Chapter 1

Physical Setting of the Rohilkhand Region
A. STRUCTURE AND RELIEF

The Rohilkhand region forms a part of the Ganga Plain. The deposits of this tract belong to the last chapter of earth's geological history. They conceal beneath them the northern fringes of peninsular formation.\(^1\) Surface features and grainity observations indicate that the Ganga Plain is deepest in the central portion and gradually gets shallow towards the west of Delhi and east of Rajmahal hills.\(^2\)

The presence of characteristic Gondwana rocks on the northern rim of this alluvial tract indicates that its sub-stratum is an extention of the peninsular rocks, viz., Archean gneiss with areas of Vindhyan and Gondwana sediments.\(^3\)

Burrard (1912), on the basis of geological data concluded that the plain occupies a deep rift-valley with parallel faults on two sides with a maximum down trough of 32 km.\(^4\)

The recent view regarding the origin of this region is that its crust formed between northward drifting Deccan plateau and the comparatively soft sediments accumulated in the Tethyan Sea as well as in the connected basins of the north. The crumpling of the sediments resulted in the formation of a mountain system.\(^5\)

According to Edward Sues (1956), a great Austrian geologist, it is a 'foredeep' formed in front of the resistant mass of the peninsula when the Tethyan sediments were thrust southward and compressed against them. The peninsula is regarded as a stable mass and Central Asia as the moving segments of the crust. The rivers from the Himalayas brought a tremendous amount of deposits since the Pleistocene period and thus the plain came into existence.\(^6\) The total thickness of the alluvium is not exactly known. The deepest bore hole made at a station in Lucknow, Uttar Pradesh is only 400 meters but it has not touched the rock bottom.\(^7\) According to Oldham (1939), it has been deduced geologically that the depth of the alluvium along the outer edge of the Himalayas amounts in between 4,416 and 6,156 metres.\(^8\)

According to Hayden (1939), the geodetic evidence seems to confirm generally that the Indo-Gangetic depression is a broad basin, shallow on the outer side and sloping gently inwards the Himalayas.\(^9\) The sediments of this basin consist of sand, silt, and clays with occasional occurrence of gravel beds and peaty organic matter, and varying proportion of loam. The older alluvium, bhangar is rather dark in colour and rich in nodules of impure calcium carbonate known as kankar in northern parts of India.

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The kankar concretions of all shapes and size. The older alluvium forms an elevated terrace above the flood level. It belongs to middle to upper Pleistocene age. The newer alluvium, khadar is light coloured and poor in calcareous matter. It contains lenticular beds of sand and gravel. It merges by insensible gradation into the alluvium and assigned to upper Pleistocene age.

B. DRAINAGE

The important rivers and their tributaries which form the drainage of the region are: the Ganga, the Mahawa, the Sot, the Ramganga, the Aril, the Deoha, the Bhagul, the Sarda, the Gangan and the Gomati (Fig. 2).

The Ganga

The Ganga is the largest river draining the Rohilkhand region. It forms western boundary of the region. It first touches the district of Bijnore in the extreme north to a place leaving the hills above the district of Haridwar in the state of Uttranchal. It reaches the vicinity of Nagal in a village of Najibabad block. The Ganga enters the Moradabad district from the northwest about 4 km. west of the village Papsari in Hasanpur block, then flows in southerly direction along the western boundary of the district for nearly 65 km and separates the district of Moradabad from that of the districts of Meerut and Bulandshahar. In this district, it has only two insignificant tributaries the Baia and the Matwali. The former joins it near the village of Kharajpur and latter near that of Dhoria in Budaun district then it forms a long boundary of 149 km in the west and south of the

The Ganga river enters the area near village Dippur in Rajpura block. It passes through the Qadarchowk block in the extreme southeast corner of Budaun district.

The Mahawa

This is the largest tributary of the Ganga. The course of the Mahawa for the most part is parallel to the Ganga river. The Mahawa originates about 3 km. to the north of the Moradabad district.

It receives water from numerous seasonal small streams. At Narioli, it is nearest to the Ganga and passes through the Ganga Khadar. It passes through the blocks of Rajpura and Sahaswan, and joins the Ganga almost in the middle of the Budaun district. There are some elongated lakes along the river Mahawa. In rainy season when it get flooded, its course is divided into two district channels, one of which is seasonal draining in the northwest of Sahaswan block at a distance of 5 km. from the Mahawa. There is one big semi-circular lake named Dhand, in addition to many small lakes formed in the rainy season and form a continuous sheet of water.

