOORIE)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	10.5	2.6	21.1	14-01-1949	-5.0	16-01-1935	64	77
February	11.6	3.4	23.3	26-02-1953	-6.7	10-02-1950	64	73
March	16.0	7.2	26.1	27-03-1971	-2.5	23-03-1960	57	63
April	20.8	11.6	29.1	27-04-1970	-1.5	02-04-1965	51	52
May	23.4	14.3	34.4	24-05-1949	3.7	12-05-1982	52	51
June	23.5	15.8	31.7	03-06-1935	4.1	01-06-1962	70	67
July	20.9	15.2	29.4	07-07-1949	11.7	27-07-1986	89	88
August	20.3	14.9	25.6	23-08-1957	7.4	05-08-1962	90	91
September	19.8	13.7	27.2	11-09-1946	1.3	16-09-1963	82	88
October	18.8	10.9	28.1	17-10-1983	2.6	31-10-1961	63	78
November	15.4	7.2	25.0	17-11-1952	-2.1	29-11-1960	59	75
December	12.8	4.3	23.3	30-12-1965	-3.9	31-12-1954	57	74
Annual	17.8	10.1	34.4	24-05-1949	-6.7	10-02-1950	67	73

TABLE – 4(a)
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(MUSSOORIE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	13	12	11	13	17	11	1	1	5	18	19	15	136
b	6	5	5	3	3	6	19	18	10	2	1	3	81
c	3.1	3.4	3.2	2.7	2.1	4.0	6.5	6.8	4.6	1.6	1.5	2.5	3.5
1730 HOURS IST													
a	6	4	4	3	5	3	0	0	1	6	16	13	61
b	10	6	5	3	4	5	19	21	10	4	2	4	93
c	4.2	4.5	4.6	4.5	3.8	4.9	6.9	7.3	6.0	3.3	2.4	2.9	4.6

a: Days with clear sky.

b: Days with sky overcast.

c: Mean cloud amount in Okta.

** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.

For example: 1 Okta means 1/8th of the sky covered.

TABLE – 5(a)
Mean Wind Speed and Predominant Wind Direction
(MUSSOORIE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	8.0	8.8	9.7	9.4	9.1	7.2	6.2	5.5	6.0	6.9	7.2	7.4	7.6
Direction in morning	C/N/S/SE/NE	C/N/S/SE	C/N/S/SE	C/S/N/SE	C/S/N/SE	C/S/SE	C/S/SE	C/S/SE	C/S/SE	C/S/SE	C/S/SE	C/N/S/SE	
Direction in evening	S/N/SE	S/SE/SW/N	S/SE/N	S	S/SE	S/C/SE	C/S/SE	C/S/SE	C/S/SE	S/SE/C	S/SE/C	S/C/SE	

TABLE – 6(a)
Special Weather Phenomena
(MUSSOORIE)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	1.1	1.6	2.8	4.0	5.7	4.1	3.0	3.4	3.4	1.3	0.6	0.3	31.3
Hail	0.9	0.8	0.8	0.2	0.7	0.2	0.1	0.0	0.1	0.2	0.0	0.3	4.3
Dust storm	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.4
Fog	2.4	1.9	1.1	0.1	0.1	4.0	10.0	14.0	7.9	3.0	1.2	0.8	46.4
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

HARDWAR DISTRICT

Hardwar district lies in the southwestern part of the state and it comes under the Garhwal division. Hardwar district has mostly gangetic plain areas and some hilly terrain of the elevation ranging from 230 metre to 869 metre above mean sea level. Peak height is about 869 metre in the northwestern part of the district. In the vicinity of Shivalik hills, the slope in the district is some steep.

The climate of this district is generally characterized by cold in winter, hot in summer and humid in monsoon period. The year may be divided in to four seasons. Winter starts from the middle of November when both the day and night temperatures fall rapidly till mid-February. The period of March to third week of June is of summer season followed by southwest monsoon season till the last week of September. The period of October to mid-November constitutes the post monsoon season.

RAINFALL

Records of rainfall in the district are available for only two rain gauge stations for a period of 34 and 41 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district is 1334.5 mm. The annual rainfall in the district varies over a moderate range. The rainfall increases from south to north. The rainfall in the southwest monsoon season (June to September) is about 84% of the annual normal rainfall, August being the rainiest month with an average rainfall of 367.5 mm and July is the second highest rainfall month with an average of 335.3 mm. The rainfall in the pre-monsoon season (March to May) accounts for 7% of the annual normal rainfall and the winter months of December to February is about 7%. In the period 1961 to 2010, the highest annual rainfall of 163% of the normal was recorded in year 1998, while the lowest was 57% of the normal recorded in 1987. During this period, there were 2 years in which the rainfall was less than 80% of the normal and which were also

consecutive years. It is seen from Table 2 that the annual rainfall was between 901 mm and 1500 mm in 16 years out of 28.

On an average there are 53 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. It varies from 47 at Roorkee observatory to 59 at Hardwar.

The heaviest rainfall recorded in 24 hours at any station in the district was 495.3 mm at Hardwar Hydro on 18 September 1880.

TEMPERATURE

Hardwar town is the headquarters of the district located at an elevation of about 583 m. There is one meteorological observatory in the district at Roorkee having altitude 274 m. The records of this observatory may be taken as representative of the meteorological conditions prevailing in the district in general. The temperatures begin to increase rapidly from the end of February. May and June are generally the hottest months with the mean maximum temperature at 37.7°C and the mean minimum temperature at 23.5°C. The heat in summer is intense and the maximum temperature on individual day goes up to 46°C. Afternoon thundershowers which occur on some days and bring some relief from hot weather though only temporarily. With the onset of the monsoon by about the beginning of July, there is an appreciable drop in the day temperatures. But nights during southwest monsoon season are slightly warmer than latter part of summer season. After September temperature starts to decrease, the drop in the night temperatures being very rapid. January is the coldest month with a mean maximum temperature at 20.1 °C and the mean minimum temperature at 6.2 °C. During winter season in association with passing western disturbances, cold waves prevail in the district and the minimum temperature occasionally drops down to below the freezing point of water. Frosts occur on such occasions. The temperatures may be 2 – 3°C lower at hilly areas than those of Roorkee.

The highest maximum temperature ever recorded at Roorkee observatory was 47.4°C on 22 May 1978 and the lowest minimum temperature was -2.2°C on 2 February 1905.

HUMIDITY

The relative humidity is high throughout the year except in pre-monsoon season. The relative humidity during July to February generally exceeds 65% on an average. The mornings are comparatively more humid than the afternoons, as the humidity is about 80% in the mornings and about 60% in afternoons. Summer (March to May) is the driest part of the year with relative humidity between the range of 35% and 45% in the afternoon.

CLOUDINESS

During the southwest monsoon season and for short spells of 2 to 3 days in the winter season in association with passing western disturbances, skies are generally heavily clouded or overcast. The hills are often enveloped in cloud. It is usually lightly clouded or clear in the rest of the year.

WINDS

Winds are generally light with some increase in force during the late summer and monsoon season. Winds are generally calm throughout the year. Southeasterly winds also appear in May to August. Northwesterly winds appear in the district during winter and summer season. Sometimes wind is calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur generally throughout the year. Its frequency is maximum in the months of May to July. In the winter season passing western disturbances affect the weather over the district causing few thunderstorms, some of

which are accompanied with hail. Duststorms occur during the summer season and early monsoon season. Fog occurs occasionally during the winter season.

Table 3, 4, 5 and 6 give the temperature and humidity, cloudiness, mean wind speed and predominant wind directions, special weather phenomena respectively for Roorkee observatory.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
HARDWAR

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Hardwar (Hydro)	34	a b	30.3 2.4	45.9 2.6	34.8 2.5	20.8 1.6	33.2 2.7	144.4 6.7	381.4 13.9	432.7 15.5	196.9 7.8	23.3 1.1	5.1 0.4	16.7 1.3	1365.5 58.5	143 (1998)	57 (1987)	495.3	18 Sep 1880
Roorkee (Obsy)	41	a b	28.0 2.3	37.0 2.2	33.6 2.4	14.3 1.2	26.8 2.3	118.6 5.4	289.2 10.7	302.4 12.0	150.5 5.8	19.0 1.2	4.5 0.5	16.8 1.2	1040.7 47.2	164 (1971)	57 (1987)	284.7	17 Sep 1880
Hardwar (District)		a b	29.1 2.3	41.5 2.4	34.2 2.5	17.5 1.4	30.0 2.5	131.5 6.1	335.3 12.3	367.5 13.8	173.7 6.8	21.1 1.2	4.8 0.5	16.7 1.2	1202.9 53.0	163 (1998)	57 (1987)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

*. Based on all available data up to 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
HARDWAR
(Data 1961-2010)

Range in mm	No. of years	Range in mm	No. of years
601 – 700	2	1301 – 1400	1
701 – 800	2	1401 – 1500	3
801 – 900	2	1501 - 1600	2
901 – 1000	1	1601 - 1700	0
1001 – 1100	5	1701 - 1800	2
1101 – 1200	2	1801 - 1900	1
1201 – 1300	4	1901 - 2000	1

(Data available for 28 years)

TABLE – 3
Normals of Temperature and Relative Humidity
(ROORKEE)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	20.1	6.2	30.1	28-01-1991	-1.1	17-01-1935	87	61
February	23.5	8.4	31.9	28-02-2004	-2.2	02-02-1905	81	53
March	28.8	13.1	39.0	31-03-1973	2.8	06-03-1945	70	44
April	35.2	18.3	43.8	27-04-1970	7.2	04-04-1905	52	35
May	37.7	22.5	47.4	22-05-1978	11.1	26-05-1980	50	37
June	37.6	24.4	46.7	13-06-1932	16.1	14-06-1900	60	47
July	33.8	25.0	45.0	01-07-1931	18.8	11-07-2003	81	69
August	32.7	24.6	39.8	14-08-1960	19.0	04-08-1990	85	74
September	32.7	22.9	38.3	10-09-1899	15.2	22-09-1972	84	68
October	31.5	17.0	38.3	07-10-1899	8.9	31-10-1953	75	57
November	27.4	11.3	33.9	01-11-1952	2.2	30-11-1966	79	59
December	22.5	7.3	30.5	03-12-1987	-0.7	25-12-1902	85	60
Annual	30.3	16.8	47.4	22-05-1978	-2.2	02-02-1905	74	55

TABLE – 4
Mean Cloud Amount ^{}(Okta of the Sky) and Mean Number**
of days of Clear and Overcast Skies
(ROORKEE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	13	10	12	14	14	9	2	0	5	20	21	14	134
b	3	2	1	0	0	1	3	2	1	0	0	2	15
c	2.4	2.2	2.5	1.7	1.7	2.6	4.0	4.2	3.2	0.9	0.7	1.9	2.3
1730 HOURS IST													
a	14	9	12	12	14	9	1	0	4	20	21	14	130
b	1	1	1	0	0	0	1	1	0	0	0	1	6
c	2.1	2.3	2.6	1.9	1.7	2.3	3.9	4.0	3.1	0.9	0.7	1.8	2.3

a: Days with clear sky.
b: Days with sky overcast.
c: Mean cloud amount in Okta.
^{**} Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE - 5
Mean Wind Speed and Predominant Wind Direction
(ROORKEE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	2.5	3.2	4.1	4.6	5.4	4.9	4.7	3.7	3.4	2.3	1.7	2.2	3.6
Direction in morning	C	C/NW	C/NW	C/NW/SE	C/SE	C/SE	C/SE	C/SE	C	C	C	C	
Direction in evening	C	C/NW	C/NW	C/NW	C/NW	C/SE/NW	C/SE	C/SE	C/NW	C	C	C	

TABLE - 6
Special Weather Phenomena
(ROORKEE)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	0.5	1.0	2.5	1.9	3.2	3.4	3.7	2.6	2.1	0.3	0.3	0.5	22.0
Hail	0.1	0.1	0.3	0.1	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.1	1.1
Dust storm	0.0	0.0	0.1	0.2	0.1	0.6	0.1	0.0	0.0	0.1	0.0	0.0	1.2
Fog	5.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	2.8	10.5
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

NAINITAL DISTRICT

The district lies in Kumaon division of the state. The district is geographically divided in two zones viz. outer Himalayan region termed as the hilly region having big and small lakes and rivers, and the foot-hills areas in the southern part of the district known as Bhabhar. The mountains in the northern portion of the district have general elevation of about 2000 metre above mean sea level. Baudhanstali is the highest peak of the district, having an altitude of 2623 m. Nainital town is the headquarters of the district located at an elevation of 1938 m.

