Part I

Environmental Setting of the State of Uttar Pradesh
CHAPTER 1

Physical Environment of Uttar Pradesh

A. Structure and Relief

The state of Uttar Pradesh structurally forms a part of the Ganga plain, which lies between the northern Gondwana land of peninsular India in the south and the recently built Himalayan chain of mountains in the north. The plain extends with a maximum width of 400 km. and about 2,400 km in length, consisting the sedimentary deposits brought down by the great Himalayan rivers through geological ages. This sedimentation is believed to have taken place in the Gangetic trough of past tertiary formation and filled by Pleistocene alluviation.

The genesis and nature of this depression is a much disputed matter among the geologists. However, from geological and geodetic evidences this depression is generally regarded as a sag in the crust formed between the northward drifting of Indian continent and the comparatively soft sediments accumulated in the Tethyan basin, when the latter was crumpled and lifted up to form a mountain system. The formation of this depression perhaps, started from the Upper Eocene and attained its greatest development during the third Himalayan upheaval in middle Miocene. Since then, it has been gradually filled up by sediments to form a level plain with a very gentle slope.

The nature and configuration of Gangetic trough beneath the alluvium are not exactly known. All drills which have hitherto been made failed to reach the rocky bottom. The deepest bore hole at Lucknow in the state is only 400m. and has not touched the rock, bottom. However, on the basis of characteristics of Gondwana rocks found on the northern rims of the alluvial belt of the plain, Wadia and Auden (1939) maintain, that the archaen gneisses and the peninsular rocks are continuous underneath the plain. The continued loading of this belt by sedimentation since the first uplift of the Himalayan mountains may have accentuated the sinking of the archaen floor, but as the process of sedimentation kept pace with that of depression, there arose the great plain. Since no boring has reached this archaen floor, it is difficult to ascertain its configuration. On the basis of geological and geodetic evidences several contradictory estimates of the depth of this depression are made.
Oldham (1917), finds the depth of this Gangetic trough to be 4,600 to 7000 m. at its northern edge. Cowle (1921) while criticizing the above findings postulated even higher figures from the same data. However, the estimations have made it clear that the deepest part is near to be the northern edge than the southern. It becomes shallower towards the peninsular margin.

With respect to the geological age, the alluvial deposits of the state can be classified as bhangar (older deposits) occupying the higher grounds and not flooded by the rivers during the rain season and khadar (never deposits) occupying the lower grounds. The general level of bhangar generally varies from 5 to 6 m. above the highest point and 15 to 21 m. above the lowest level of the river Ganga. It contains carbonate of lime in the form of nodules called kankar and is characterized by patches of saline and alkaline efflorescence which is the result of the gentle slope of the land and the composition of the alluvium. The gradient of the land at various places in eastern part of the state is less than 1 m. per km. Naturally, the gradient of the water-table associated with gentle slopes is correspondingly small which makes the movement of surface water sluggish and slow. Consequently, with the monsoon rain, soil nutrients are washed down to the deeper horizons of the soil, but the process of leaching is intercepted in dry summer and extensive evaporation exerts a capillary pull on the solution in the pores of the soil. On reaching the surface the solution evaporates leaving behind crystallized salts in the form of white incrustation. Alkaline formation is characteristically a dominant constituent of the bhangar. Clay and sodium clay reacting with kankar nodules, which liberate sodium carbonate, are turned into calcium clay.

The khadder or the newer deposits occupies relatively a lower levels of land and are liable to inundation at the time of floods. The low level of khadar land is in conformity with the principle that as a river gets older, more and more of its deposits are found to be of a younger age, and as the land of the river sinks lower, these younger deposits come to occupy a level land lower than that occupied by the earlier ones. The khadar lands owe their origin in bhangar lands through the erosive river actions due to changes in direction of the meandering channels of the river. The khadar is most conspicuous in the eastern half of the state forming a belt of varying width along the bank of the Ghaghara, Ganaga and Sarju rivers. The surface of the khadar along the banks of these three rivers is marked by irregular depressions.
marking the old courses of the rivers, some of them resembling tributary valleys and other surviving as narrow lakes. The *khadar* is free from *kankar* and *reh* (salts). There are of course differences between the *khadar* deposits of the Ganga and those of the Ghaghara and the Sarju. The Ganga deposits are principally of mud and floods in the Ganga proves useful to the cultivators in the lowlands, as it adds fertile silt to it, whereas in case of the Ghaghara the floods bring a large amount of sand and destroy the standing crops.