The Sot

It flows in a southeasterly direction through the block of Sambhal in Moradabad district. It has a well defined and fairly broad valley and at most places it attains a considerable depth. It is a perennial stream and contains a large volume of water throughout the year.

The Sot takes water firstly from the Bhaisaur and then flows southeastward and finally joins the Ganga. The presence of a number of oxbow lakes close to the left bank of the river clearly indicates that previously
the river was flowing at a distance of about 2 or 3 km. away from its present course. The river enters the Shahjahanpur district where it receives numerous small streams. The Kadwara is one of them which originates and drains the low lands of Dataganj block in Budaun district and forms numerous elongated lakes.

**The Ramganga**

It is the first major tributary of the Ganga to join it on its left-bank. It rises in lower Himalayas, at an altitude of about 3,110 m. above mean sea level, near the village Lohba in the Garhwal district of the state of Uttranchal, and after passing through the districts of Bijnore and Moradabad, it enters the district of Rampur. It flows in a northwest to southeast direction and drains the southwestern part of Rampur and Bareilly districts. It flows south along the western border and then enters in the district of Moradabad, skirting the city on the east and takes a bend towards the district of Rampur. It has no affluent on its right bank but on its left side it receives several streams.

During its course the Ramganga assumes dimension spreading out over the *khadar* and carving out for itself fresh channels through the soft alluvial land in most capricious manner.\(^1\) To the west of Bareilly city, these are two alternative channels several kilometers apart, and the river is constantly shifting from one channel to the other. There are several ox-bow lakes in the low lands which represent old channels abandoned at different periods.\(^2\) Owing to the breadth of the *khadar* and the depth of the channel

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below to the level of the upland, the Ramganga and its water is used for irrigation.¹³

**The Aril**

It originates in Maithan village of block Bilari in Moradabad district. It is one of the large tributaries of the Ramganga. It is a perennial river and become much force full in the rainy season. In the upper part of the slope is gentle and consists of loamy soil, but in lower parts of the area to the northeast of Village Sisarka, it forms a common boundary (upto 1.8 km.) between Moradabad and Budaun districts. It again forms a long boundary (upto 13 km.) in between Rampur and Bareilly districts with Budaun as it leaves the area to cross a distance of over 4 km. between the Bareilly and Budaun districts. The Bajha Nadi coming from northwest and Andheria Nadi from north join the Aril river. The courses through which the Bajha and the Aril river flow in this region are devious and meandering. There are numerous elongated curved lakes. Then it joins the Ramganga on its right bank at least 1 km. to the northeast of village Chitri.

**The Deoha**

The river has its source in the southern slopes of the lower hills in the Nainital district in the state of Uttrakhand. In the beginning it is called Nandhaur, but after leaving the hills it is called Deoha. It preserves this name throughout Pilibhit district but after leaving it the Deoha changes its name to Gaira, which it retains till its junction with the Ramganga. The Deoha enters into Pilibhit district in the extreme north and flow in a southerly direction.

The Bhagul

It is an important river which takes its rise in the tarai and drains the eastern part of the Bareilly district of Rohilkhand region. It flows in a southerly direction and leaves the district about 5 miles southeast of the village Mastipur to join the Ramganga.

The Bhagul attains considerable dimension during the rains, but in dry season it shrinks to a mere trickle. It has a bed of sand and its water is used for irrigation by means of numerous dams built by the land owners.

The Sarda

The Sarda river enters the region through the district of Pilibhit about 32 km. to the east of Alampur village and flows in a southeasterly direction. It has a low velocity except at the initial stage and afterwards the mud. During floods the Sarda is opt to change its course to a remarkable extent, and this accounts for the creation of numerous channels and backwaters. The Sarda has been dammed in its upper reaches at Ban-Basa, and a canal with the same name the Sarda canal provides irrigation to several neighbouring districts of the state of Uttar Pradesh.

The Gangan

Rising in the north of the district of Bijnor, this river enters the district of Moradabad near the village of Kaimukhia and forms boundary of the district in the north for a short distance. It flows in a southeasterly direction for about 5 km. and then takes a turn towards the southwest for about 2 km. to reach near the village of Isapur, again flows in a southeast
direction as far as upto the village of Sibalinarain where it is fed by the Karula stream on the left bank and further by the Ban stream on the right bank. In its upper course, its bed is characterized with clay-sand and which gradually replaced by clay in the south.