The climate is characterized by severe cold in winter and mild hot in summer in the northern part whereas in southern part it is hot in summer, cold in winter and abundant rain in the monsoon period. In general the year may be divided in to four seasons. The summer season is from March to third week of June and thereafter southwest monsoon season starts and lasts till September. The period of October to mid-November constitutes the post monsoon season followed by winter season till early March.

RAINFALL

Records of rainfall in the district are available for seven raingauge stations for period ranging from 19 to 50 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district is 1521.2 mm. Rainfall in the district is highly variable spatially and depends upon physiographic features. More rainfall occurs on the windward (southern) side of the hills. Nainital itself owing to its position on the southern slope receives about double the rainfall of Mukteshwar which is located at a higher elevation. The variation in annual rainfall from year to year is large. The rainfall in the southwest monsoon season (June to September) is about 86% of the annual normal rainfall, while the rainfall in the pre-monsoon months (March to May) is about 6% of the annual. July and August are the rainiest months with an average of 434.7 mm. In the winter months (December to February) rainfall occurs about 5% of the annual normal mostly as snowfall in the hills and rain at lower elevation in association with the

passage of western disturbances. In the fifty years period of 1961 to 2010, the highest annual rainfall of 157% of the normal was recorded in year 1971, while the lowest was 33% of the normal recorded in 1991. During this period, there were 12 years in which the rainfall was less than 80% of the normal and there were two occasions of two consecutive years of such a low rainfall. It is seen from Table 2 that the annual rainfall was between 1201 mm and 1900 mm in 22 years out of 39 for which whole year data is available.

During winter months precipitation is received about 70 to 100 cm in the form of snow at high peaks in the district.

On an average there are 59 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 37 at Kilpuri to 91 at Nainital Observatory.

The heaviest rainfall recorded in 24 hours at any station in the district was 413.0 mm at Haldwani on 11th July 1970.

TEMPERATURE

There are two meteorological observatories, one at Mukteshwar (alt. 2311m) and other is at Nainital (alt.1953m.). Meteorological records for Mukteshwar and Nainital may be taken as fairly representative of the meteorological conditions in the hilly parts of the district, whereas temperature and other meteorological conditions in Tarai region for which metrological records are not available, hence the records of adjacent observatory Pantnagar at altitude 233 m in Udham Singh Nagar district may be taken to describe the climate for this region. Temperature begins to increase from mid-February. May and June are the hottest months with mean maximum temperature of the order of 22°C to 24°C and mean minimum temperature is of the order of 12°C to 16°C in the mountainous terrain. In the plains during this season, the mean maximum temperatures is of the order of 35 °C to 37 °C and mean minimum temperature is of the order of 21°C to 24°C. With the onset of the

southwest monsoon by about the end of June, the day temperature decreases while night temperature remains same or slightly more in the summer season. After withdrawal of monsoon by the end of September, both the temperatures begin to decrease steadily. January is the coldest month with the mean minimum temperature being about 1 - 2°C and mean maximum temperature of about 10 -12°C in the mountainous region. In the plains during this month, the mean minimum temperature is of about 5°C and the mean maximum temperature is of about 20°C. On individual days in association with cold waves in the wake of western disturbances which affect the district during the winter season, the minimum temperatures may go down to 1 to 7°C below the freezing point of water in the mountainous region and near about the freezing point of water in the plains.

The highest maximum temperature ever recorded in the district was 32.5°C at Mukteshwar observatory on 16th June 2012 and the lowest minimum temperature was -7.8°C at Mukteshwar on 10th February 1905.

HUMIDITY

The atmosphere over the district is humid during the southwest monsoon season. The values of relative humidity are about 80% to 90% during this period. It is slightly less humid during winter months, when its values are about 60%. The summer season is the driest part of the year with values of relative humidity in order of 40% to 60%. In general values of humidity in the evenings are slightly more than mornings especially in the hilly region.

CLOUDINESS

The skies are heavily clouded to overcast on many days in the southwest monsoon season. The skies are generally clear or lightly clouded in the rest of the year except for few days each time in association of western disturbances when the skies become cloudy.

WINDS

Winds are generally light to moderate throughout the year. In the northern portion of the district winds mainly blow from west or southwest direction. In winter and southwest monsoon seasons northeasterly winds also blow especially in the mornings. In the southern portion of the district during southwest monsoon season easterly wind in the mornings and easterly / southeasterly wind in the evenings are predominant. In the rest of year westerly wind especially in the evening is predominant. Sometimes wind is calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Its frequency is more in the northern portion of the district than southern portion. Its frequency is also more in the latter part of pre-monsoon and southwest monsoon season and least in the months of November and December. In winter and pre-monsoon season thunderstorms are occasionally accompanied with hail. Fog is common almost throughout the year especially in the northern portion of the district. Fog over hills is common during monsoon months. In the winter months fog generally occur in the wake of western disturbances. In the valleys fog is frequent in the mornings during winter.

Table 3, 4, 5 and 6 and 3(a), 4(a), 5(a) and 6(a) give the temperature and humidity, cloudiness, mean wind speed and predominant wind directions, special weather phenomena respectively for Nainital observatory and Mukteshwar observatory.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
NAINITAL

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Haldwani	35	a b	20.5 1.3	26.8 2.0	17.1 1.4	11.0 1.0	34.2 2.0	229.8 8.3	579.0 16.1	504.2 14.6	255.2 8.3	55.9 1.6	5.0 0.4	8.7 0.7	1747.4 57.7	169 (1971)	28 (1998)	413.0	11 Jul 1970
Kaladhungi	35	a b	31.6 1.6	25.7 1.6	19.6 1.5	8.6 1.0	29.8 2.2	133.3 6.0	449.5 14.0	385.9 14.3	235.2 8.8	33.3 1.4	0.9 0.2	10.3 0.9	1363.7 53.5	141 (1961)	63 (1965)	304.8	13 Jul 1953
Kathgodam	21	a b	26.5 1.9	28.1 1.8	18.1 1.6	7.2 0.7	45.1 1.9	242.9 8.6	425.9 13.3	555.5 17.9	307.3 9.1	34.9 1.5	3.3 0.2	7.0 0.5	1701.8 59.0	167 (1973)	83 (1972)	306.6	15 Jul 1897
Kilpuri	19	a b	14.3 1.2	16.6 1.3	8.0 0.8	6.0 0.6	10.0 0.9	125.8 4.9	297.0 9.2	273.8 10.8	133.9 5.1	24.3 1.5	3.3 0.4	8.4 0.6	921.4 37.3	223 (1961)	75 (1965)	330.2	06 Aug 1885
Mukteshwar (Obsy)	50	a b	48.0 3.4	60.1 4.3	55.3 4.0	39.7 3.1	66.6 5.6	139.6 9.2	289.7 15.0	283.5 15.1	227.8 10.1	38.9 2.1	8.9 0.7	21.4 1.4	1279.5 74.0	154 (1980)	64 (1979)	254.5	18 Sep 1914
Nainital (Obsy)	20	a b	62.9 3.6	67.2 3.9	54.5 3.6	35.9 2.8	77.6 4.9	363.0 13.2	753.5 21.9	600.2 20.4	358.6 11.5	62.4 3.2	6.7 0.4	22.0 1.4	2464.5 90.8	127 (1961)	75 (1965)	313.7	15 Sep 1957
Ramnagar	35	a b	23.6 1.3	28.9 1.5	20.8 1.4	12.7 0.8	30.7 2.0	158.7 6.3	382.4 12.3	306.1 11.3	157.6 5.8	38.2 1.4	3.2 0.3	7.2 0.7	1170.1 45.1	166 (1961)	09 (1991)	291.0	14 Oct 1985
Nainital (District)		a b	32.5 2.0	36.2 2.3	27.6 2.0	17.3 1.4	42.0 2.8	199.0 8.1	453.9 14.5	415.6 14.9	239.4 8.4	41.1 1.8	4.5 0.4	12.1 0.9	1521.2 59.5	157 (1971)	33 (1991)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
NAINITAL
(Data 1961-2010)

Range in mm	No. of years	Range in mm	No. of years
501 – 600	1	1501 – 1600	0
601 – 700	0	1601 – 1700	5
701 – 800	0	1701 – 1800	2
801 – 900	2	1801 – 1900	1
901 – 1000	2	1901 – 2000	3
1001 – 1100	5	2001 – 2100	1
1101 – 1200	1	2101 – 2200	0
1201 – 1300	5	2201 – 2300	1
1301 – 1400	3	2301 – 2400	1
1401 – 1500	6		

(Data available for 39 years)

TABLE – 3
Normals of Temperature and Relative Humidity
(NAINITAL)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	10.7	1.7	18.4	26-01-1974	-5.6	17-01-1953	63	67
February	12.3	3.5	21.7	26-02-1953	-4.3	07-02-1972	54	61
March	16.3	7.5	24.6	20-03-1974	-3.0	09-03-1979	47	54
April	20.8	11.9	28.0	14-04-1964	0.0	03-04-1965	44	45
May	23.5	14.6	29.6	19-05-1972	5.0	02-05-1969	46	46
June	23.5	16.4	30.0	18-06-1972	10.0	01-06-1975	67	65
July	21.6	16.5	26.1	01-07-1954	10.4	11-07-1964	84	84
August	21.0	16.0	26.6	17-08-1972	9.6	24-08-1969	85	85
September	20.7	14.1	24.6	20-09-1972	-1.1	22-09-1962	77	81
October	18.7	9.7	24.8	31-10-1964	4.4	31-10-1961	57	68
November	15.4	5.7	21.4	01-11-1964	0.5	29-11-1966	53	65
December	12.9	3.1	21.8	04-12-1964	-4.4	31-12-1954	55	63
Annual	18.1	10.1	30.0	18-06-1972	-5.6	17-01-1953	61	65

TABLE – 4
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(NAINITAL)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	16	17	18	18	20	10	2	3	7	21	23	20	175
b	7	5	4	3	3	11	19	18	10	4	2	3	89
c	2.8	2.4	2.2	1.9	1.8	4.4	6.6	6.2	4.3	1.4	1.2	1.7	3.1
1730 HOURS IST													
a	15	14	17	15	18	10	4	3	6	16	17	18	153
b	6	5	4	3	3	6	15	15	10	4	3	3	77
c	3.1	2.7	2.5	2.2	1.9	3.8	6.1	6.4	4.6	1.7	1.8	2.3	3.3

a: Days with clear sky.
b: Days with sky overcast.
c: Mean cloud amount in Okta.
** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE - 5
Mean Wind Speed and Predominant Wind Direction
(NAINITAL)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	7.2	7.7	7.8	7.7	7.8	7.0	7.8	7.9	6.8	6.6	6.6	6.5	7.3
Direction in morning	C/W	C/W/N	C/N/E	C/E/N	E/C/W	E	E	E	C/E	C/E	C/E	C/W	
Direction in evening	W	W	W	W/N/E	W/N/E	W/E/N	E/SE	E/SE/W	W/E/SE	W	W	W	