**B. Physiography**

With a total area of 2,40,928 sq km. The enjoys central location in south Asia. It is landlocked by the state of Uttarakhand and Himachal Pradesh in the north, Haryana in the west, Madhya Pradesh in the south and Bihar in the east. After shading off thirteen northern districts of the Himalayan region to a newly formed Uttarakhand state, Uttar Pradesh can be divided into two distinct physiographic divisions: (1) the Ganga plain and (2) the southern uplands. The state reserves the upper and almost half of the middle Ganga valley from the district of Saharanpur in the northwest to Ballia in the east. The northern part of Saharanpur has the highest altitude of 600m. The Siwalik range, which forms the southern foothills of the Himalaya gradually slopes down into a the boulder bed called *bhabar* and merges into the alluvium of the great Ganga plain. This belt is running along the entire length of the state from the districts of Saharanpur in the northwest to Deoria in the east. The *bhabar* tract, along its southern fringes gives place to the *terai*, which is covered with tall *elephant* grasses and thick forests interspersed with marshes and swamps.

The Ganga plain is the youngest quaternary-fluvial plain. It runs the state in a west-northwest to east-southeast direction almost from end to end, forming the southern boundary of the mountains and northern boundary of the peninsular upland. This aggradational plain covers about 1,49,000 sq. km of the surface area and is characterized by imperceptible changes in elevation and uniform surface material. Physical landscape, in general, has wide open valleys and the axis of the topographic trough is nearer the peninsular margin or along the Ganga river which flows in the south-southeast direction. Rivers flow in a braided-cum-meander pattern. The meanders, changing river courses and ox-bow lakes are the main characteristics of the region. The average elevation is about 150m. above mean sea level but adjacent to the foothills, the elevation is more than 300m.
Based on the micro topographic characteristics, the Ganga plain can be divided into three sub-regions, viz. (i) the older alluvium or bhangar; (ii) the newer alluvium or khadar, and (iii) the tarai belt adjoining the bhabar area. The narrow piedmont zone, known as bhabar, is 10-15 km. wide and spreads over the districts of Saharanpur and Bijnor and areas between Yamuna in the west and Sarda rivers in the east. This zone is composed of assorted debris-boulders and sands derived from the Himalaya in which streams disappear. The tarai, 15-30 km. wide in the north and northeast, runs parallel to the bhabar in a thin strip through the districts of Saharanpur, Bijnor, Rampur, Bareilly, Pilibhit, Kheri, Baharaich, Gonda, Basti, Gorakhpur and Deoria. The strip, originally 80-90 km. wide is considerably narrowed down today due to the reclamation of land and use of it for a number of business activities. The soils of tarai consist of silt and clay, and the land with numerous big and small water streams. Low gradient and high water table results in the formation of swamps and marshes, which dominate the entire landscape.

The Ganga-Yamuna doab with an elevation in between 100 and 300m. is formed by khadar. The area stretches across the entire length of the state from east to west. The area between Ganga and Ghaghara rivers can again be divided into as Rohilkhand plains in the west and the Awadh plains in the east. The catchment area between the Ganga and the Yamuna rivers is divided into upper doab in the northwest and lower doab in the south and southeast. The eastern tract covering almost fourteen districts are subjected to periodic floods and droughts. These districts have highest density of population thereby having lowest per capita land. The other two regions, central and western, are in a better condition with well developed irrigation system. However, this area also suffers from water logging and in water scarcity zones land has the usar tracts, devoid of natural vegetation. The southern margin of the Ganga plain near its contact with peninsular upland consists of highly ferruginous arkosic material of banda alluvium which projects rocky peninsular mass at several places.