**The Gomati**

Name of this river corresponds with the local word ‘Ghoomti’ which means curving or meandering. This characteristics feature is found throughout its course. This river originates near the village of Sabalpur lying at a distance of 7 km. from headquarters of the district of Pilibhit. As it receives the Jakrai stream, it becomes a big river. This river possesses a defined course, while banks of the river Gomati are high and permanent. It is important, that the khadar tract along its right side is safely cultivated in the greater part of the year, and there is no danger of erosion of land or deposition of coarse or infertile sand during the floods.

**C. PHYSICAL DIVISIONS**

On the basis of relief and drainage the Rohilkhand region may be divided into the following five physical divisions:

(I) Khadar and Bangar lands;

(II) Tarai Region;

(III) (a) Ganga, Sot-Interfluve;
     (b) Bahgul, Deoha Trans-Gomati Plain;

(IV) (a) Aril, Kawara, Bahgul Tract;
     (b) The chauka, Deoha, Ramganga-Interfluve, and

(V) Trans-Ramganga Plain.
1. Khadar and Bhangar lands

The newer alluvium of the Gangetic Plain, known as khadar, corresponds with the recent geologic age of the Quarternary era. It has been formed by the silt and sand brought down by the major rivers and deposited along their banks. The khadar is made up of light coloured, sandy and poor in calcareous matter, and is found generally in the river valleys. The khadar areas in the Gangetic Plain are like fingers along the main stream and their sub-parallel tributaries namely, the Ramganga, the Gomati, the Deoha, and the Sarda. The surface soil varies from sandy loam to mere sandy soil and the sandy proportion decreases as one moves away from the river and it is replaced by fine silt. This fine silt, called ‘panga’ is most fertile and laid down by the river as the flood water is receded. The sand and gravel grading imperceptibly into recent alluvium and good reservoirs of underground water. The khadar lands owe their origin to bangar lands through the erosive action of the river channels. The amount of nitrogen and organic matter in khadar is derived from the silts of the flood water and needs renewal every year for the purpose of cultivation of cultivable lands. Khadar is deficient in calcareous constituents but is entirely protected from injurious salt of soda and magnesia accumulations and forms saline or alkaline salts.

The bhangar lands occupy the higher lands and are not subject to flood by the rivers during the rainy season. The material present in the

bhangar alluvium constitutes the nodular kankars of carbonate of lime. The kankars found are in abundance and irregular concretion of impure calcareous matter. The bhangar land is characterized by patches of saline and alkaline constituents found over the surface, which are the result of gentle slope of the land, and composition of the alluvium. The bhangar lands generally lying above the flood level and possess clay and sodium clay as dominant constituents reacting with kankars which liberate sodium carbonate and are turned into calcium clay. According to Medlicat and Blanford (1879), the kankar nodules and the calcareous beds have been deposited by water which contains a solution of carbonate of lime derived from the older rocks of various kinds. \(^{18}\)

II. The Tarai Region

The tarai belt in the region extends from east to west along the northern boundary of the area to cover the northern parts of the districts of Bijnore, Pilibhit and Bareilly. This region is built up of alluvial soil. These soils are predominantly clayey and rich in plant nutrients and noted for their productivity. This tract is known for its extreme unhealthy climate due to proximity of jungles, uncleared lands, the nearness of spring level, heavy rainfall, imperfect drainage of heavy soil and exceptionally bad quality of water are some of the chief characteristics restricting human inhabitation in the region.

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III.a Ganga, Sot-Interfluve

This area possesses several small seasonal streams, consequently large tracts of wasteland have developed in the western part, mainly due to the erosive action of the streams. The water table remains very low and the water level in the Mahwa and Sot rivers is reduced considerably during summer months. Usar lands, jungles and meadows are found in the form of small and big patches along the cultivated land. The soil is chiefly sandy loam in nature. The slope of the land is from northwest to southwest.