TABLE - 6
Special Weather Phenomena
(NAINITAL)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	0.0	0.2	0.2	0.3	0.1	0.7	0.4	0.4	0.3	0.0	0.1	0.0	2.7
Hail	0.4	0.2	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.1	1.7
Dust storm	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Fog	0.8	0.5	0.1	0.0	0.0	0.8	2.6	2.7	1.0	0.1	0.4	0.2	9.2
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0

TABLE – 3(a)
Normals of Temperature and Relative Humidity
(MUKTESHWAR)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	12.3	1.7	23.0	24-01-1990	-7.6	12-01-1992	53	63
February	13.4	2.4	24.2	03-02-1988	-7.8	10-02-1905	55	63
March	17.4	5.4	28.5	20-03-2004	-5.9	09-03-1979	50	60
April	22.2	9.5	31.5	30-04-1999	-1.7	05-04-1937	42	46
May	23.7	11.7	31.1	17-05-2004	2.3	21-05-1993	57	59
June	23.6	13.4	32.5	16-06-2012	5.9	04-06-1999	71	69
July	21.5	13.8	30.6	01-07-1901	4.6	07-07-1972	91	88
August	20.8	13.6	27.9	01-08-1983	9.8	24-08-1993	92	90
September	20.7	12.2	26.8	03-09-1968	1.3	26-09-1964	82	86
October	19.8	9.1	25.5	07-10-1974	0.8	17-10-1980	60	74
November	17.0	5.6	23.1	17-11-1962	-2.3	23-11-1992	51	69
December	14.2	3.3	22.5	04-12-1987	-5.0	31-12-1954	46	62
Annual	18.9	8.5	32.5	16-06-2012	-7.8	10-02-1905	63	69

TABLE – 4(a)
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(MUKTESHWAR)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	11	9	11	13	11	6	1	0	3	15	17	13	110
b	3	3	3	2	2	6	12	12	7	1	1	2	53
c	2.7	3.0	2.8	2.4	2.5	4.1	6.3	6.4	4.5	1.5	1.3	2.2	3.3
1730 HOURS IST													
a	6	3	4	5	4	2	0	0	0	6	11	9	50
b	3	3	3	2	2	3	8	10	5	1	1	2	43
c	3.2	3.8	3.8	3.6	3.4	4.4	6.2	6.5	4.9	2.3	1.7	2.5	3.9

a: Days with clear sky.

b: Days with sky overcast.

c: Mean cloud amount in Okta.

** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
 For example: 1 Okta means 1/8th of the sky covered.

TABLE – 5(a)
Mean Wind Speed and Predominant Wind Direction
(MUKTESHWAR)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	5.4	6.8	7.8	8.5	5.2	5.5	4.7	4.3	3.6	3.7	3.9	4.9	5.4
Direction in morning	C/NE/W	C/NE/W	C/W/NE	W/C/SW	W/C/SW	W/C/SW	C/NE/W	C/NE/W	C/NE/W	C/NE/E	C/NE/W	C/NE/W	
Direction in evening	C/W/SW	W/SW/C	W/SW/C	W/SW/NE	W/SW/C	WSWC	W/SW/C	W/C/SW	W/SW/C	C/W/SW	C/W/SW	C/W/NE	

TABLE – 6(a)
Special Weather Phenomena
(MUKTESHWAR)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	0.9	2.8	3.9	5.6	8.7	9.0	4.8	4.3	5.2	2.2	0.5	0.7	48.6
Hail	0.5	1.5	1.4	1.0	1.0	0.4	0.1	0.0	0.2	0.1	0.2	0.4	6.8
Dust storm	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Fog	2.2	2.2	1.0	0.8	1.3	6.4	16.0	17.7	10.6	2.3	1.2	1.4	63.1
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PAURI GARHWAL DISTRICT

The district has mostly hilly terrain with high ridges, narrow deep valleys, perennial rivers and some area of low elevation in southern part. The elevation in some parts of the district goes up to 3000 metre above mean sea level and therefore elevation has a great influence on the climate of the district. The district headquarters is Pauri town situated at an altitude of 1646 m. It is situated in the Garhwal division of the state.

Being situated on the southern slopes of the Himalayas, the district gets good rainfall from southwest monsoon current. The climate is generally characterized by severe cold in winter and mild hot in summer in hilly terrain (northern part). However, in the valleys and comparatively low elevated areas and almost southern part in the district, climate is a hot during April to mid-June. In general the year may be divided into four seasons. The rainy season generally commences from the end of June and lasts till September. The period of October to mid-November constitutes the post monsoon season and is followed by winter season till early March. Summer or pre-monsoon season starts from March and lasts till the third week of June.

RAINFALL

Records of rainfall in the district are available for four raingauge stations for period ranging from 21 to 35 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. Rainfall in the district has large variations due to its orography. The annual rainfall variation from year to year is also large. The average annual rainfall is 1040.1 mm. The rainfall in the southwest monsoon season (June to September) is about 82% of the annual normal, July being the month with the highest rainfall with an average of 306.2 mm. The rainfall in pre-monsoon months (March to May) is about 7% of the annual normal. The winter months (December to February) account for about 9% of the annual normal rainfall. There are two rainfall minima one in April and other in November. After April, the rainfall gradually increases till June and thereafter sharply increases in July. It decreases rapidly after withdrawal of the southwest monsoon by September. During

monsoon season under favourable conditions spurts of heavy rain occur in the hills causing inundation of the small tributaries. Precipitation during winter months is often associated with the passage of western disturbances and is sometimes in the form of snowfall particularly at higher elevations. Precipitation during pre-monsoon months is mostly associated with thunderstorms. In the period 1961 to 2000, the highest annual rainfall of 196% of the normal was recorded in year 1989, while the lowest was 24% of the normal recorded in 1997. During this period, there were three years in which the rainfall was less than 80% of the normal and there was one occasion of two consecutive years of such a low rainfall. It is seen from table 2 that annual rainfall in the district is between 801mm to 1300 mm in 7 years out of 18 years.

In the monsoon season the depressions or low pressure systems from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

On an average there are 44 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 30 at Srinagar to 64 at Landsdown.

The heaviest rainfall recorded in 24 hours at any station in the district was 349.0 mm at Kotdwara on 27th August 1892.

TEMPERATURE

There is one meteorological observatory at Pauri in the district but meteorological records of this observatory are not sufficient (available for very short period) for description. Hence the meteorological parameters recorded at Pauri which is the headquarters of the district situated at an altitude of 1646 m and Tehri observatory (Alt 770 m) in the neighbouring districts may be taken for climatic description for this district. The district being hilly with deep valleys, the temperature varies from place to place depending on elevation. Generally June is the hottest

month with mean maximum temperature of about 27°C and mean minimum temperature of about 18°C at Pauri town. However, on individual days maximum temperature may rise to about 34°C at Pauri. With the onset of the monsoon, the maximum temperature falls by about 2°C and minimum temperature is same or slightly more as in summer. With the withdrawal of the monsoon by end of September, both day and night temperatures decrease and weather becomes gradual cool and pleasant. The temperatures fall rapidly from November to January. January is the coldest month with mean maximum temperature about 12°C and minimum temperature about 3°C at Pauri. During the winter months, cold waves associated with the western disturbances may bring down night temperatures appreciably, even below freezing point of water on some occasions. The temperatures may be 8 - 10°C higher in low elevated areas and 5 – 7°C lower in high altitudinal areas with reference to Pauri.

HUMIDITY

The atmosphere over the district is humid throughout the year except summer season. During the southwest monsoon season particularly in the rainiest months July and August, when values of relative humidity are about 90% in the mornings and about 75% to 80% in the afternoons. The driest part of the year is the pre-monsoon season, when humidity may become as low as 25% - 35% during the afternoons.

CLOUDINESS

The skies are clouded to overcast on many days in southwest monsoon season particularly in the rainiest months July and August. During winter months skies are heavily clouded to overcast for short spells, when the district is affected by western disturbances. In the rest of the year skies are mostly clear or lightly clouded.

WINDS

Owing to the nature of the terrain, local effects are pronounced and when the general prevailing winds are not strong to mask these effects, there is a tendency for

diurnal reversal of winds, blowing up the slopes during the day (anabatic flow) and down the slopes at night (Katabatic flow). Katabatic wind blows with considerable force. In the afternoon wind mainly blows from southwest / south direction in winter, east in summer and southeast / west directions in southwest monsoon season. Sometimes, wind is calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Some thunderstorms during the latter part of winter and pre-monsoon are associated with hail or dust storms. Fog is common over hilly terrain during the monsoon and fog occasionally occurs in other seasons in the district. Its frequency is more in monsoon months and during the cold season, in the wake of western disturbances. In the valleys, fog occurs frequently in mornings during winter.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
PAURI GARHWAL

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Bironkhol	35	a b	37.7 1.7	50.0 2.5	31.4 1.7	12.9 1.1	37.3 2.7	97.3 4.9	205.2 9.1	202.8 10.6	128.0 4.9	12.4 1.0	1.4 0.1	26.0 0.9	842.4 41.2	203 (1963)	11 (1997)	255.3	29 Sep 1924
Kotdwara	26	a b	37.1 1.6	21.9 1.3	16.9 1.1	10.0 0.4	35.2 1.5	147.6 5.2	350.8 10.3	326.3 10.7	203.5 5.8	23.6 0.9	1.8 0.2	12.8 0.6	1187.5 39.6	192 (1961)	24 (1968)	349.0	27 Aug 1892
Landsdown	35	a b	42.2 2.2	36.8 2.2	31.2 1.7	26.9 1.6	38.1 2.5	152.1 7.1	538.1 17.1	506.8 18.4	196.8 8.5	29.9 1.4	9.4 0.3	27.5 1.4	1635.8 64.4	162 (1961)	25 (1997)	323.1	29 Sep 1924
Srinagar	21	a b	25.9 1.7	42.4 2.6	23.4 1.6	6.5 0.6	15.0 1.4	51.7 3.0	130.7 6.3	107.0 6.6	66.4 3.7	7.0 0.7	4.5 0.6	14.2 1.1	494.7 29.9	267 (1961)	10 (1972)	190.5	18 Sep 1880
Pauri Garhwal (District)		a b	35.7 1.8	37.8 2.2	25.7 1.5	14.1 0.9	31.4 2.0	112.2 5.1	306.2 10.7	285.7 11.6	148.7 5.7	18.2 1.0	4.3 0.3	20.1 1.0	1040.1 43.8	196 (1989)	24 (1997)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

TABLE - 2
Frequency of Annual Rainfall in the District
PAURI GARHWAL
(Data 1961-2000)

Range in mm	No. of years	Range in mm	No. of years
201 – 300	1	1201 – 1300	2
301 – 400	0	1301 – 1400	3
401 – 500	0	1401 – 1500	1
501 - 600	0	1501 - 1600	0
601 – 700	1	1601 - 1700	1
701 – 800	0	1701 - 1800	2
801 – 900	1	1801 - 1900	0
901 – 1000	0	1901 - 2000	1
1001 – 1100	2	2001 – 2100	1
1101 – 1200	2		

(Data available for 18 years)

PITHORAGARH DISTRICT

Pithoragarh district has hilly terrain with valleys and rivers. It lies in the northeastern part of Kumaon division of the state. The headquarters of the district is Pithoragarh town at an altitude of 1635 metre above mean sea level. The terrain of this district is highly rugged marked with high mountains, snow-capped peaks, valleys, forests, waterfalls, perennial rivers and glaciers. Peak height in the district is about 6861 m. It lies in the southeastern part of the central Himalayas with Indo - Tibetan watershed divided in the north and the Kali river forming a continuous border with Nepal in the east. The enormous snow reservoirs act as a natural source of big rivers originating at the base of the Himalayas. Roughly 30% area of the district wears the perpetual snow cover and gigantic masses of sliding snow feed a number of glaciers which in turn feed the three important northern most rivers viz. Kunti, Yangti, Dhauli and Gori. The general slope of valleys is from northwest to southeast.

