CHAPTER II

PHYSIOGRAPHY

The district of Ghaziabad forms a part of Meerut division in the state of Uttar Pradesh and is situated in the upper doab (Interfluves) of the Ganga and Yamuna. On the east the Ganga separates this district from the Muradabad district and on the west Yamuna forms the western boundary. To the north lies the Meerut district and to the south Bulandshahar district.

The general surface of the country, in this country present an almost uniform level appearance with a general slope from north west to south east as indicated by the courses of Ganga and Yamuna as well as by the Kali river and on the lines of drainage. This slope is almost 0.3 m/km and elevation above the level of the sea varies from 221 m in the north to 210 m in the south. At the same time the district presence several distinct characteristics, some idea of which will perhaps best be obtained by a consideration of the rivers and drainage on which the configuration of the soil mainly depends. The Yamuna first touches upon this district opposite Delhi and flows along its western border for 75 Kms. The flood velocity of the river in the district is 1.35 m/s and in the cold weather it falls about 0.45 m/s but these figures depend to a large extent upon the amount of water diverted into the canals. In the floods of 1871 when the water rose to 3.0 m. above the old level, the area consequently suffered from inundation. These floods lasted from 31st July to the end of the August 1871. Minor floods occurred in the low valleys of the river during the series of wet season ending in 1895.
YAMUNA KHADIR (LOW VALLEYS OF YAMUNA)

Adjoining the Yamuna is a stretch of low lying country known as Khadir. This khadir forms a wide tract of the country stretching back from the river to a distance that varies, from above 14 km. in the north to about 8.0 km in the south, at this widest point the Khadir measures nearly 15 km from the bank of the Yamuna to the crest of the upland.

THE UPLAND TRACT

Beyond the Khadir of the Yamuna lies the main upland of the district which extends eastward as far as the Khadir of the Ganga and consist of a wide and level plain broken only by various drainage line and streams. The rise from the lowland to the upland is seldom abrupt but often a slope is so gradual that it is difficult to see where the high land ends and the lowland begins. All along the top of the ridge runs a belt of sandy soil, in some places cut off by ravines. From the highest point of the ridge, the land slopes gradually inland down to a somewhat ill defined line of drainage, this formation enters the district from Meerut at Hasanpur and extends in southerly direction through Dadri, Dankaur and Jewar and ON into Aligarh. It consist rather of a series of depression and swamps in which the surface water of the surrounding tract collect and find their way across the country.

THE CENTRAL SANDY RIDGE

To the east of this channel the land rises again with a very gradual slope which culminates in a ridge of raised sandy soil which may be traced from the northern border of the district down to Shadipur in Bulandshahar district, and there from it continues into Aligarh.
THE CENTRAL PLAIN

Beyond this sandy ridge stretches another level of loess and clay soil which extends right across the district to the sandy heights that form the cliff above the Ganga. The plain is drawn by Kali and Nim rivers. Between the Kali on the west and Kali on the east flows a river Nim which originates in the north in Meerut. East of the main Ganga canal the land sinks towards the Khadir of Kali river, a river which enters the district from the north and flows in southerly direction. It flows in clearly defined valley which has an average width of about 0.75 km with the bed of the river widening through it. This Khadir is depressed below the surface of the surrounding area and after heavy rain it occasionally under water. Between the Kali river and the Ganga river there is another line of drainage which goes by the name of Nim. Further east of the Nim river passes the Anupshahr branch of upper Ganga canal which flows along the slope of the ridge above the Khadir of the Ganga. Beyond the canal due east lies a belt of inferior soil which terminates on the east in the high bank of Ganga and which greatly improve by the upper Ganga canal, is characterised by the frequent stretches of poor light or uneven soil which in the neighbourhood of the river Ganga, is broken by numerous ravines.

The Ganga flows along the eastern border of the district and first touches at the east of Garh-Mukteshwar. It flows in a southerly direction. The bed of the river is in the form of course sand which extends to a depth of 10 m. below water while beneath it there is a stratum of clay and kankar (Cale Concretion) of 3 m in depth and below that again some 5.4 m of brown sand, its course changes yearly
and loose stretches of land in the northeast bank are annually cut away. The high banks of the Ganga alters but little is protected by strong hard lands of clay and calc. Concretion and concretion, standing above the high flood level.