III.b Bahagul, Deoha, Trans-Gomati Plain

This part of the region includes some areas of the district of Pilibhit and a major portion of the districts of Bareilly and Rampur. It is almost level land, sloping gradually from north to south. The elevation varies from 214 metres in the north to 203 metres in the south. The slope is so uniform that there seems hardly any difference in the average elevation of parallel points form east to west. The sub-soil water-table is low and varies form 5 to 7 meters. The area is well drained by some small seasonal streams. The area is also dotted with few lakes. The tract consists of loamy soil which is well drained. There are several lakes and seasonal streams. The seasonal river UI which forms the northeastern boundary of Shahjahanpur district

IV.a Aril, Kadwara, Baghul Tract

This tract spreads over low lying areas which are very oftenly subjected to waterlogging and is made up largely from clay and clayey loam, with the accumulation of water on the ground, some lakes have been formed, some seasonal streams takes a run off due to heavy rain. The eastern
part is narrow on account of the extent of Ganga *khadar* in the south and a low land area in the north. The waterlogging during the rainy season becomes so serious that communication are practically disrupted between the connecting villages.

**IV.b The Chauka, Deoha, Ramganga-Interfluve**

The Chauka is a perennial stream that follows the old bank and marks the westerly course adopted by the river Sarda in the past. The Deoha river forms the eastern limit of the region. The region is almost a leveled plain. The slope is uniform with few local inundations. It is drained by several river namely, the Gomati, the Kanout, the Mala. A considerable area along the river Mala is swampy and covered with thick forests.

The region has a varying in character from *tarai* in the north and Ganga plain in the south. The northern half at the area is mainly cultivated with rice, and southern part is typical wheat producing area.

**V. Trans-Ramganga Plain**

The parts of Shahbad and Aonala tehsil south of the Ramganga river constitute this plain. Besides the Ramganga, the river Aril drains the region. The tract slopes down from northwest to southeast. Lying in the most southwestern part of the region it receives least rainfall as compared to other areas. The soils are generally sandy loams and characterized with the presence of patches of fertile loams.
D. CLIMATE

To a larger extent, climate determines where man can live and continue his life, which crops can be grown and which types of home he may appropriately built, what sort of clothing he needs and what pests and diseases he must combat.\textsuperscript{19}

The potential crop producing ability of a given area is dependent primarily upon the climate and soil conditions under which the crop in question must be grown.\textsuperscript{20} The climate of the Rohilkhand region on the whole is healthy, except the swampy tract of the tarai. The Rohilkhand region experiences a tropical monsoon type of climate which is characterized by a rhythm produced by the southwest and northeast monsoons. The word monsoon derived from the Arabic word 'mausam' which means 'season'. In its meaning, based simply on day to day experience, the term 'monsoon' designates the seasonal surface air currents which are reversed from summer to winter.\textsuperscript{21} The reversal of pressure take place regularly twice a year due to these prevalent winds. During the northeast monsoon period, the winds blow form west to east. They are almost dry because they originate over the landmass. The weather during this season is marked by clear skies, low humidity and extremes of temperature. During the southwest monsoon season, the winds blow from east to west. They are oceanic in origin therefore, they are moisture-laden. The associated weather during this season is characterized by over-cast

\textsuperscript{19} Whitback, R.H., \textit{The Geographical Factor}, Century Co., 1932, p. 87.
\textsuperscript{20} Singh, J., \textit{An Agricultural Geography of Haryana}, Haryana, 1976, pp. 43-44.
skies, heavy rainfall and high relative humidity. In the light of most salient characteristics of these two types of winds, the appropriate term of 'dry monsoon' and 'wet monsoon' is applied.

The pressure gradients during the dry season are very low and the resultant wind force is also weak. On the other hand, the intense heating of area during the wet monsoon season gives birth to steep gradients owing to which the winds blow relatively with a high speed.

The seasonal rhythm of monsoon reversal is the chief characteristic of the region – the slightest variation largely control the agricultural operations in the area. The two seasons of kharif and rabi correspond with the wet and dry monsoons. Dry monsoon period extends roughly from November to mid-June and the temperature variations between the first four months and last three and a half months are so great that it becomes safe to divide this period into cold weather season (which extends from the month of November to February) and the hot weather season (extending from March to the first half of June). The cold weather season corresponds with the season of rabi crops, but the hot weather season by virtue of dryness permits restricted cultivation of crops. The wet monsoon season includes the remaining months from mid-June to October and corresponds with the kharif season. Thus, there are three distinct seasons commonly recognized in the region.