The climate, therefore largely depends on physiographic features. The climate of district is generally characterized by severe cold in winter, mild hot in summer and abundant rain in monsoon period. Moderate hot weather is also experienced in the southern valleys during the summer. As most of the district is situated on the southern slope of Himalayas, monsoon currents penetrate through deeply trenched valleys and rainfall is maximum in the southwest monsoon season from the third week of June to September particularly in the southern half of the district. The period October to mid-November constitutes the post monsoon season is followed by winter till mid-March. Summer season is from mid-March to mid-June. Northern part of the district gets considerable rain during the winter season.

RAINFALL

Records of rainfall in the district are available for nine raingauge stations for period ranging from 10 to 45 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. Table 1 also gives the heaviest rainfall in 24 hrs recorded at individual stations up to 2010. All these stations are more representative of the river valleys. Rainfall generally increases from the south

towards the north till Munsyari sector thereafter it progressively decreases in northern areas. The average annual rain in the district is 1775.4 mm. The variation in annual rainfall from year to year is large in the district. Owing to the nature of terrain, the rainfall is variable spatially and depends upon physiographic features. Most of the rainfall to the south of Munsyari occurs during the south west monsoon season (June to September), which accounts for 70 to 80 percent of annual precipitation. While northern part receives rainfall for about 40% to 55%. During winter months (December- February) substantial amount of precipitation occurs in association of western disturbances, particularly in the northern parts where it is considerably more than rest of the district, being 20% to 35%. The winter months (December to February) account for about 10% rainfall of the annual normal in the district. While the rainfall in the pre-monsoon months (March to May) accounts for 12% of the annual normal rainfall. July and August are the rainiest months with an average of 431.4 mm. In the period 1961 to 2008, the highest annual rainfall of 223% of the normal was recorded in year 2007, while the lowest was 29% of the normal recorded in 1997. During this period, there were 7 years in which the rainfall was less than 80% of the normal and there was one occasion when such a low rainfall occurred in four consecutive years. It is seen from Table 2 that the annual rainfall was between 1401 mm and 2200 mm in 12 years out of 36.

In the district especially in higher reaches considerable amount of precipitation is received in the form of snow during winter season.

On an average there are 84 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 53 at Millam Obsy to 119 at Munsyari Obsy.

The heaviest rainfall recorded in 24 hours at any station in the district was 475.0 mm at Berinag on 06th September 1965.

TEMPERATURE

There is no meteorological observatory in the district hence the meteorological parameters recorded at Mukteshwar at an elevation of approximately 2311 metre in the neighboring Nainital district and Joshimath at an elevation of 1875 metre in the neighbouring Chamoli district may be taken as representative for southern and northern half respectively of this district. Temperature and other meteorological conditions vary depending on the topography of the place. The winter season is from mid-November to mid-March. Temperatures begin to decrease from mid-November and severe cold condition continues till February. January is the coldest month with the mean minimum temperature of the order of 3°C and mean maximum temperature about 15 °C at Pithoragarh town (Alt. 1635 m). Mean minimum temperature may be less than -4°C at stations having altitude more than 5 km and maximum temperatures may be about 0°C at stations having altitude more than 5 km. In association with cold waves, the minimum temperature may sometimes drop to below -3°C at Pithoragarh on individual days. The temperatures begin to rise from March and continue till June. The day temperature reaches its highest in May and June, which are the hottest months with a mean maximum temperature of about 28°C and mean minimum temperature of about 17°C at Pithoragarh. On some days, during the period of April to August the maximum temperature reaches up to 35°C.

HUMIDITY

The atmosphere over the district is much humid during the southwest monsoon season particularly in the rainiest months; July and August, when values of relative humidity are about 80% to 90%. It is slightly less humid during winter months, when its values are about 60%. In general values of humidity in the evenings are slightly more than mornings especially in the hilly region. The summer season is the driest part of the year with values of relative humidity in order of 40% to 60%.

CLOUDINESS

The skies are clouded to overcast on many days in southwest monsoon season particularly in the rainiest months July and August. During winter months skies are heavily clouded to overcast for short spells, when the district is affected by western disturbances. In the rest of the year skies are mostly clear or lightly clouded. In general at the high altitudinal stations evenings are cloudier than mornings.

WINDS

Owing to the nature of terrain, local effects are pronounced and prevailing winds are not strong to mask these effects, there is tendency for diurnal reversal of winds blowing up the slopes during the day (anabatic flow) and down the slopes at night (katabatic flow). Katabatic wind blows with considerable force. Winds are light to moderate with some strengthening during winter and early part of summer season and mainly blow from east direction. Easterly or westerly/ northeasterly winds blow in the morning throughout the year. In the afternoon wind mainly blows from southwest / west direction throughout the year. Sometimes wind is calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Its frequency is more in the period latter part of pre-monsoon and south west monsoon season i.e. from April to September and least in months November and December. In winter and pre-monsoon, thunderstorms are sometimes accompanied with hail. Fog is common almost throughout the year. Fog over hilly terrain is common during monsoon months. In the winter months fog generally occurs in the wake of western disturbances. In the valleys fog is frequent in morning during winter.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
PITHORAGARH

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Askote	17	a b	28.7 2.1	51.5 3.5	29.1 1.6	35.0 3.0	48.4 3.8	248.7 11.1	549.2 23.1	517.5 20.9	254.3 11.5	25.1 2.2	2.8 0.3	7.4 0.5	1797.7 83.6	156 (1961)	87 (1972)	191.8	17 Jun 1952
Askote (Obsy)	26	a b	50.3 3.3	56.7 4.2	58.3 4.0	51.7 3.9	114.2 7.4	414.4 15.3	682.3 22.6	667.7 22.0	406.1 14.6	53.0 3.5	8.5 0.6	24.9 1.5	2588.1 102.9	143 (1982)	72 (1965)	450.0	05 Sep 1982
Berinag	23	a b	42.9 1.8	57.1 2.7	36.3 1.9	21.9 1.7	61.6 3.4	216.8 9.1	407.3 14.1	331.7 9.4	240.7 9.0	25.7 1.9	0.9 0.1	9.3 0.4	1452.2 55.5	291 (1965)	35 (1963)	475.0	06 Sep 1965
Chaukuri	17	a b	32.9 2.1	44.1 3.2	61.4 3.1	25.4 2.5	46.3 4.1	230.6 10.6	597.1 20.3	455.4 17.3	299.7 13.1	36.1 2.1	4.1 0.5	12.3 0.9	1845.4 79.8	148 (1963)	61 (1972)	274.3	22 Jun 1916
Dharchula (Obsy)	45	a b	52.3 3.5	69.9 4.6	67.5 5.1	51.3 4.6	104.7 7.2	287.7 14.3	619.1 24.0	591.4 24.1	297.7 15.0	49.9 3.8	8.8 0.8	22.6 1.6	2222.9 108.6	163 (2003)	59 (1999)	271.4	14 Jun 1971
Garbyang (Obsy)	10	a b	121.4 4.9	169.6 8.1	298.9 7.5	71.3 5.3	68.8 7.2	126.4 12.7	173.5 16.6	131.7 14.8	162.0 12.3	41.6 3.1	66.0 3.1	186.1 3.9	1617.3 99.5	151 (1987)	72 (1964)	118.2	16 Sep 1963
Millam (Obsy)	13	a b	189.5 9.4	117.8 7.1	63.6 4.7	47.8 3.0	22.8 2.4	18.2 2.5	75.2 6.6	76.5 7.5	121.8 6.3	11.9 1.1	7.8 1.0	25.4 1.7	778.3 53.3	129 (1968)	45 (1970)	126.2	22 Sep 1992
Munsiyari (Obsy)	44	a b	56.4 3.8	86.2 5.0	127.7 6.6	83.8 6.1	147.7 9.1	360.8 15.0	773.9 24.5	692.0 25.4	336.7 16.4	69.3 4.8	20.6 1.5	14.2 1.1	2769.3 119.3	181 (2000)	87 (1976)	233.2	17 Jun 1973
Pithoragarh (Obsy)	32	a b	32.8 1.9	36.6 2.7	34.6 2.6	25.4 1.8	71.4 4.8	110.2 7.3	224.7 13.0	199.1 11.3	110.7 7.0	42.0 1.7	5.0 0.5	14.6 0.9	907.1 55.5	198 (1961)	12 (1972)	200.7	24 Jun 1921
Pithoragarh (District)		a b	67.5 3.6	76.6 4.6	86.4 4.1	46.0 3.5	76.2 5.5	223.8 10.9	455.8 18.3	407.0 17.0	247.7 11.7	39.4 2.7	13.8 0.9	35.2 1.4	1775.4 84.2	223 (2007)	29 (1997)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data up to 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
PITHORAGARH
(Data 1961-2008)

Range in mm	No. of years	Range in mm	No. of years
501-600	2	2301-2400	4
601-700	1	2401-2500	1
701-800	0	2501-2600	1
801-900	0	2601-2700	1
901-1000	1	2701-2800	2
1001-1100	1	2801-2900	1
1101-1200	1	2901-3000	1
1201-1300	1	3001-3100	0
1301-1400	0	3101-3200	0
1401-1500	0	3201-3300	0
1501-1600	0	3301-3400	0
1601-1700	1	3401-3500	0
1701-1800	3	3501-3600	0
1801-1900	0	3601-3700	1
1901-2000	4	3701-3800	1
2001-2100	3	3801-3900	0
2101-2200	1	3901-4000	1
2201-2300	3		

(Data available for 36 years)

RUDRAPRAYAG DISTRICT

Rudraprayag district has hilly terrain with valleys and perennial rivers. Elevation of the district generally increases northward from 650 metre to 7130 metre above mean sea level. The district headquarters is Rudraprayag town situated at an elevation of 670 m. The climate of district varies largely depending upon the physiographic features of location. The terrain is marked with deep and narrow valleys and steep and high ridges, whose general slope is towards the south. Larger part of the district is situated on the southern slopes of the Himalayas, monsoon currents penetrate through trenched valleys and rainfall reaches its maxima in between June and September. The northern part of the district is perennially under snow cover.

The climate of the district is generally characterized by severe cold in winter, short and mild hot in summer and abundant rain in monsoon period. In general the year may be divided into four seasons. Winter season starts from mid-November and lasts till mid-March and is followed by pre-monsoon season till the end of June. Thereafter southwest monsoon season begins and lasts till September and is followed by the post monsoon season till mid-November.