South of the Ganga plain, the Vindhyan hills and plateaus demarcate the region. The area covers 2,52,280 sq. km. in four districts of Jhansi, Jalaun, Banda and Hamirpur belonging to Bundelkhand division; Meja and Karchhana tehsils of
UTTAR PRADESH
Physiography

Fig. 1.1

district; the whole of Mirzapur district south of the Ganga and Chakia tehsil of Varanasi district. The region, covering the southern uplands of Bundelkhand is a broad undulating land, the elevation of which ranges from 100 to 300m. The area is interspersed with low ridges running parallel to the drainage lines in the districts of Jhansi, Hamirpur and Banda to reach up to Mirzapur hills. In between the Mirzapur and Kaimur hills lies the Kaimur plateau. This rolling upland, touches the Vindhya hills which exhibits a complex and heterogeneous nature of topographic features with detached hills, flat- topped ridges, summit plains and entrenched narrow as well as broad valleys almost reaching the base level. In the eastern part, the east-west trending Vindhyan range is composed of shallow marine deposits of Proterozoic age, divides the Ganga plain in the north and vast peneplain which is characterized by the exposed metamorphic rocks where peneplain merges with the Ganga plain in the north. The western part of the state, adjacent to Haryana and Delhi, is marked by a number of disconnected hills.

C. Geology

Geologically, land of the state is made up of diverse rock types, ranging in age from the oldest achaean metamorphites or granitodes to the youngest quaternary alluvium. Depending upon lithological, tectonical and sedimentation chronology, the landforms can be divided into two broad geo-tectonic divisions: (i) southern uplands on the peninsular foreland of the Gondwana block where achaean, lower pre-cambrian, upper pre-cambrian, paleozoic and carboniferous-permian systems are found, and (ii) the Ganga plain, formed with the process of alluvial sedimentation during the pleistocene-holocene periods. This is the youngest and geologically least noticeable part of the state. A brief description of these two regions will indicate the geological set up of land formation of the state.

(i) Southern Uplands

The crystalline rocks of the archaean-palaeoproterozoic period, exposed in the peninsular region are the extensions of sequences exposed in central India and the state of Bihar. They represent dominantly igneous rocks, mostly granites along with metamorphic rocks. These metamorphic rocks include various types of schist, quartzite, marble and gneiss. Metavolcanics, meta-sediments of the Sidhi group and meta-sediments of the Bijawar group belong to the palaeo and palaeo-
mesoproterozoic periods. Rocks exposed in the Bundelkhand region in the west are dominantly gneissic. The two regions are separated by east-northeast to west-southwest following a trend determined by younger rocks of Sidhi-Bijawar-Vindhyan sequences. In the Bundelkhand region granites constitute the dominant rock and the assemblage is termed as 'Bundelkhand Granitode Complex'. In Sonbhadra region, gneiss is the dominant rock and the assemblage is termed as 'Dudhi Gneissic Complex'. The Bundelkhand granitode complex contains a wide variety of plutonic and hypabyssal rocks dominated by porphyritic granites of several generations, gneisses, migmatites and leucogranites. Among the enclaves, metabasic rock, rafts of schists and meta-sediments are also present. The rocks of the Bundelkhand granitode complex extend into the neighbouring state of Madhya Pradesh. Dolerite dykes are very common in Bundelkhand granitode complex and represent the last phase of intrusion. Generally, the dykes trend northwest to southeast and cut across 'Quartz Reefs'. Metasedimentaries of the Dudhi gneissic complex are exposed in Sonbhadra, Lalitpur and Chhattarpur. Isolated outcrops of Ajabgarh group occur in parts of Mathura district of the state.