(i) The cold weather season – (November to February)

(ii) The hot weather season – (March to mid-June)

(iii) The season of Rains – (mid-June to October)
(i) The Cold Weather Season

With the retreat of southwest monsoon, the region comes gradually under a high pressure belt which develops over the plain due to the prevailing temperatures. The prevailing winds blow from west to east and their direction is determined by the combined effect of the pressure distribution and the presence of lofty mountains ranges of Himalayas. The pressure gradients are not steep enough to produce stormy winds. The breezes are light with a velocity of about 3 or 4 km per hour in the months of November and December. The mean monthly maximum average temperature at Bijnore, Moradabad, Rampur, Budaun, Bareilly, Pilibhit and Shahjahanpur stations in the months of December are, 27.7°C, 27.3°C, 27.4°C, 25.4°C, 23.7°C, 23.8°C and 23.3°C respectively. The mean minimum average temperature in the months of December for the same stations are 5.3°C, 5.2°C, 5.1°C, 6.6°C, 9.8°C, 9.9°C and 9.7°C respectively (Table 1.1). In the month of January, the temperature further decreases and the day becomes less warm, whereas the nights remain colder. The month of January records the lowest temperature of the year and, therefore, it is considered to be the coldest month. The minimum temperature is recorded 4.5°C at Moradabad in the region. During these months, heavy mist or fog locally known as kohra often occurs at night and lasts until the early morning hours. The month of February registers a slight increase in temperature, but the nights are still very cold and the days are comparatively warmer. The minimum temperature at Bijnore and Shahjahanpur stations are recorded 7.3°C and 10.6°C respectively.
### Table 1.1

**Winter Mean Monthly Maximum and Minimum Average Temperature (°C) in Rohilkhand Region**

<table>
<thead>
<tr>
<th>Station</th>
<th>November</th>
<th>December</th>
<th>January</th>
<th>February</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bijnore</td>
<td>31.8</td>
<td>6.4</td>
<td>27.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Moradabad</td>
<td>32.0</td>
<td>6.7</td>
<td>27.3</td>
<td>5.2</td>
</tr>
<tr>
<td>Rampur</td>
<td>31.6</td>
<td>6.8</td>
<td>27.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Budaun</td>
<td>29.1</td>
<td>7.0</td>
<td>25.4</td>
<td>6.6</td>
</tr>
<tr>
<td>Bareilly</td>
<td>28.6</td>
<td>13.6</td>
<td>23.7</td>
<td>9.8</td>
</tr>
<tr>
<td>Pilibhit</td>
<td>28.7</td>
<td>9.4</td>
<td>23.8</td>
<td>9.9</td>
</tr>
<tr>
<td>Shahjahanpur</td>
<td>28.5</td>
<td>12.6</td>
<td>23.3</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Source: Meteorological Centre, Lucknow.

The rainfall during the cold weather season is small, irregular and sporadic. It is locally heavy where the thunderstorms are associated with disturbances. The winter rainfall is highly beneficial to the *rabi* crops. The effectiveness of this rainfall is further increased by the prevailing low temperatures. Amidst the general fine weather, there occurs some weather disturbances brought by the western depressions during the months of December, January and February. The region is benefited with a small quantity of rainfall when these depressions bring with them. Some of these depressions originate in the Mediterranean Sea and a few come from the Atlantic Ocean. The rainfall caused by these depressions is preceded by a warm weather with light southerly or easterly winds and are followed by a considerable fall in temperature and strong and cool westerly winds blow.

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The cloudy weather with the depressions is temporary for a day or so, and is followed by a clear sky.

Trewartha\textsuperscript{23} considered the course of western depressions with the presence of a jet stream across the northern India. These disturbances reach their maximum development when the jet stream lies south of the Himalayan mountains. In rare case these cold weather depressions bring with them hailstorms. These hailstorms are liable to damage the \textit{rabi} crops heavily, if they occur late in the months of January and February when the flowers and immature ears of the plants are bruised by them. In case they occur during the months of November and December, the damage done by them is comparatively low. It is often experienced that, the crop in one field may be seriously affected by them, while the crop of next field only a few meters away are totally immune from their adverse effects.