RAINFALL

Records of rainfall in the district are available for two rain gauge stations for a period of 14 and 34 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district is 1546.2 mm. The annual rainfall variation from year to year is large. The rainfall in the district also varies by moderate range due to topographic variation. The rainfall in the southwest monsoon season (June to September) is about 74% of the annual normal rainfall. July and August are the rainiest months with an average rainfall of 398.7 mm. In the monsoon season there are few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers. The rainfall in the pre-monsoon months (March to May) is about 14 % of the annual normal. The winter months of December to February account for about 9% rainfall of the annual normal. Precipitation during the winter months is associated

with the passage of western disturbances and is mostly in the form of snow particularly at higher elevations. Pre-monsoon rainfall is mostly associated with thunderstorms. In the period of 1961 - 2009, the highest annual rainfall of 189% of the normal was recorded in year 1970, while the lowest was 57% of the normal recorded in 2007. During this period, there were 6 years in which the rainfall was less than 80% of the normal and none of them were consecutive. It is seen from Table 2 that the annual rainfall was between 1201 mm and 1900 mm in 10 years out of 24.

In the monsoon season the depressions or low pressure system from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

On an average there are 86 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 73 at Rudraprayag Hydro to 99 at Okhimath.

The heaviest rainfall recorded in 24 hours at any station in the district was 208.3 mm at Okhimath 8th August 1925.

TEMPERATURE

There is no meteorological observatory in the district, hence the meteorological parameters recorded at Tehri at an elevation of 770 metres in the neighbouring Tehri Garhwal district may be taken as representative for this district. Temperature and other meteorological conditions vary depending on the topography of the place. Winter season is from mid-November to mid-March. Temperatures begin to decrease from November and severe cold condition continues till February. January is the coldest month with the mean minimum temperature about 5°C and mean maximum temperature about 20°C at Rudraprayag town (Alt. 670 m). In association with cold waves, the minimum temperature may sometimes drop to

below 0°C on individual days. The temperatures begin to rise from March and continue till June. The day temperature reaches its highest in May and June, which are the hottest months with an average of maximum temperature of about 37°C and an average of minimum temperature of about 21°C at Rudraprayag. On some days, during months May and June the maximum temperature may sometimes reach 42°C on individual days at low altitudinal stations. The temperatures may be lower by up to 35°C approximate at high altitudinal areas with reference to Rudraprayag town.

HUMIDITY

The driest part of the year is the summer from April to May, when the relative humidity in afternoons is about 30% in the valleys and about 50% over highlands. Humidity increases rapidly with the onset of the monsoon. During the rainiest months July and August, morning humidity is about 80% to 85% in the valleys. In the valleys humidity is a maximum during winter months, when its values are about 90% in mornings. Relative humidity generally decreases towards afternoons appreciably in the valleys and only slightly at high elevations due to rise of moisture from below with the advance of the day.

CLOUDINESS

In the monsoon months of July to September, skies are generally heavily clouded to overcast and also for short spells during the winter months when the region is affected by passing the western disturbances. Cloudiness is the least in May and November. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are mostly light. In the wake of western disturbances and also in association with thunderstorms, they are quite strong. Katabatic wind is also experienced during night as local effects produced by nature of terrain. In high hilly terrain wind mostly blows from northwest / west and from south on some days. While in valleys region wind is mostly calm in the mornings throughout the year it mostly blow in southern part of the district, while in pre-monsoon season it blows from west / northwest directions.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. They frequently occur in the year except November and December where its frequency is least. The thunder activity is a maximum in April to July, about 60% of the thunderstorms occurring during this period. During pre-monsoon and winter seasons, thunderstorms are sometimes accompanied by hail and the activity is more pronounced at higher altitudinal stations. In few days dust-storms occur in the valleys in summer season. Fog is common over hilly terrain during monsoon months. Fog also occurs in association with western disturbances. In the valleys fog frequently occurs in the morning during winter.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL

RUDRAPRAYAG

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Okhimath	34	a b	61.6 3.7	66.9 4.6	76.4 5.3	60.4 5.1	88.3 6.9	202.1 12.1	530.4 22.2	573.1 21.9	204.3 11.2	31.9 2.8	10.1 1.0	31.8 1.7	1937.3 98.5	151 (1970)	59 (1977)	208.3	08 Aug 1925
Rudraprayag (Hydro)	14	a b	32.1 3.1	63.6 3.8	50.7 4.0	46.2 4.2	103.9 7.6	156.3 10.5	256.6 14.0	234.6 13.4	139.5 7.9	46.7 2.2	7.0 0.8	17.7 1.6	1155.1 73.1	138 (2003)	77 (2007)	170.4	03 Sep 2003
Rudraprayag (District)		a b	46.9 3.4	65.3 4.2	63.6 4.7	53.3 4.6	96.1 7.3	179.2 11.3	393.5 18.1	403.8 17.6	171.9 9.6	39.3 2.5	8.6 0.9	24.7 1.7	1546.2 85.9	189 (1970)	57 (2007)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
RUDRAPRAYAG
(Data 1961-2009)

Range in mm	No. of years	Range in mm	No. of years
801 – 900	1	1901 – 2000	1
901 – 1000	0	2001 – 2100	0
1001 – 1100	1	2101 – 2200	2
1101 – 1200	4	2201 – 2300	1
1201 – 1300	2	2301 – 2400	1
1301 – 1400	2	2401 - 2500	0
1401 – 1500	0	2501 - 2600	0
1501 – 1600	3	2601 - 2700	1
1601 – 1700	0	2701 – 2800	1
1701 – 1800	2	2801 - 2900	0
1801 – 1900	1	2901 - 3000	1

(Data available for 24 years)

TEHRI GARHWAL DISTRICT

Tehri Garhwal is one of the mountainous districts of Uttarakhand state. The physiography of the district is characterized by high mountain peaks, deep gorges, valleys and perennial rivers. Major part of the areas is inaccessible due to extremely rugged topography and dense forest cover. The altitude varies from 370 metre to 6670 metre above mean sea level. The climate therefore depends on elevation and aspect.

The climate of the district varies from place to place due to topographic variation. The northern and western parts of the district have severe cold during winter whereas central and southern parts are comparatively warm and humid. The snowfall is quite common in northern and western parts. Other parts of the district experienced dry mild hot in summer and cold in winter. Prolong and severe cold in winter season is the chief climatic feature. Southwest monsoon season is from the end of June to September followed by the post monsoon season (October to mid-November). The period of mid-November to mid-March is of winter season followed by the summer season till June.

RAINFALL

Records of rainfall in the district are available for seven raingauge stations for a period ranging from 30 to 48 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. The average annual rainfall in the district is 1216.7 mm. The rainfall in the district generally increases from south to north. Due to the nature of terrain, rainfall is variable and depends upon elevations and exposure to the prevailing wind. The rainfall in the southwest monsoon season (June to September) is about 76% of the annual normal rainfall, July and August being the months with the highest rainfall with an average value of 323.6 mm. The rainfall in the pre monsoon months of March to May is 11% of the annual normal. There is one rainfall minima in November. The winter months (December to February) account for about 11% rainfall of the annual normal. The rainfall after April gradually increases till June, and then it sharply increases in July. It rapidly decreases after withdrawal of the monsoon. During the monsoon season, spurts of

heavy rain occur in the hills, causing floods in rivers. The winter precipitation is in association with the passage of western disturbances and is often in the form of snow particularly at higher elevations. Pre-monsoon rainfall is mostly associated with thunderstorms. In the period 1961 to 2010, the highest annual rainfall was recorded 156% of the normal in year 2007, while the lowest was 38% of the normal recorded in 1997. During this period, there were 10 years in which the rainfall was less than 80% of the normal and there were one occasion of two consecutive years and one occasion of three consecutive years of such low rainfall. It is seen from Table 2 that the annual rainfall was between 901 mm and 1500 mm in 17 years out of 34.

During winter season the precipitation is mostly received in the form of snow at high elevated areas. About 60 to 70 cm snowfall is received in months of November to March in the high reaches in the north eastern part of the district. In the monsoon season the depressions or low pressure systems from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

On an average there are 60 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 42 at Tehri Garhwal to 84 at Mukhim observatory.

The heaviest rainfall recorded in 24 hours at any station in the district was 396.0 mm at Narendranagar on 27th July 1999.

TEMPERATURE

There are two meteorological observatories in the district viz Tehri situated at an elevation of 770 m and Mukhim at an elevation of 1981 m. The description that follows is based on the meteorological records of these observatories. The district being hilly with the deep valleys, temperature varies considerably from place to place with elevation. As the insolation at high altitudes is intense, temperatures are much

higher in the open than in shade in summer, while in the valleys stagnant pool of cold air causes large diurnal variation in temperature. The temperatures begin to rise from the middle of February to June. June is the warmest month with mean maximum temperature of about 36°C in valleys with elevation less than 1km , 27°C at places of 2 km altitude and still lower temperatures at stations at higher altitudes. With the onset of the monsoon towards the end of June, day temperatures fall by about 1°C to 3°C and night temperature is almost same as in summer. With the withdrawal of monsoon in September, both day & night temperatures decrease till January which is the coldest month with mean maximum and minimum temperatures respectively of about 20°C and 5°C in valleys (elevation less than 1km), 14°C and 3°C at places of 2 km altitude and still lower at higher elevations. During winter season cold waves in the wake of western disturbances cause the temperature to fall appreciably. There is considerable accumulation of snow in the valleys. The temperatures may be lower up to 15 - 20°C at high altitudinal areas with reference to Mukhim.

The highest maximum temperature ever recorded at Mukhim observatory was 36.3°C on 30th May 2004 and lowest minimum temperature ever recorded was -9.0°C on 9th February 1974. Whereas the highest maximum temperature ever recorded at Tehri was 43.8°C on 8th June 1966 and lowest minimum temperature was -2.4°C on 31st January 2008.

HUMIDITY

The driest part of the year is the summer from April to May, when the relative humidity towards afternoons is about 25% to 35% in the valleys and about 50% over highlands. Humidity increases rapidly with the onset of the monsoon. During the rainiest months July and August, morning humidity is about 80% to 85% in the valleys. In the valleys humidity increases during winter months, when its morning values are about 90%. The humidity generally decreases towards afternoons appreciably in the valleys and only slightly at high elevated areas due to rise of moisture from below with the advance of the day.

CLOUDINESS

In the monsoon months of July to September, skies are generally heavily clouded to overcast and also for short spells during the winter months when the region is affected by passing western disturbances. Cloudiness is the least in May and November. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are mostly light. In the wake of western disturbances and in association with thunderstorms, they are quite strong. Katabatic winds are also experienced during night as local effects produced by nature of terrain. In high hilly terrain winds mostly blow from northwest / west and from south on some days. While in valleys region wind is mostly calm in the mornings throughout the year it mostly blows from southeast and southwest in afternoons, while in pre-monsoon season it blows from west / northwest / southwest direction.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Thunderstorms occur frequently in hilly terrain areas (altitude about 2 km) with a number of 104 days in a year. The thunder activity is at its maximum in April to July, about 60% of the thunderstorms occurring during this period. During pre-monsoon and winter thunderstorms are sometimes accompanied by hail and the activity is more pronounced at higher altitudinal stations. In a few days dust-storms occur in the valleys in summer season. Fog is common over hilly terrain during monsoon months. Fog also occurs in association with western disturbances. In the valleys fog is frequent in morning during winter.