The Vindhyan super group transgresses the Bijawar group and separates outcrops of Mahakoshal and Bijawar groups. This group is divisible into the Parsoi formation overlying the Agori formation. The Barsana formation in the state is the northeastward continuation of the Ajabgarh group of palaeo to mesoproterozoic period. A linear tectonic belt in the Jungel valley of Mirzapur-Sonbhadra area also represents the same period. The neoproterozoic era is represented by the rock of Rewa and Bhandar groups. Paleozoic symptom is found in the rocks of the Gondwania super group, which occupies a smaller area in Sonbhadra district, but laterally continues in the adjoining Sidhi district of Madhya Pradesh. Detached outcrops of basic volcanic materials of the mesozoic period overlie the Bundelkhand granitode complex, Bijawar group and Vindhyan super group in Bundelkhand region. Granitic intrusion metasomatically transformed the earlier metamorphic-basic rock association into different types of granitic gneisses and schists during the late archaean period. Structurally, the general trend of these rocks in Mirzapur area varies from east-west to east-northeast or west-southwest. Bijawar group trends east-west is unconformable with the Bundelkhand granitode complex. It is folded into a syncline. The Vindhyan super group shows open folds with axes trending east-northeast to west-southwest.
UTTAR PRADESH
Geology


Fig. 1.2
(ii) Ganga Plain

Geologically, the Ganga plain extends from Aravalli-Delhi ridge in the west to the Rajmahal hills in the east. The upper and middle parts of the Ganga plain fall in the state of Uttar Pradesh. The plain exposes fluvial sediments of quaternary period. The alluvium subsurface exploration reveals that a thick pile of alluvium rests over the Siwalik sequence of neogene - early pleistocene period. The Ganga plain is a part of Indo-Ganga foreland basin, developed during the upper tertiary period and is closely related to the birth and rise of the Himalayas.

D. Climatic characteristics

The entire state has a tropical monsoon climate, except the Himalayan region, which is characterized by temperate climate. The climate is characterized by a rhythm of seasons caused by the southwest and northeast monsoons. The pressure reversal takes place twice in the course of year. At the time of northeast monsoon winds are of continental origin and blow mostly from west to east, while during the southwest monsoon they are oceanic in origin and blow mostly west to east. The southwest monsoon usually enters the state by the end of the month of June and the state gets most of its rainfall from it, while the western depressions bring few showers during the winter season.

The *kharif* and *rabi* agricultural seasons closely follow the dry and wet monsoons. The northeast monsoon extends from the month of November to middle June, while the southeast monsoons extend from mid-June to October and corresponds with rainy season. On the basis of temperature and rainfall, the entire year is divided into three distinct seasons:

(i) The cold weather season (November to February),
(ii) The hot weather season (March to mid-June), and
(iii) The season of general rains (mid-June to October).

(i) The cold weather season

During the month of November a high pressure belt extends from northwestern India and covers the whole of the Ganga Valley. The prevailing direction of the winds is from west to east, owing to pressure distribution and the influence exerted by the Himalayan relief. Since the pressure gradients are not steep,
the land breeze blows gently in the months of November and December having a velocity of 2 to 3 km. per hour.

The month of January is the coldest month and records lowest temperature conditions accompanied by mist and fog known as kohra, which often reduces the visibility to almost nil. Frost is also noticed frequently, which sometimes adversely affects standing crops. February is the month of clear sky with increasing temperature, but still remains colder than the month of November.

(ii) The hot weather season

The months of March, April, May and the first half of June constitute the remaining half of the dry monsoon season. A sharp rise in temperature with a continuous fall in pressure occurs in the month of March. The excessive heat during season has a dessicating influence on the vegetation and the surface of the earth becomes parched. The month of May and half of June is the period of intense hot dry west winds, locally known as loo. Thus, the months of May and June before the outbreak of the monsoon are the hottest in the entire state.

The occurrence of dust storms locally known as andhi forms a significant feature of this season. The andhi is characterized by huge clouds of dust which obstructs the visibility in the atmosphere. The storms are caused by the interaction between the dryland winds of the upper strata and the damp sea winds which creep into the lower strata. These storms are short-lived and frequently end-up in the light showers of rain; sometimes they are accompanied by hail and thunderstorm which modify the weather for a short period. Rainfall received during hot weather season gives temporary relief from the heat and helps in the sowing of early rice crop. In the month of June the features of hot weather season become more intensified and continuous heat and dryness of the air causes unbearable conditions.