(ii) The Hot Weather Season

The beginning of the month of March is well marked by a subsequent increase in temperature because of the apparent movement of the sun northward.\textsuperscript{24} In this season the area is dominated by a few pressure systems due to high temperature. The mean maximum monthly temperatures in the month of March at, Bijnor, Moradabad, Rampur, Budaun, Bareilly, Pilibhit and Shahjahanpur stations are 34.3°C, 34.2°C, 34.1°C, 32.2°C, 28.9°C, 32.5°C and 31.6°C respectively, while the mean minimum temperature for the same months at the respective stations are 9.7°C, 8.8°C, 8.9°C, 9.2°C, 15.0°C, 9.8°C and 15.5°C, respectively (Table 1.2). The month of May


registers the highest temperatures of the year. The mean minimum average temperature for this month at, Bijnore, Moradabad, Rampur, Budaun, Bareilly, Pilibhit and Shahjahanpur stations are 19.7°C, 19.5°C, 19.4°C, 20.6°C, 23.3°C, 20.9°C and 25.3°C, respectively while the mean maximum average temperature at the same stations are 45.5°C, 45.1°C, 45.3°C, 40.8°C, 39.9°C, 41.7°C and 39.8°C, respectively. The temperature begins to decrease in the months of June. The mean monthly maximum temperatures are 41°C and 36.8°C at Bijnore and Shahjahanpur station respectively.

### Table 1.2

<table>
<thead>
<tr>
<th>Station</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bijnore</td>
<td>34.3</td>
<td>9.7</td>
<td>41.5</td>
<td>16.4</td>
</tr>
<tr>
<td>Moradabad</td>
<td>34.2</td>
<td>8.8</td>
<td>40.8</td>
<td>15.1</td>
</tr>
<tr>
<td>Rampur</td>
<td>34.1</td>
<td>8.9</td>
<td>40.9</td>
<td>15.8</td>
</tr>
<tr>
<td>Budaun</td>
<td>32.2</td>
<td>9.2</td>
<td>38.5</td>
<td>16.0</td>
</tr>
<tr>
<td>Bareilly</td>
<td>28.9</td>
<td>15.0</td>
<td>38.2</td>
<td>21.6</td>
</tr>
<tr>
<td>Pilibhit</td>
<td>32.5</td>
<td>9.8</td>
<td>38.7</td>
<td>16.5</td>
</tr>
<tr>
<td>Shahjahanpur</td>
<td>31.6</td>
<td>15.5</td>
<td>37.2</td>
<td>21.5</td>
</tr>
</tbody>
</table>

Source: Meteorological Centre, Lucknow.

In summer months a hot dry wind locally known as *loot* is a regular phenomena and its intensity becomes greater in the months of May and June. The most characteristics features of the hot wind are its intense dryness and excessive temperature. The velocity of the wind increases in the
afternoon of a day and they blow with violent force till 4 p.m. In the evening when their force is retarded to such an extent that they practically disappear from the scene. Such conditions persist until the middle of the month of June prior to the onset of the southwest monsoon.

The occurrence of dust storms locally known as *andhi* is another phenomena in this season. These dust storms last for a short time, give peculiar reddish yellow glare to the sunlight, more specially in the afternoon and sometimes bring a small amount of rainfall. Sometimes these dust storms are accompanied by thunderstorms which do a lot of damage to buildings and trees.

The rainfall during this season is sporadic, shortlived, subject to great local variations and frequently repeated at the same hours of the day, after day and for many days in succession. The rainfall during the month of June at Bijnore and Shahjahanpur stations are 58.2 mm and 119.2 mm (Table 1.3) the rain occurring during the hot weather season provides a temporary relief from the intense heat and makes the weather pleasant often for a day or couple of days. With the occurrence of rain the air becomes cool and the circulation of dust particles in the atmosphere is reduced to a minimum. The relative humidity is slightly increases for sometime, but again decreases gradually during the dry period when there is no rainfall, and the scorching heat again becomes unbearable.

(iii) The Season of Rains

Within a wide range of temperature conditions the occurrence of rain is more important then any other climatic factor in crop production.²⁵ The

beginning of June is marked by more severe characteristics of the hot weather season when the heat associated with dryness of the atmosphere becomes intolerable. At this time an intense low pressure area develops over northwestern India, as a result the zonal westerlies over northwest India begin to move northward, but they are obstructed by the presence of mountains. Consequently, the jet stream which has been south of the mountains at about 30°N during winter tends to alternately disappear with the northward advance of summer monsoon. Finally as late as in the month of May or June, the Jet stream disappears completely over north India and takes a position at about 40°N to the north of the Himalayas. At the same time there occurs a westward movement of the low pressure though 85°E to 75°E longitudes over western India. With the disappearance of jet stream over northern India and a northward shift of the trough, monsoon winds enter the plain. These moisture-laden winds bring an abrupt change in the weather and a sudden fall in day temperature is experienced. The atmosphere becomes cool and pleasant. The mean temperature in the month of July drops and relative humidity increases. The sky remain overcast for days together and rainfall assumes continued downpours, and sometimes accompanied by violent thunders and lightening. With the burst of the monsoon that normally starts from the middle of the month of June and lasts till October there is a complete change in weather which also bring an immediate fall in temperature and an increase in relative humidity.