Table 3, 4, 5 and 6 and 3(a), 4(a), 5(a) and 6(a) give the temperature and humidity, cloudiness, mean wind speed and predominant wind directions, special weather phenomena respectively for Tehri i Observatory and Mukhim Observatory.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL

TEHRI GARHWAL DISTRICT

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Deoprayag	33	a b	39.6 2.5	49.0 3.2	39.1 2.9	18.9 1.6	40.0 3.2	101.3 6.6	216.2 10.9	173.0 10.4	75.4 4.2	22.1 1.2	5.3 0.4	18.4 1.1	798.3 48.2	137 (1961)	50 (1997)	215.9	09 Oct 1956
Dhanolti	33	a b	46.9 2.6	63.7 3.6	49.2 3.1	40.5 3.2	66.2 4.4	175.6 9.3	361.6 16.2	349.2 15.9	119.4 6.2	28.9 1.5	12.7 0.7	23.7 1.2	1337.6 67.9	151 (1966)	37(1997)	188.0	17 Jul 1972
Mukhim (Obsy)	48	a b	61.5 4.0	82.3 5.1	90.0 5.8	61.4 4.5	88.3 6.4	163.1 9.4	375.8 16.7	412.6 16.9	244.3 10.0	38.8 2.5	7.4 0.7	25.5 1.7	1651.0 83.7	170 (2007)	31 (1974)	267.2	19 Jul 1957
Narendranagar	33	a b	46.8 2.1	42.5 2.1	31.7 1.8	15.2 1.0	37.7 2.8	193.7 7.9	710.4 19.0	771.5 21.1	300.7 11.2	30.8 1.7	5.8 0.3	22.7 1.3	2209.5 72.3	155 (1966)	10 (1997)	396.0	27 Jul 1999
Tehri (Obsy)	31	a b	47.6 3.5	64.7 4.1	58.1 4.1	36.3 3.3	50.5 4.8	86.3 6.1	231.3 12.8	231.2 12.7	127.5 5.9	20.8 1.5	10.3 0.9	28.8 1.7	993.4 61.4	130 (1978)	65 (1979)	194.8	12 Dec 1957
Tehri-Garhwal	30	a b	42.9 2.1	57.8 3.7	39.7 2.7	25.9 2.3	30.3 2.7	82.7 5.4	157.9 8.8	156.0 7.4	77.3 3.8	16.9 1.2	8.5 0.5	30.6 1.2	726.5 41.8	162 (1961)	28 (1998)	150.6	09 Oct 1956
Keertinagar	31	a b	41.4 2.4	50.8 3.4	38.1 2.3	25.0 2.2	41.5 3.1	95.6 5.7	193.9 11.0	189.4 10.7	81.1 4.7	18.3 0.8	5.4 0.3	21.2 1.0	801.7 47.6	179 (1961)	13 (1972)	198.1	08 Oct 1956
Tehri-Garhwal (District)		a b	46.7 2.7	58.7 3.6	49.4 3.2	31.9 2.6	50.6 3.9	128.3 7.2	321.0 13.6	326.1 13.6	146.5 6.6	25.2 1.5	7.9 0.5	24.4 1.3	1216.7 60.3	156 (2007)	38 (1997)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
TEHRI GARHWAL
(Data 1961-2010)

Range in mm	No. of years	Range in mm	No. of years
401 – 500	1	1201 – 1300	2
501 – 600	1	1301 – 1400	5
601 – 700	1	1401 – 1500	3
701 – 800	3	1501 – 1600	3
801 – 900	1	1601 – 1700	2
901 – 1000	3	1701 – 1800	1
1001 – 1100	1	1801 – 1900	3
1101 – 1200	3	1901 – 2000	1

(Data available for 34 years)

TABLE – 3
Normals of Temperature and Relative Humidity
(TEHRI)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	19.9	4.5	25.6	24-01-2009	-2.4	31-01-2008	91	48
February	22.4	7.1	30.6	26-02-1966	-1.6	09-02-2012	84	40
March	27.9	11.0	36.7	31-03-1977	1.9	05-03-1962	74	33
April	33.3	15.6	41.0	27-04-1970	3.8	19-04-2007	57	26
May	36.3	18.9	42.5	14-05-1970	8.6	02-05-2004	48	25
June	36.5	22.9	43.8	08-06-1966	12.1	24-06-1957	63	40
July	33.2	23.5	40.2	09-07-1973	13.2	13-07-1957	81	61
August	32.5	23.2	37.2	07-08-1979	15.0	05-08-2012	85	64
September	32.4	20.9	37.1	13-09-1968	11.2	25-09-2012	81	55
October	30.2	15.3	36.7	02-10-1978	5.3	31-10-2004	77	45
November	26.1	9.3	31.7	02-11-1977	1.6	30-11-2012	80	42
December	21.6	4.7	29.7	07-12-1979	-1.5	22-12-1961	91	48
Annual	29.4	14.7	43.8	08-06-1966	-2.4	31-01-2008	76	44

TABLE – 4
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(TEHRI)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	14	10	12	17	16	10	1	0	5	19	21	19	144
b	5	4	4	2	2	3	10	9	4	1	1	2	47
c	3.1	3.2	2.5	2.0	1.8	3.3	5.6	5.7	3.6	1.2	1.3	1.9	2.9
1730 HOURS IST													
a	11	9	9	7	8	4	1	1	3	14	17	18	102
b	4	3	3	3	4	2	6	6	3	1	1	1	37
c	2.9	3.3	3.3	3.2	3.3	3.7	5.3	5.2	3.4	1.6	1.3	1.7	3.2

a: Days with clear sky.

b: Days with sky overcast.

c: Mean cloud amount in Okta.

** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE - 5
Mean Wind Speed and Predominant Wind Direction
(TEHRI)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	1.0	1.6	2.1	2.9	3.6	3.8	2.8	2.2	2.0	1.8	1.2	0.7	2.1
Direction in morning	C	C	C	C	C/NE/N	C	C	C	C	C	C	C	
Direction in evening	C/SE	C/S	C/SE/SW/S	C/W/NW/SW	C/W/NW/SW	C/W/S	C/SW/S/SE	C/SE/S/SW	C/SE/S/SW	C/SE/S/SW	C/SE	C/SE	

TABLE - 6
Special Weather Phenomena
(TEHRI)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	0.7	2.1	4.4	5.7	8.9	8.4	5.7	3.0	3.6	2.0	0.5	0.4	45.4
Hail	0.0	0.0	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1.4
Dust storm	0.2	0.3	0.3	1.0	1.2	1.3	0.5	0.0	0.1	0.0	0.0	0.0	4.9
Fog	2.4	0.5	0.4	0.2	0.1	0.1	0.9	0.0	0.1	0.0	0.4	2.2	7.3
Squall	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1

TABLE – 3(a)
Normals of Temperature and Relative Humidity
(MUKHIM)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	14.3	2.7	23.4	01-01-2004	-3.4	22-01-1960	64	61
February	15.2	3.1	25.6	24-02-2006	-9.0	09-02-1974	64	61
March	18.4	5.0	28.8	31-03-1973	-1.6	23-03-1960	61	57
April	22.9	7.5	30.5	27-04-1970	1.9	05-04-1995	53	50
May	26.3	10.5	36.3	30-05-2004	3.8	01-05-1994	53	48
June	26.7	12.3	35.3	01-06-2004	4.8	06-06-1998	62	54
July	25.4	12.2	31.6	04-07-2003	5.4	25-07-1994	81	71
August	25.0	12.3	33.1	02-08-2002	5.4	24-08-1994	84	74
September	24.8	11.9	29.9	09-09-2004	5.2	05-09-1993	78	69
October	23.2	9.3	28.1	01-10-2002	2.6	30-10-2004	60	54
November	20.7	6.4	28.9	03-11-1999	1.3	30-11-1986	54	50
December	17.7	4.4	25.9	04-12-2003	-0.6	27-12-1977	56	54
Annual	21.7	8.1	36.3	30-05-2004	-9.0	09-02-1974	64	59

TABLE – 4(a)
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(MUKHIM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	12	8	11	12	12	6	0	0	2	12	16	13	104
b	5	4	4	2	2	3	9	10	5	1	1	3	48
c	2.9	3.2	3.0	2.4	2.2	3.6	6.2	6.4	4.8	1.7	1.4	2.4	3.3
1730 HOURS IST													
a	7	4	4	3	3	1	0	0	1	6	13	11	53
b	5	5	6	6	8	8	9	9	6	2	1	2	67
c	3.2	3.9	4.1	4.4	4.6	5.3	6.2	6.2	5.0	2.4	1.6	2.3	4.1

a: Days with clear sky.

b: Days with sky overcast.

c: Mean cloud amount in Okta.

** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE – 5(a)
Mean Wind Speed and Predominant Wind Direction
(MUKHIM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr													
Direction in morning	W/S/NW	NW/W/S	NW/W/S	W/NW/S	W/NW/S	NW/W/C	W/NW/C	NW/W/C	NW/WS	W/SW/NW	W/NW/S	W/S/NW	
Direction in evening	S/W/N	S/NW/W	W/NW/N	NW/N/S	NW/S/N	S/NW/N	S/NW/W	NW/N/S	S/W/N	S/W/NW	W/S/NW	W/S/NW	

TABLE – 6(a)
Special Weather Phenomena
(MUKHIM)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	2.0	4.0	8.9	12.5	17.8	18.7	14.2	8.8	10.0	4.6	1.2	0.9	103.6
Hail	0.3	0.4	1.0	1.5	1.9	0.7	0.0	0.0	0.1	0.6	0.1	0.1	6.7
Dust storm	0.2	0.4	1.1	2.7	2.5	2.3	0.1	0.1	0.0	0.2	0.2	0.1	9.9
Fog	0.3	0.3	0.2	0.1	0.1	0.5	4.0	6.5	1.9	0.1	0.0	0.1	14.1
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

UDHAM SINGH NAGAR DISTRICT

The district lies in the Tarai region of Kumaon Division and is located in foot-hills of Himalayan. It has plain areas of low elevation with a large number of rivers. Rudrapur town is the district headquarters situated at an altitude of 205 metre above mean sea level. It may be broadly divided into two physiographic regions from north to south viz. narrow forest covered belt known as Bhabhar and southern part of its lies the swampy area called Tarai.

The climate is characterized by hot in summer, cold in winter and humid throughout the year. The year is generally divided in to four seasons. The summer season is from March to third week of June. Thereafter, southwest monsoon season starts and lasts till September followed by post monsoon season till November. The period of December to February is of winter season.

RAINFALL

Records of rainfall in the district are available for seven raingauge stations for a period ranging from 16 to 34 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. There is general increase of rain from southwest towards the northeast in the district. The average annual rainfall in the district is 1071.1 mm. The variation in annual rainfall from year to year is large. The rainfall in the southwest monsoon season (June to September) is about 87% of the annual normal rainfall, while the rainfall in the pre-monsoon months (March to May) and winter months (December to February) account for 4% and 5% of the annual normal respectively. July and August are the rainiest months with an average of 315.5 mm. In the period 1961 to 2010, the highest annual rainfall about 190% of the normal was recorded in year 2003, while the lowest was 62% of the normal recorded in 1965. During this period, there were 3 years in which the rainfall was less than 80% of the normal and there was one occasion of two consecutive years of such a low rainfall. It is seen from Table 2 that the annual rainfall was between 801 mm and 1300 mm in 13 years out of 26.

On an average there are 42 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 29 at Gadarpur to 57 at Pantnagar Aero observatory.

The heaviest rainfall recorded in 24 hours at any station in the district was 405.6 mm at Khatima on 15th September 1972.

TEMPERATURE

There is a meteorological observatory in the district at Pantnagar at an elevation of about 233 m. The records of this observatory may be taken as representative of the meteorological conditions prevailing in the district. Day and night temperatures begin to increase rapidly from the end of February. May and June are generally the hottest months with an average of maximum temperature at 36.3°C and mean minimum temperature at 22.5°C. Nights in June are slightly warmer than during May. The heat in summer is intense and the maximum temperature on individual day goes up to 44°C. Afternoon thundershowers which occur on some days bring welcome relief though only temporarily. With the onset of the monsoon by about the end of June, there is an appreciable drop in the day temperatures. But nights continue to be slightly warmer as compared to May. The temperatures start to decrease from October and there is a drop in the night temperatures rapidly. January is generally the coldest month with a mean maximum temperature at 20.3°C and mean minimum temperature at 5.4 °C. During winter season in association with passing western disturbances, cold waves affect the district; the minimum temperature occasionally reaches near the freezing point of water. Frosts occur on such occasions.