(iii) The season of general rains

With the burst of monsoon that normally occurs in middle of June and lasts till the October a complete change in the weather is brought about with immediate fall in temperature and follows an upward trend in humidity. Rainfall alternates with rainless gaps of a day or two in the months of July and August, and these are the rainiest months of the year.
October is the month of retreating monsoon but the mean maximum temperature remains as high as in the month of September. Rainfall though little is useful for the *rabi* crops and for the maturity of late rice. Rainfall in the months of June and September is irregular and affect the agricultural practices to be followed in *kharif* and *rabi* seasons. Whereas, continuous rainfall for several days lead to flood conditions, which result in sheet and gully erosion and often brings floods in the rivers which destroy the standing crops and bring loss to life and property.

Climatic condition of the state can be examined with reference to temperature and rainfall distribution.

(a) Temperature Distribution

Spatial distribution of mean annual temperature in the state shows a gradual decrease from south to north because of the increasing distance area from the Tropic of Cancer, which passes through the state Madya Pradesh, only touching the southern tip of the state of U P.

All isopleths are latitudinal and follow the boundaries of state relief. Temperature gradient is low in plains but increases towards the north with the rise of elevation. The mean maximum and mean minimum temperatures at different stations in the states are: Banda (43.0°C and 26.4°C) and Jhansi (42.6°C and 28.8°C), Orai (42.6°C and 27.1°C), Fatehpur (42.3°C and 27.3°C), Mainpuri (42.2°C and 26.2°C), Allahabad (42.1°C and 27.4°C), Agra (41.8°C and 27.2°C), Kanpur (41.7°C and 27.2°C), Varanasi (41.4°C and 26.1°C) and Lucknow (41.2°C and 26.5°C). The isotherm line of 26°C passes through the stations of Fatehpur, Allahabad, S. R. Nagar, Mirzapur and Varanasi. A major part of the state comes under the temperature zone of 25°C and above, whereas the northern portions of the state remain below 25°C. All the isopleth lines pass through the state, almost parallel to latitude, while temperature tend to decrease from south to north. In the Ganga plains, the mean annual maximum temperature deviates because of the homogenous alluvial surface.

From the month of March to May there is a sharp rise in the mean monthly temperature (Lucknow: mean monthly temperature in the months of March are recorded 24.6°C and in May 33.9°C ) while the central and western the state (including the Bundelkand region) experience spells of heat waves. But with burst of summer monsoon in the month of June, temperatures decline sharply. In the month of
September there is a slight increase in temperature which again shows a downward trend from the month of October to January, which is the coldest month of the year.

January is the coldest month of the state as a whole. Isotherm lines are almost parallel. May is the hottest month of the state but July is the typical period during of southwest monsoon. During the cold season, particularly in January, the cold waves sweep over the entire Ganga plain. These cold waves oftenly accompanied with winter depressions. Temperature zone are prepared by calculating the difference between the average temperature of the warmest and coldest months. The variation in the degree of annual range of temperature is controlled by continentality, vapour pressure, cloudiness, and latitudinal position and with the effects of altitude.

(b) Rainfall Distribution

The state is blessed with plenty of rainfall, about 80 per cent of which is received almost during the months of July to September. The state lies 625 km. away from the Bay of Bengal and 800 km. from the Arabian Sea. The vast expanse of the state, both north-south and east-west orientations show spatial and annual variations in the distribution of rainfall. Fig. shows the average annual distribution of rainfall in different zones and monthly average rainfall at some selected stations namely, Gorakhpur, Varanasi, Allahabad, Fatehpur, Jhansi, Kanpur, Lucknow, Gonda, Bahraich, Mainpuri, Agra, Aligarh and Bareilly.