Table 1.3
Mean Monthly Distribution of Average Rainfall (mm) in Rohilkhand Region

<table>
<thead>
<tr>
<th>Station</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bijnore</td>
<td>58.2</td>
<td>470.6</td>
<td>508.9</td>
<td>287.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Moradabad</td>
<td>25.0</td>
<td>566.0</td>
<td>491.0</td>
<td>111.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Rampur</td>
<td>34.0</td>
<td>412.9</td>
<td>492.6</td>
<td>66.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Budaun</td>
<td>17.0</td>
<td>433.4</td>
<td>567.6</td>
<td>110.0</td>
<td>9.5</td>
</tr>
<tr>
<td>Bareilly</td>
<td>77.1</td>
<td>626.1</td>
<td>619.0</td>
<td>119.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Pilibhit</td>
<td>122.7</td>
<td>496.0</td>
<td>418.5</td>
<td>75.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Shahjahanpur</td>
<td>119.2</td>
<td>404.0</td>
<td>414.7</td>
<td>189.1</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Source: Meteorological Centre, Lucknow.

Rainfall alternates with rainless gaps of one day or two in the months of July and August, and these are the rainiest months of the year which receive more than 50 percent of the total annual rainfall (Table 1.3).

By the month of September the rains normally slacken and the rainless intervals become longer and the day temperatures vary. The relative humidity however, remains high with little movement of the air. The average monthly rainfall in the month of September at Bijnore, Moradabad, Rampur, Budaun, Bareilly, Pilibhit and Shahjahanpur stations is 287.6, 111.0, 66.0, 110.0, 119.7, 75.2 and 189.1 mm respectively (Table 1.3). The rainfall occurring during the month of September is beneficial to the standing crops. High humidity, low amount of clouds, long rainless intervals, high temperature and calm atmosphere together make the month of September sultry. October is the month of retreating monsoon but the mean maximum temperature remains as high as in September. Rainfall though little, is useful for the rabi crops and for the maturity of late rice.
E. SOILS

Soils constitute a most important resource for agriculture.\textsuperscript{27} Besides climatic considerations, the texture and depth of the soil, soil nutrients, salinity and alkalinity, drainage conditions and groundwater table all go to determine the crop which would be suitable for an area and the mode and extent of irrigation to be applied to them.\textsuperscript{28}

Generally the soils are so uniform and similar in their characteristics that it is often difficult to differentiate the soil of one region from that of the another. However, the soils of Rohilkhand region are of alluvial origin. These soils have developed from the deposition of the alluvium brought by the rivers of Ganga system and their tributaries. The alluvium of the region on the basis of origin can be divided into two broad sub-divisions: new alluvium and old alluvium. The newer alluvium of sandy texture, with less kankar composition and light in colour is known as \textit{khadar}. It is in the process of building up. The older alluvium with more clayey composition, full of kankar, and dark in colour is called \textit{bhangar}. It is in the process of denudation. The \textit{khadar} occupies the flood plains of the river and their tributaries as a result of which the constituents of such land are renewed each year. The \textit{bhangar} soils are represented by level plains above the flood level of the river and their tributaries. These soils differ considerably in their texture which ranges from sandy \textit{bhur} to loam, and silt to heavy clay which are ill-drained and sometimes charged with injurious salts resulting into the

ROHILKHAND REGION
SOILS

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- BHABAR SOILS
- TARAI SOILS
- ALLUVIAL SOILS

SOURCE: BASED UPON MAP OF STATE SOIL SURVEY ORGANISATION, KANPUR.

FIG 3
formation of *reh*. Thus the soils of the Rohilkhand region can be divided into (i) Newer alluvium or *khadar*, (ii) Older alluvium or *bhangar*, (iii) foot-hill or *bhabar* soils, and (iv) Tarai soils (Fig. 3).

(i) Newer alluvium or *khadar*

*Khadar* is limited in extent and strictly confined to the terraces and the flood plains built up by the Ganga and the Ramganga rivers and their tributaries. They make a narrow strip along both sides of the main rivers and are always exposed to floods and waterlogging. Their water retention capacity is very poor. The colour of soil varies from light-grey to ash-grey and the texture is sandy to silty loam.