The highest maximum temperature ever recorded at Pantnagar observatory was 45.6°C on 16th June 1995 and the lowest minimum temperature was -2.2°C on 5th January 2007.

HUMIDITY

The atmosphere over the district is most humid during the southwest monsoon months (July to September) and the values of relative humidity are 80% to 85% in the mornings and 70% to 77% in the evenings during this period. It is also much humid during winter months (December- February) especially in the mornings, when its values are about 85% to 90% in the mornings. The summer season is the driest part of the year, when values of relative humidity in the evenings are between 30% and 45%.

CLOUDINESS

The skies are heavily clouded to overcast on many days in the southwest monsoon season. The skies are generally clear or lightly clouded in the rest of the year except for few days when western disturbances pass during winter season the skies become cloudy.

WINDS

Winds are generally light throughout the year. Sometimes it becomes moderate to strong during summer and monsoon seasons. In the district winds mainly blow from westerly direction in winter and pre-monsoon season. Easterly wind appears in April and become predominant through southwest monsoon season and post-monsoon season especially in the mornings. Westerly winds blow throughout the year in the evenings. Sometimes wind is variable and calm also.

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Its frequency is more in the period latter part of pre-monsoon and south west monsoon season i.e. from May to September and least in months November and December. Pre-monsoon thunderstorms are occasionally accompanied with dust. Fog is common in the winter months and sometimes it occurs in post monsoon season.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
UDHAM SINGH NAGAR

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Bazpur	34	a b	19.1 1.6	25.9 2.0	7.3 0.9	10.3 0.9	23.9 1.7	132.1 5.1	324.5 11.0	280.0 10.9	149.7 6.0	41.4 1.3	4.1 0.2	10.1 0.8	1028.4 42.4	212 (1971)	60 (1965)	298.5	21 Jul 1954
Gadarpur	25	a b	17.0 1.2	13.3 0.9	5.9 0.9	3.0 0.3	6.9 0.9	64.2 2.6	236.7 8.7	243.7 8.0	124.8 3.9	10.4 0.9	0.0 0.0	4.0 0.4	729.9 28.7	258 (1961)	69 (1965)	274.3	05 Jul 1950
Kashipur	34	a b	25.6 1.4	18.9 1.4	11.9 1.0	5.8 0.6	25.1 1.7	99.6 4.3	361.5 10.6	279.3 10.5	139.3 5.6	31.3 1.4	2.9 0.4	5.9 0.8	1007.1 39.7	213 (1971)	67 (1965)	315.0	02 Oct 1954
Khatima	33	a b	21.6 1.4	16.1 1.3	10.9 0.9	12.1 1.0	44.7 2.0	210.2 7.2	359.9 12.3	378.2 13.7	248.8 7.1	46.5 1.4	2.8 0.2	10.7 0.8	1362.5 49.3	249 (1971)	61 (1965)	405.6	15 Sep 1972
Rudrapur/Kitchha	33	a b	22.3 1.6	24.2 2.0	14.3 1.1	9.0 0.7	42.8 1.9	137.2 5.7	393.9 12.1	337.8 12.0	202.6 6.4	38.0 1.5	2.3 0.2	13.1 0.8	1237.5 46.0	211 (1971)	55 (1965)	307.1	25 Jul 1907
Ph.Bag/P.Nagar (A) Obsy	16	a b	22.6 1.5	39.9 2.5	14.6 1.6	17.9 1.1	58.5 4.0	157.7 7.5	374.1 13.1	406.3 13.5	284.4 9.1	46.7 1.9	3.0 0.3	11.4 0.8	1437.1 56.9	142 (2003)	56 (1965)	209.4	16 Aug 2011
Nagla	17	a b	16.5 1.0	11.3 1.2	6.4 0.5	1.3 0.2	1.8 0.3	100.9 5.4	218.6 8.3	222.5 8.9	93.7 4.5	18.2 1.0	0.0 0.0	3.5 0.4	694.7 31.7	311 (1961)	44 (1966)	325.6	20 Sep 1922
Udham Singh Nagar (District)		a b	20.7 1.4	21.4 1.6	10.2 1.0	8.5 0.7	29.1 1.8	128.8 5.4	324.2 10.9	306.8 11.1	177.6 6.1	33.2 1.3	2.2 0.2	8.4 0.7	1071.1 42.2	190 (2003)	62 (1965)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data upto 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
UDHAM SINGH NAGAR
(Data 1961-2010)

Range in mm	No. of years	Range in mm	No. of years
601 – 700	1	1401 – 1500	2
701 – 800	1	1501 – 1600	1
801 – 900	1	1601 – 1700	3
901 – 1000	3	1701 – 1800	0
1001 – 1100	6	1801 – 1900	2
1101 – 1200	2	1901 – 2000	0
1201 – 1300	1	2001 – 2100	1
1301 – 1400	2		

(Data available for 26years)

TABLE – 3
Normals of Temperature and Relative Humidity
(PANTNAGAR)

MONTH	Mean Maximum Temperature	Mean Minimum Temperature	Highest Maximum ever recorded		Lowest Minimum ever recorded		Relative Humidity (%)	
	°C	°C	°C	Date	°C	Date	0830 IST	1730 IST
January	20.3	5.4	28.4	29-01-2007	-2.2	05-01-2007	90	68
February	23.8	7.4	34.0	26-02-2006	-0.6	13-02-2008	85	57
March	29.0	11.3	36.7	28-03-2010	0.0	03-03-1992	72	45
April	35.2	15.7	41.5	20-04-2009	0.0	08-04-1992	52	31
May	36.7	20.9	44.3	29-05-1988	10.5	05-05-2008	55	39
June	36.0	24.0	45.6	16-06-1995	17.5	01-06-2007	69	53
July	33.2	24.9	42.1	02-07-1987	13.0	31-07-2008	83	73
August	32.7	24.6	39.6	04-08-1998	19.3	31-08-1986	85	77
September	32.3	22.8	38.6	27-09-2007	16.2	30-09-1991	84	74
October	30.8	16.7	38.0	05-10-1987	8.3	21-10-1993	75	68
November	27.3	10.4	28.2	05-11-1997	1.2	30-11-2006	79	70
December	22.7	6.3	29.4	17-12-2003	0.2	31-12-2007	87	71
Annual	30.0	15.9	45.6	16-06-1995	-2.2	05-01-2007	76	60

TABLE – 4
Mean Cloud Amount ** (Okta of the Sky) and Mean Number
of days of Clear and Overcast Skies
(PANTNAGAR)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0830 HOURS IST													
a	10	12	15	17	15	9	1	1	6	22	22	16	147
b	9	4	3	1	3	7	13	13	8	1	1	5	68
c	3.5	2.5	2.1	1.6	2.0	3.7	6.0	5.9	4.2	1.1	0.9	2.2	3.0
1730 HOURS IST													
a	12	10	11	12	13	8	1	0	4	18	20	16	125
b	4	2	3	1	2	3	6	7	4	1	1	2	36
c	2.8	2.4	2.3	2.0	1.9	3.0	5.0	5.2	3.5	1	1	1.8	2.7

a: Days with clear sky.
b: Days with sky overcast.
c: Mean cloud amount in Okta.
** Okta = Unit equal to area of one eighth of the sky used in specifying cloud amount.
For example: 1 Okta means 1/8th of the sky covered.

TABLE - 5
Mean Wind Speed and Predominant Wind Direction
(PANTNAGAR)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind speed in km/hr	1.7	2.1	2.6	2.9	3.5	3.1	2.8	2.3	1.9	1.1	0.9	1.2	2.2
Direction in morning	C/W/V	C/W/E	C/W/V	C/E/W	E/C/W	E/C/V	E/C/V	E/C/V	C/E/V	C/E/V	C/E/W	C/W/E	
Direction in evening	C/W/V	W/C/V	W/C/V	W/C/V	W/C/E	W/C/E	E/C/W	C/E/W	C/W/E	C	C	C	

TABLE - 6
Special Weather Phenomena
(PANTNAGAR)

Mean No. of Days With	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunder	0.5	1.3	1.0	1.2	2.4	2.9	2.5	3.0	3.0	0.8	0.2	0.2	19.0
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dust storm	0.0	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Fog	11.7	5.8	0.6	0.0	0.0	0.0	0.0	0.2	0.5	0.3	1.8	7.2	28.1
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

UTTARKASHI DISTRICT

Uttarkashi district lies in the northwestern part of Uttarakhand state. It is the largest district in the state. The district has highly rugged topography marked with series of high ridges, glaciers, perennial rivers and valleys. There are very sharp undulations owing to high mountains, narrow valleys and deep gorges. The northern and eastern parts are of high elevation covered with snow throughout the year. There are many glaciers in these parts. It has upper reaches of the rivers Ganga and Jamuna and contains their snowbound source region near Gangotri and Jamnotri. The elevation in the district ranges from 800 to 6900 metre above mean sea level. The land slopes down steadily towards southwest, where the elevation at places in the valleys dips down to 800 metre.

The climate varies naturally according to physiographic features. Severe cold in winter for fairly long period is the chief climatic feature. As most of the district is situated on the southern slope of Himalayas, monsoon currents generally penetrate through deeply trenched valleys and rainfall is a maximum in the southwest monsoon season from the end of June to September particularly in the southern part of the district. The period of October to mid-November is of post monsoon season. Winter season starts from mid-November and lasts till mid-March followed by summer to the end of June.

RAINFALL

Records of rainfall in the district are available for nine raingauge stations for period ranging from 11 to 28 years. The details of rainfall at these stations and for the district as a whole are given in Tables 1 and 2. All these stations are more representative of the river and valleys areas. Rainfall generally increases up the valleys over the southern half of the district and decreases beyond the certain elevation. The average annual rainfall in the district is 1288.8 mm. The variation in annual rainfall from year to year is large. Owing to the nature of terrain, the rainfall is variable spatially and depends upon topography. The rainfall in the southwest monsoon season (June to September) is about 67% of the annual normal rainfall. July is the rainiest month with an average of 312.0 mm. During winter months

(December- February) substantial amount of precipitation mostly in the form of snow occurs in association of western disturbances across the region and accounts for about 12% of the annual normal rainfall while the rainfall in the pre-monsoon months (March to May) accounts for 17% of the annual normal rainfall. In the period 1961 to 2009, the highest annual rainfall of 189% of the normal was recorded in year 1969, while the lowest was 14 % of the normal recorded in 1976. During this period, there were 8 years in which the rainfall was less than 80% of the normal and there was one occasion when such a low rainfall occurred in three consecutive years. It is seen from Table 2 that the annual rainfall was between 1001 mm and 1600 mm in 20 years out of 34 years of which whole year data is available.

In the district especially in higher reaches a considerable amount precipitation is received in the form of snow during winter. Snow accumulation in the valleys is also considerable. In the monsoon season the depressions or low pressure system from the Bay of Bengal occasionally reach near the district and affect the weather in the district. Sometimes heavy rain occurs with the interaction of the monsoon system and extra-tropical system. In the monsoon season there are a few occasions when the rainfall in the plain districts decreases but there are spurts of heavy rain in the hills causing floods in the rivers.

On an average there are 75 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. This number varies from 68 at Purola Hydro to 84 Bhatwari and Uttarkashi observatory.

The heaviest rainfall recorded in 24 hours at any station in the district was 300.0 mm at Bhatwari on 15th July 1985.