In plain areas the annual amount of rainfall is below 1,200mm. It decreases from east to west to record in Faizabad (1050mm), Lucknow (1,010mm), Hardoi (970mm), Etah (780mm), Agra (770mm) and Mathura (540mm). The southwest region remains dry because of the weakening of southwest monsoon reaching further west and as the winds coming from the Arabian Sea cannot penetrate through the Aravalli system of mountain. Rainfall is relatively higher over the southern uplands district of Mirzapur and Bundelkand region as they are affected with the arrival of western disturbances originate from Mediterranean sea in winter.

Fig. 1.4
Incorporating the stations of Saharanpur, Bijnor, Rampur and Pilibhit the entire northwestern region receives rainfall which ranges from 1,000 to 1,100mm. In eastern part, a similar amount is received by the stations namely Balrampur, Siddharth Nagar, Maharajganj and kushi Nagar. The isohyet lines from 800 to 900mm cover the areas dominated by the stations of Bijnor, Bareilly, Shahjahanpur, Kheri, Baharaich, Gonda, Basti, S. K. Nagar, Gorakhpur, Faizabad, and the entire eastern and southeastern parts of the state. The whole of middle part of the state comes under the isohyet lines of 700mm. The western part of Uttar Pradesh is intersected by 600mm and 700mm isohyet lines. The amount of rainfall decreases as we move toward the west, as the western station of Mathura receives 600mm of annual rainfall.

Monthly variation of rainfall can be viewed from the histograms of thirteen stations selected from all over the state. Rainfall varies from month to month due to different climatic conditions. On an average, the rainfall is ample during the months of July to September due to onset of southwest monsoon, whereas the amount of rainfall decreases as one proceeds onward the month of October. Distribution of mean annual rainfall shows that a low amount of rainfall (below 700mm) is received by the southwestern parts of the state at Agra, Mathura, and gradually increasing towards the north, east and southeast. Ample amount of rainfall received in almost all parts of the state, it has made the state agriculturally rich.

E. Soils

The state has a large variety of soils having zonal characteristics, depending upon their origin from the parent rocks, topographic features, climate, vegetation and nature of weathering processes in operation.

The soils of the state can be divided into six major groups; (i) *Alfisols* or the older alluvial soils which cover almost two-third of the Ganga valley and constitute the most important soil group as they support more than ninety per cent of its population and account for their rich agricultural wealth. They are composed of alluvium deposited by the Ganga river and its tributaries. However, they vary in texture due to the local and regional variations in the younger *khadar* and relatively older *bhangar* soils with the presence of *bhur* tracts or *usar (reh)* tracts. In clayey areas, nodules of concentrated lime (*kankar*) appear near the surface, they are particularly noted in eastern parts of the state. These soils are moderately alkaline and
calcereous. They are poor in nitrogenous matter but are rich in potash, phosphorous and calcium.

(ii) Inceptisols or calcereous alluvial soils form various groups of bhat soils, which occur in a tract in the eastern Saryupar plain between the Gandak and the little Gandak rivers in Deoria district. They are noted for a high proportion of calcium ranging from 25 to 30 per cent. These soils are fairly drained and very good for cultivation purposes. They have alkaline reactions as well as good moisture holding capacity. The soils are particularly most suitable for the cultivation of sugarcane.

(iii) Entisols or newer alluvium covers areas on both sides of the Ganga and Yamuna rivers. They occur in central, eastern, western and southern portions of the state with Yamuna river as its western and southwestern boundary along the entire course, except some portion of Agra and Mathura districts. River Gandak as its eastern boundary separates it from the state of Bihar. The soils are developed from the alluvium deposited by the two rivers, Ganga and Yamuna, with their tributaries including the Ghaghara, Gandak, Gomti and Ramganga. The alluvial material owes its origin to the soft dolomitic rocks of the Himalayas and is mechanically transported by rivers. The soils widely differ in nature from one district to another, and are broadly classified into younger alluvium and skeletal soil associations.