GANGA KHADIR (LOW VALLEYS OF GANGA)

The Khadir of the Ganga differ very greatly from that of Yamuna. As a rule the Khadir of the Ganga is a narrow fringe along the foot of the hard clay cliff and throughout most of its length there is no cultivation of Khadir. The cultivation of the Khadir is greatly confined to the melon beds and small area of cereal with little sugarcane. The waste land is usually covered with thick grass and jungle that forms the refuge for the wild animals.

However, the district of Ghaziabad can be divided into three distinct physiographic units, these are (1) The North Western Upland, (2) The Central Depression (3) The Eastern Upland. The study area falls in the Eastern upland of the above mentioned physiographic divisions. The study area starts from the Kali river in the west to the Ganga river in the east of Ghaziabad district.

THE EASTERN UPLAND

The eastern upland which comprises the study area extends from the water-shed to the ravines above Ganga Khadir. It is drained by the Kali river and its effluents, the watershed on the east culminating in the ridge along which flows the Anupshahr canal beyond which the influence of the Ganga is felt, the land is becoming poor and sandy, while water is only found at great depth. The chief characteristics of the entire tract is the existence of the lines of sand dunes which
A VIEW OF LOW VALLEYS OF KALI RIVER

A VIEW OF LOW VALLEYS OF GANGA RIVER
enters the district from the north and whose presence is so strongly marked in the eastern part of the Garh Mukteshwar. They occur in the form of rolling dunes or sandhills which continually change their position. These sandhills seem to owe their origin to the admixture of the sand in the stratum through which the drainage lines run and to subsequent action of the wind. These sandhills are not confined to the vicinity of Ganga but occur in the direction of the Kali river as well. In between the ridges there are intervening levels of the better soil. In some cases these stretches are quite extensive. The long line of the good soil running through Mawana and right down in the line of Anupshahr canal. The construction of the Anupshahr branch of the Ganga canal has greatly improved the eastern portion of this tract. In many places it runs quite close to the ravines of the Ganga and the broken country which separates the upland from the Ganga Khadir there is much good land in the interstices between the sandhills. These tract is not a good one. In the neighbourhood of the Kali river and the eastern Chhoiyya there is a large tract of bad soil as poor as any in the area. Further south to this where all the rivers meet there is an extensive stretches of sand ridge of a more pronounced character. However, the area under study can be divided into four district physiographic units from the east to west as following.

**PHYSIOGRAPHIC DIVISIONS**


**Ganga Khadir:** It extends from the high banks of Ganga upto the present active channel. All along the Ganga there is a fringe of
low lying land or khadir which separates from the upland by a high cliff under which there is generally a depression with much swampy ground, near the river. The surface is broken by many channels, separated by stretches of rough grass jungle but the centre of the Khadir is high and open. Many parts of the Khadir are capable of cultivation. It is a tract with many wandering depressions but fairly raised on the whole with the soil that are poor and light instead of being heavy and low lying and not exposed to any particular danger either of flood or of water logging. In the north the Ganga lies about 10.5 kms from the ravines but the distance between them gradually and south of the Garhmukteshwar the Khadir is very narrow. the total length of the Khadir is about 11.2 kms and width is about 5.1 kms.

Ganga Nim Doab (Interfluves): It extends westwards from the high banks of the Ganga river to the banks of the Nim river. The construction of the Anupshahar branch of the Upper Ganga canal has greatly improved the area. In many places this canal runs close to the ravines which separates the upland from the Ganga Khadir. The eastern portion of the area is damaged by the proximity of the Ganga while the western margin is poor by the prevalence of sand.

The ravines show the influence of the Ganga in the upland. It is a level plateau covered with the network of ridges of sandy soil the origin of which is due to the river. The larger of these strips the Bhur (sandy soil) enters the area about the middle of the north border i.e. village Puth and passes southward west of the canal. Several other lines take off from the ravines which stretch in the unbroken lines from north to south but these spur are much narrower.
The highest level is that along which the Upper Ganga canal runs. The west of this is a sudden drop ending in a depression which extends from the sandy ridges of the canal to the tract of the Bhur which traverses the eastern border of Hapur from north to south. The length of these ravines is about 8.4 kms and breadth is about 1.9 km.