TEMPERATURE

There is meteorological observatory in the district at Uttarkashi but data of meteorological elements for sufficient long period is not available. The description that follows, is based on available data of the neighbouring observatory- Mukhim situated at an elevation of 1981 metre in Tehri Garhwal district where similar climatic conditions exist together with the general inference drawn from the nature of altitude,

location etc of the places in the district. The district headquarters is Uttarkashi town situated at altitude 1170 m. The variation in temperature from place to place is a considerable and depends upon elevation and exposure to the sun. The winter season has persistence of cold weather conditions for fair long period from mid-November to mid- March. Temperatures generally begin to rise from March. May and June are the warmest months, when mean maximum temperature may be about 31°C at Uttarkashi town, 26°C at stations located at 2 km altitude and temperatures less than 9°C at higher stations having altitude more than 5 km, and mean minimum temperature may be about 15°C at Uttarkashi town, 11°C at stations located at elevation of 2 km and temperatures less than -3°C at higher stations having altitude more than 5 km. On some days during the months; May and June the maximum temperature may sometimes reach 38°C on individual days in the valleys. With the onset of monsoon towards the end of June, day temperature falls by about 1°C to 2°C. With the withdrawal of the monsoon by the end of September both day and night temperatures begin to decrease initially at slower rate but more rapidly after October. January is the coldest month with mean maximum temperature of the order of 16°C at Uttarkashi town, 12°C at stations located at elevation of 2 km and, temperatures less than 2°C at higher stations having altitude more than 5 km high and a mean minimum temperature of about 1°C at Uttarkashi, -1°C at stations located at elevation of 2 km and, temperatures less than -7°C at higher stations having altitude more than 5 km. In the wake of western disturbances during the cold season, cold waves prevail and affect the temperature to fall appreciably.

HUMIDITY

The atmosphere over the district is generally humid during the monsoon season, when relative humidity is about 70% to 85%. Driest part of the year is pre-monsoon season, when relative humidity is about 50% in the afternoons.

CLOUDINESS

The skies are heavily clouded to overcast on many days in the rainiest months July and August and short period in the winter when the district is affected by

passing western disturbances. In the rest of the year skies are clear or lightly or moderate clouded. In the winter season, the skies are sometimes obscured in the morning due to lifted fog which clears with the advance of the day.

WINDS

Winds are generally light and they mostly blow from the south, west and north west direction in the mornings and from the northwesterly direction in the afternoons throughout the year. Sometimes westerly wind also blows in afternoons. On other occasions especially calm conditions generally prevail. The district being hilly and mountainous local winds such as katabatic and anabatic winds which play a role to maintain the speed and direction of wind at places

SPECIAL WEATHER PHENOMENA

Thunderstorms occur throughout the year. Thunderstorms occur frequently in hilly terrain areas (altitude about 2 km) with a number of 100 days in a year. Its frequency is more in the period latter part of pre-monsoon and southwest monsoon seasons i.e. from April to September and thereafter with the activity being least in November and December. Hail is rather rare and confined to winter and summer months. Fog is common almost throughout the year with its occurrence being more during the winter months in valleys areas and during the monsoon months over peaks of hills.

TABLE – 1
NORMALS AND EXTREMES OF RAINFALL
UTTARKASHI

STATION	No. of Years of Data		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ANNUAL RAINFALL AS % OF NORMAL & YEARS**		HEAVIEST RAINFALL IN 24 HOURS*	
																HIGHEST	LOWEST	AMOUNT (mm)	DATE
Barkot	11	a b	49.4 3.6	68.0 4.3	109.8 5.3	51.1 4.1	69.2 5.4	160.3 10.9	337.8 17.0	251.0 12.3	144.7 8.7	76.2 2.9	9.0 0.8	61.3 2.2	1387.8 77.5	133 (1988)	48 (1997)	134.0	22 Jul 1988
Barkote (Hydro)	28	a b	59.0 3.8	75.5 4.4	97.2 5.9	56.1 4.3	72.7 6.2	119.3 8.1	272.5 13.8	242.0 13.1	148.9 8.0	41.3 2.3	10.9 0.7	33.0 1.9	1228.4 72.5	193 (1988)	24 (2009)	152.0	25 Sep 1988
Bhatwari	19	a b	28.1 2.7	58.5 4.6	75.3 5.5	70.5 4.7	68.2 5.7	125.7 10.3	339.7 19.6	283.9 18.2	100.6 8.4	41.3 2.5	6.6 0.5	29.5 1.7	1227.9 84.4	127 (1985)	69 (1999)	300.0	15 Jul 1985
Dunda	20	a b	52.9 3.1	75.6 4.8	82.7 5.0	47.8 3.4	70.2 5.8	181.2 9.2	373.1 16.6	356.8 14.8	135.9 7.7	43.3 2.1	8.5 0.8	36.2 2.1	1464.2 75.4	157 (1998)	63 (1991)	150.0	14 Aug 1982
Naitwar (Hydro)	26	a b	51.1 3.8	82.4 5.6	87.2 4.6	59.3 4.4	47.1 4.9	65.5 6.0	221.2 14.1	213.6 14.2	128.9 9.8	14.2 1.2	6.3 0.9	28.6 2.0	1005.4 71.5	181 (1995)	15 (2009)	210.0	10 Feb 1986
Purola	12	a b	44.0 3.6	71.2 4.2	105.7 6.5	42.1 4.0	88.2 6.9	130.6 8.8	268.1 15.0	234.4 12.6	130.2 7.2	57.7 2.3	8.2 0.6	38.0 2.0	1218.4 73.7	123 (1998)	95 (1999)	127.0	17 Oct 1998
Purola (Hydro)	28	a b	62.9 4.0	75.2 4.2	90.2 5.3	53.3 4.0	74.2 5.4	102.6 7.0	269.1 13.8	219.8 12.2	126.3 7.5	38.1 2.3	11.6 0.7	28.0 1.6	1151.3 68.0	128 (1998)	25 (2009)	127.0	17 OCT 1998
Rajgarhi	20	a b	31.1 2.7	76.9 3.8	80.9 4.5	28.4 2.6	193.6 5.7	157.4 9.4	302.3 12.1	315.4 16.6	162.5 8.0	22.0 1.9	23.6 0.9	20.1 1.4	1414.2 69.6	231 (1971)	13 (1976)	134.6	25 Sep 1964
Uttar Kashi (Obsy)	21	a b	54.3 3.8	61.9 4.8	52.3 4.1	48.2 4.0	72.3 5.8	151.6 9.8	423.8 19.6	384.2 17.7	167.8 9.8	63.3 2.9	8.7 0.9	11.6 1.0	1500.0 84.2	129 (1973)	79 (1979)	150.0	20 Aug 1988
Uttar-Kashi (District)		a b	48.1 3.5	71.7 4.5	86.8 5.2	50.8 3.9	84.0 5.8	132.7 8.8	312.0 15.7	277.9 14.6	138.4 8.3	44.2 2.3	10.4 0.8	31.8 1.8	1288.8 75.2	189 (1969)	14 (1976)		

a: Normal rainfall in mm.

b: Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

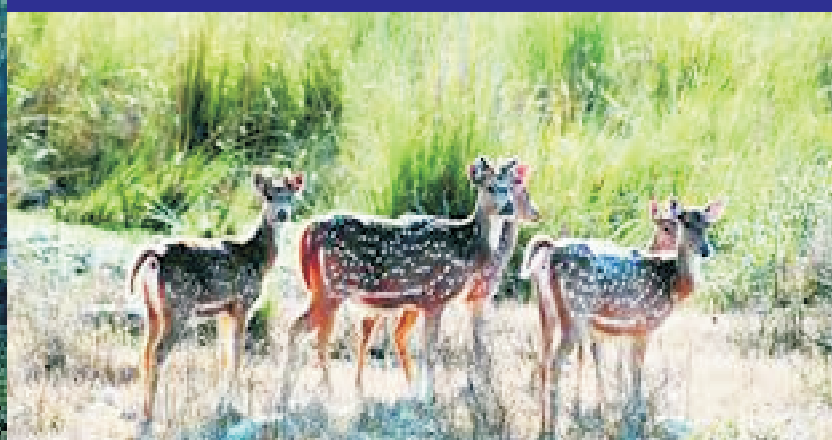
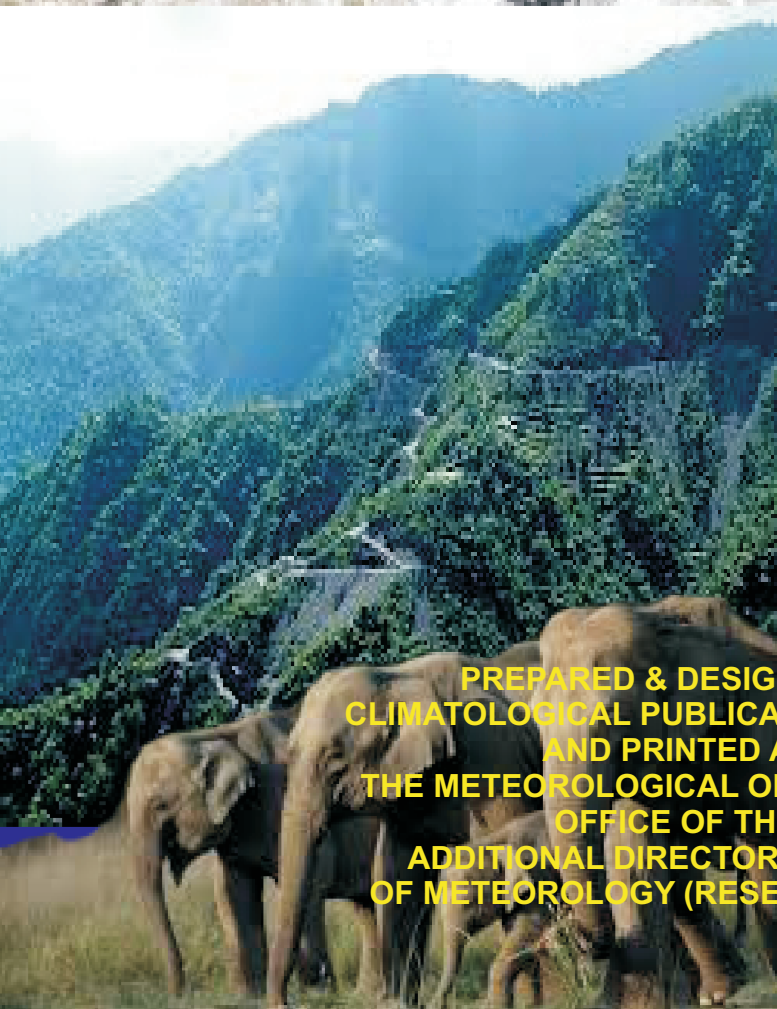
* Based on all available data upto 2010.

** Years of occurrence given in brackets.

TABLE - 2
Frequency of Annual Rainfall in the District
UTTARKASHI
(Data 1962-2009)

Range in mm	No. of years	Range in mm	No. of years
101 – 200	1	1301 – 1400	2
201 – 300	1	1401 – 1500	2
301 – 400	0	1501 – 1600	2
401 – 500	0	1601 – 1700	1
501 – 600	0	1701 – 1800	2
601 – 700	0	1801 – 1900	1
701 – 800	1	1901 – 2000	0
801 – 900	2	2001 - 2100	0
901 – 1000	3	2101 - 2200	0
1001 – 1100	0	2201 - 2300	0
1101 – 1200	7	2301 - 2400	1
1201 – 1300	7	2401 - 2500	1

(Data available for 34 years)



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