The soils of the uplands exhibit zonal characters and the profile shows all the signs of maturity. Ferruginous concretions are occasionally met. Lowland soils show the phenomenon of gleying in the sub-soil. Soils of the Ganga family differ from those of the Yamuna family in morphological features depending upon the region from which the two rivers flow. Fully matured soils of the Ganga family exhibit resemblance with the brown earths or tropical brown earths. The soils of the Yamuna family have likewise been known as 'tropical tschemozems.

(iv) Aridisols are found covering two-thirds of the Bundelkhand region and extend from Jhansi to Banda district. These soils are highly argillaceous and are noted for their high moisture retentive capacity. They are rich in iron, calcium and alumina but poor in phosphorous and organic matter. They are associated with granitic and basic gneisic formation and are black in colour due to the presence of iron.

Fig. 1.5
(v) Vertisols are a variant group of red soils and are associated with crystalline formations in southern Lalitpur district of Bundelkhand and in the trans-Yamuna tract of Agra district where red sandy soils overlie heavy sub-soils. In their chemical composition, they are mainly siliceous and aluminous due to the presence of quartz as sand. They are generally deficient in calcium, phosphates, nitrogen and humus, but rich in potash.

(vi) Mollisols or the tarai soils are the last variety spotted in the northern parts of the districts of Pilibhit and Kheri, and small patches in Bijnor district. These soil are young and virgin as well as rich in humus. The soils are saturated during the monsoon months and remain moist during the winters due to very high level of underground water table. These soils are responsive to fertilization and are most suited for multiple cropping.

F. Drainage

One of the most sacred rivers of India, the Ganga, flows through the state and another sacred river, the Yamuna joins it at Allahabad. These two rivers along with their numerous tributaries form a riverine alluvial land known as upper and middle Ganga plain. Other than these two important rivers the Ramganga, Son, Betwa, Gandak, Rapti, Gomti, Ghaghara, Rind etc. are the other prominent rivers. The entire state lies within one major basin known as the Ganga Basin, which is again divided into many sub-basins like the Yamuna, Gomti, Ramganga, Ghaghara, Gandak, Betwa, Son, Tons and Ken.

On viewing a drainage map of the state, it reveals that the entire state is riverine. The dendritic pattern of drainage follows the general slope of landform, i.e. from the northwest to southeast. The entire state lies in the catchment area of the river Ganga and its principle tributaries of the Yamuna, Ramganga, Sarda, Gomti, Saryu and the Ghaghara. All these rivers originate in Himalayan. Other rivers like the Son, Betwa, Ken etc. have their origin in the hills of central India.

The river Ganga, originating from Gaumukh in the Gongotri glacier, enters the great plain at Hardwar then flows towards south and southeast reaching up to Allahabad, and then continues towards the east until it crosses into the state of Bihar on its onward journey to West Bengal. Its total length is 2,525 km. of which 1,450 km
lies in the state. Principal tributaries of the river Yamuna join on its right and the rivers Ramganga, Gomti and Saryu rivers on its left.

The river Yamuna, (which combines the waters of the beheaded Saraswati) has its source at Yamnotri in Uttarkashi district of the state of Uttarakhand descends on the plains near Tejewala; flows almost parallel until it joins river Ganga at Allahabad. Its entire length is 1,376 km. long and its important tributaries are the Chambal, Betwa and Ken originating from the Deccan plateau.

The river Ramganga originates in Garhwal district of the state of Uttarakhand, enters the plain near Kalagarh then flows parallel to river Ganga to some distance till it joins it at Kannaui after traversing a course of 596 km.

The river Gomti has its source in terai region of Pilibhit district and joins Ganga beyond Varanasi. Its total length is 940 km. It's most important tributary is the Sai, sharing nearly one-third of the Gomti basin. Lucknow, the state capital is situated on its bank.

The snow-fed Ghaghara has its source near Lake Mansarovar. The river flows in the southern direction parallel to the river Ganga up to Chhapra before joining it. The total catchment area is 1,27,950 sq km. The river Sarda or the Chauka formed the boundary between the state of Uttar Pradesh and Nepal is the main tributary on the right. River Saryu is another important tributary on whose bank lies the historical Ayodhya. Two other important tributaries are the Rapti and the Gandak.