**Nim-Kali Doab** It extends from the right bank of the Nim river up to the high sandy banks of the Kali river. In this area the land is becoming poor and sandy while the water is found relatively at a greater depth. The chief characteristics of the area is existence of lines of Bhur or sand. It occur in the form of rolling dunes or hills of sand which continually changes its position. These sandhills seem to owe their origin to the admixture of sand in the stratum through which the drainage lines run and to the subsequent action of wind.

**Kali Khadir (Low Valleys of Kali)** It flows in a clearly defined valleys which has an average width of about .8 km with the bed of the river widening through it, usually nearer to the one bank than the other and only at intervals at the centre. This Khadir is depressed below the surface of the surrounding country and after rainfall is occasionally under water.
MONSOON MAP OF INDIA SHOWING
ONSET AND WITHDRAWAL OF MONSOON
RAINFALL

In the study area the monsoon breaks in the third week of June and heavy precipitation takes place in the months of July and August, the monsoon ends in the last week of September (Plate IV). The area on an average receives 910.4 mm of annual rainfall. (Plate-V).

AREAL DISTRIBUTION OF RAINFALL

A perusal of the Isohyetal map (Plate X) of the study area shows that the intensity of rainfall decreases from east to west and on an average the eastern part of the area receives slightly more than 1000 mm annual rainfall (Appendix X) proximal to the banks of the river Ganga which gradually decreases 800 mm (Appendix X) to the west proximal to the river Kali.

VARIABILITY OF RAINFALL

The available rainfall data of Garh-Mukteshwar, Simbhaoli and Hapur raingauge stations for the period 1901-89 have been statistically analysed and results are tabulated (Appendix X). It is seen that the Garh-Mukteshwar raingauge station receives highest rainfall of 1680 mm and lowest rainfall of 400 mm whereas the Simbhaoli raingauge station receives highest rainfall of 1640 mm and lowest 400 mm, and Hapur raingauge station receives highest rainfall of 1580 mm and lowest rainfall of 272 mm. The study further show that the average annual rainfall of Garh-Mukteshwar raingauge is 1000.2 mm whereas the average annual rainfall at Hapur raingauge becomes 696.85 mm. Further, it was found that the standard deviation at Garh-Mukteshwar is 267.0 mm whereas at Simbhaoli it becomes
288.98 and at Hapur it has become 69.8, finally the study of the rainfall shows that at Garhmukteshwar the coefficient of variation is 26.62% whereas it becomes 31.73% at Simbhaoli and the Co-efficient of variation at Hapur is only 10.1%.

APPLICATION OF ISOHYTAL METHOD FOR THE ANALYSIS OF MEAN ANNUAL RAINFALL

An Isohyte is a line joining points of equal rainfall magnitude. In this method, the catchment area was drawn to the scale and the Isohytes were plotted with the help of record available of, in and around raingauge stations of the catchment area (Plate VI). The area between the Isohytes were determined with the help of a Plain meter. The average values of rainfall indicated by two Isohytes is assumed to be acting over the Inter - Isohytes area. A perusal of the Isohytal map shows that the entire area of Kali - Ganga basin has been divided into A, B, C, D, between the Isohytes namely 800, 900 and 1000 values.

Then as per formula

\[ P = \frac{a_1(P_1 + P_2)}{2} + \frac{a_2(P_2 + P_3)}{2} + \frac{a_3(P_3 + P_4)}{2} + \frac{a_n(P_{n-1} + P_n)}{2} \]

Where \( a_1, a_2, a_3, \ldots, a_n \) is the area of catchment between two Isohyets and \( P_1, P_2, \ldots, P_n \) is the value of Isohyts respectively.

From the map it is evident (Plate - VI).
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Total area of Basin</th>
<th>Average value of the Isohyt</th>
<th>Corresponding area (sq. km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>513.8 Sq. km.</td>
<td>$\frac{700+800}{2} = 750$</td>
<td>$a_1 = 12.0$</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>$\frac{800+900}{2} = 850$</td>
<td>$a_2 = 94.0$</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>$\frac{900+1000}{2} = 950$</td>
<td>$a_3 = 172.6$</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>$\frac{1000+11000}{2} = 1050$</td>
<td>$a_4 = 127.6$</td>
</tr>
</tbody>
</table>

Then from the formula -

Mean annual rainfall $P = \frac{120.1 \times 750 + 94.0 \times 850 + 172.1 \times 950 + 127.6 \times 105}{153.8}$

$= 909.78$

$P \approx 910$ mm.