The groundwater table is usually very high and lies near the surface. The sandy soil popularly known as *bhur* for the most part consist of sand of white colour. The *khadar* tract is quite precarious for agriculture. It is generally used for the production of millets and pulses in *kharif* and barley and gram in *rabi* season. Salt efflorescence is quite negligible in sandy tract. The fertility status of the soil in alluvial tract, has a normal pH value in all the districts of the region with a single exception of Bijnor district where it is slightly acidic. Phosphorus, potash and organic carbon contents are low in soils of all the districts of the region with the exception of Bijnor district where it is moderate.

(ii) Older alluvial or *bhangar*

The *bhangar* soils are more extensive in extent occupying the inter-fluvial zones. The most important constituent material in *bhangar* soil is clay which at some places has been converted by the natural processes into
loam or sandy-loam. It generally contains *kankars* and is of dark in colour. On the basis of texture, the *bhanger* soils can further be sub-divided into sandy, sandy-loam and clayey-loam. Sandy-loam or *bhur* has some unusual geomorphic features that add a variety to the rather monotonous landscape. The sandy ridges with a flat-topped and gentle lateral slopes extends into the Moradabad district which from northwest to southeast are roughly parallel to the Ganga river. They extend upto Budaun district only, and there are no *bhur* areas elsewhere.

The sandy-loam is poor in humus content. These soils have undergone several stages of oxidation. The tracts of land occupied by these soil have partly been reclaimed with the application of manure and by providing irrigation for the cultivation of crops. The chief crops grown in the tract are millets and pulses among the grain crops, groundnut among other crops of *kharif* season, and wheat, barley and peas in the *rabi* season.

Sandy-loam soils occupy a considerable portion of a generally well drained areas of the plain. The tract comprising sandy-loam stretches in an elongated strip along the Ganga river and runs just in immediate vicinity of the *khadar* lands. It is inter-spread by long patches of good quality loam chiefly in the districts of Budaun and Moradabad, and stretches along *bhur* tract on both eastern and western sides as well as to the north and south of it. The most important characteristic feature of these soils is its homogeneity and level topography throughout the area. The texture of the soil is predominantly sandy and the colour of the soil ranges from yellow to brown and to reddish brown. It contains some humus which is lesser in amount than that of the loamy soils with less irrigation and less amount of manuring.
the soils become weak to support the production of crops. The water holding capacity is generally poor. Sense of the main crop grown on these soils are millets, pulses, maize, tobacco and groundnut in kharif season, and barley, peas and potatoes in rabi season. Sugarcane is also grown in some areas where irrigation facilities are available. Loamy soil occurs in disconnected patches. It is considered to be the best soil which is rich in humus and inorganic matter. Water retention capacity of the soil is relatively high and the underground water table is low. These soils are locally known by different names as: matyar, domat and kalihar. Important tracts of these soils occur in the districts of Moradabad and Budaun. These soils also cover a considerable area in Shahjahanpur district. The colour of the soil ranges from light grey to brownish grey. The surface soil have more sand and show light acidic reaction at places where the percentage of clay increases, the reaction is mostly basic, and the surface is covered with efflorescence. In many depressed areas, the percentage of clay increases towards the lower depth, with the result that kankar pans are found at the bottom.29

Clayey-loam soils occur in lowlying areas where jhils and swamps are the common features and the drainage is very much restricted. The tracts of these soils are found in the northwest and western parts of the Ramganga river in Budaun, Shahjahanpur and Moradabad districts. The calcareous pans also occur in sub-soil. These soils allow to grow transplanted rice. Some millets and kharif pulses are grown in relatively higher and drier parts, whereas gram, peas and fodder crops are grown in rabi season.

(iii) Foot hill or *bhabhar*

The foot-hill or *bhabhar* soils have been formed by the mechanically transported alluvium from the adjoining Siwalik and the Himalayan ranges which comprise small pebbles and coarse gravels. The *bhabar* soils cover a small area in the northern part of the region. These soils are dark in colour and moderately alkaline in reaction. These soils possess rich plant nutrients but are less productive owing to acute scarcity of moisture. Therefore, these soils support to grow only inferior crops which mature early on less water.

(iv) Tarai soils

The tarai soils cover only small patches in the Rohilkhand region. The texture varies from clay-loam to sandy-loam. Due to excellent moisture retention the need of irrigation is less; the surface soils are rich in organic matter and nitrogen content.