The southern uplands of the state show a complex pattern of drainage. The river Ganga receives most of the tributaries from this region. The largest river of this region is Son with a number of tributaries namely Rihand, Kambar, Bijul, Pandu, Karmanasa and others.

Rivers of the Ganga plain are well known for changing their courses. Heavy rainfall and sudden change of slope are responsible for this. Streams in such conditions overflow their banks following a meandering course and carve-out new channels. The confluence of the Ghaghara and the Ganga is shifting towards the west. The Gandak has migrated about 140 km. to the west. The Ghaghara has receded gradually westward until it reached its present course. The changing courses of the rivers have affected the human settlements in many ways.
UTTAR PRADESH

Drainage


Fig. 1.6
There are numerous ox-bow lakes, ponds (tals) and deserted channels of the rivers which never become dry. During the rainy season, they assume a great dimension in length and width, covered with weeds, aquatic plants and herbs partially or wholly. In the dry season their size contracts. Baghel tal, Anarkali, Sitadohar tal, Ganeshpur tal, Amfar, Chittaur, Ramgarh etc are some of the major tals well known in different parts the state. Many water bodies are the sources of origin of small rivers. They serve the region as a reservoir for irrigation, fisheries and other useful purposes. There are two important lakes the Gobind Sagar lake (in Lalitpur district), and Gobind Vallabh Pant Sagar lake (in Sonbhadra district) which is one of the most important source for irrigation in southern hilly tract.

G. Natural Vegetation

The state was previously under the forest cover area especially in the northern part but after the formation of Utrakhand as a separate state which forms the part of lesser Himalaya, it has become a poor state in forest resources. Some northeastern districts in Himalayan foothills and the bhabar area possess some of the forests in the state. The forest cover of the state can broadly be divided into: (a) moist deciduous forests (b) dry deciduous forests (c) moist temperate forests (d) dry temperate forests, and (e) thorn forests.

(a) **The moist deciduous forests.**

They occur mainly in the western part of the Ganga Plain, particularly the tarai region and the sub-Himalayan tract and account for 15.29 per cent of the total forest cover of the state. The extreme northern part of the districts of Saharanpur, Bijnor, Kheri, Bahraich, Ballarpur and Maharajganj along with small patches in the Ganga Plain are seen moist deciduous type of trees namely, silver fir, deodar, oak, chir, sisam, poplar, segun, kadam, eucalyptus, mahua, neem, mango, imli, bel, pipalkhair, jamun, etc.

(b) **Dry deciduous forests**

These are found in areas with long dry season and widely scattered in western parts of tarai, the sub-Himalayan zone and Ganga Plain accounting 32.24 per cent of the forest cover area of the state.
UTTAR PRADESH
Natural Vegetation


Fig. 1.7
(c) **Moist temperate forests**

They cover nearly 14.23 per cent of the area in the altitudinal zones of 1,800 to 2,800m. and 1,500 to 3,500m on the valley side where rainfall exceeds 1,500mm. Important trees are chir, deodar, oak, fir, sisam, simul, sal, hare, bahera, etc.

(d) **Dry temperate forests**

They are dominated by the trees of with sal, khair, neem, babul, etc. scattered over all parts of the state. Both moist and dry deciduous type of forests are also found in southern uplands covering the districts of Lalitpur, Chitrakoot, parts of Allahabad, almost whole of the districts of Mirzapur and Sonbhadra.

(e) **Thorn forests**

Thorn forests are the disintegrated form of dry deciduous forests with a dominance of thorny trees and bushes because of the arid conditions. They are scattered over the districts of Mirzapur Allahabad, Banda, Hamirpur, Jalaun, Kanpur, Etawah, Agra and Mathura. In terms of coverage they share only 1.75 per cent of the area. dhak, babul, tendu, chiroji, etc. are some of important tree species.
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