The result calculated from the statistical method (see Appendix I-A) and from Isohytal method comes as mean annual rainfall value as 910.0 mm. which supports the appropriate value of precipitation of the Kali-Ganga sub-basin in Ghaziabad district.

**DROUGHT ANALYSIS**

The analysis of drought was done on the basis of departure of the annual rainfall from the mean annual rainfall. The departure of the annual rainfall from the mean annual rainfall have been calculated for Garh-Mukteshwar, Sambhaoli and Hapur raingauge stations (Appendices I-A, I-B and I-C). The study shows that there is
no cyclicity as such but mild to normal drought sets in three to four years and severe drought is every twenty years almost.

The analysis further shows that the frequency of occurrence of mild drought at Garh-Mukteshwar is 16.91 % whereas at Simbhaoli it is 25.58 % and at Hapur it has become 16.9 %. The normal drought occurred as 22.25% and 12.46% at Garh-Mukteshwar, Simbhaoli and Hapur respectively. It was also found that frequency of severe drought at Garh-Mukteshwar is 2.67% at Simbhaoli it is 3.49% and at Hapur the frequency of occurrence of severe drought is about 0.89%. Finally the study shows that very severe drought never occurred on all the above mentioned areas.
DRAINAGE

The area under study is drained by Kali, Chhoiya, Nim and Ganga rivers. Apart from the minor drains the area is also irrigated through Upper Ganga canal and Parichhatgarh as well as Kithor distributories. The Kali river forms the Western most boundary whereas the Ganga river forms the easternmost boundary of the study area.

KALI RIVER

Kali is the chief river of the eastern upland. The Kali river actually rises in the Muzaffarnagar district through Meerut and forms the western hydroboundary of the study area, finally joining the Ganga at Fatehpur. The Kali river has no important town on its banks, it is crossed by the bridges on the road. The stream contains very little water except in the rainy season and is never navigable. It is joined in its course by three smaller streams which forms part of the same drainage system. Two of these are known under the generic name of Chhoiya.

CHHOIYA RIVER

The Chhoiya river which lies on the left bank of the Kali river and traverses nearly the whole length of the study area rising at the point close to Niloha in Hastinapur while the other one is on the right bank and has its origin in central depression, a short distance to the south of Meerut. The river Chhoiya closely resembles to river Kali in its character. In its early parts of its course it is an ill defined straggling water course running through low ill cultivated land, and except few places, it is perfectly dry. It has a total length of about 45 kms. and join the Kali about 13.5 kms below Hapur.
A VIEW OF UPPER GANGA CANAL

A VIEW OF GANGA RIVER
The Nim River

The Nim river starts in the study area near Buklana and in fact it is the only other drainage of the area where the syphon carries the drainage under the canal into this river. It flows to Bulandshahar district from the Birampur locality of the study area. The length of this river in the study area is estimated as 10.0 kms.

The Eastern Watershed and Other Canal Network

The area forming the watershed between the Kali river and the Ganga. This tract has been divided into two by the Chhohiya river. This tract has been traversed by the Anupshahar branch of the Upper Ganga canal but this canal does not define the actual line of drainage as in many places it has been found necessary to construct syphon under it. Generally the natural drainage into the Ganga, east of the canal, is as perfect as possible but in a few cases it has been supplemented by the excavation of artificial drainage channel. To the south east the country between Buxar and Puth is drained by the Wait and Buxar cuts which leads into Syana escape. Apart from this, two distributories namely Kithor and Parichhatgarh are running parallel to the Anupshahar branch as its distributories.

The Ganga River

The Ganga river enters the district from the east of Garh flows in South-south easterly direction, separating Ghaziabad from Muradabad. The banks of the river are generally slightly defined on the one side and abrupt on the other side to the position of
the main stream. The channel is fairly stable but in some places the banks suffer slowly from erosion. The ganga is not now used for navigation, it is also in no case used for irrigation owing to the distance of the stream from the banks. The velocity of the stream varies at different periods of the year. In July and August both descended at the rate of 70 km/day and september and October from 25 to 30 Km/day but in winter months it does not make 12 to 15 km/day.
Tectonic Map of Himalayan Foothills and Indo-Gangetic Plains