CHAPTER I

STRUCTURE RELIEF AND DRAINAGE

The district of Bareilly lies between Lat. 28°-1' and
28°-54' N and Long. 78°-58' and 78°-47' (Fig. I). Its maximum
length from North to South is about 50 miles or 96 kilometres
and its maximum breadth from east to west is about 47 miles
or 75.2 kilometres. The northern boundary of the district is
continuous with that of Nainital, on the east lies the district
of Pilibhit while on the South-East is situated the district
of Shahjahanpur. On the south and South-West it is bounded
by the district of Budaun, the Ramganga forming the natural
boundary between the two districts for about 19 miles or
30.40 kilometres and on the West lies the district of Rampur.

According to the district records, its area is 1,578
square miles or 4239.70 square kilometres and according to
the Survey Department of India, it is 1,591 square or 4072.96
1 square kilometres. It stands forty-fifth in the State in
respect of area. The area of the district fluctuates from

1. District Gazetteer of Bareilly, 1908, p.1
year to year on account of changes in the course of the Ramganga. The district comprises the five sub-divisions, viz, Aonla, Baheri, Bareilly, Faridpur and Nawabganj, each forming a tahsil of the same name.

Geologically the district forms a part of the Indo-Gangetic alluvium which consists of sand, clay, Kankar and reh. The foothills of the Siwaliks lie about 70 to 80 miles or 112 to 128 kilometers to the north and the east of the Bareilly town. The presence of boulders in the northern part of the district in the river beds at a depth of 10 feet or less, indicate that in the not very remote past the Himalayan detritus found its way farther south than observed at present.

The geological evolution of the Indogangetic depression of which Bareilly district is an integral part, lying at the foot of the mountains, is a matter of discussion. It is believed that this depression came into existence concommitantly with the elevation of the Himalayas and is of the nature of a synclinal basin. Sedimentation started and the basin was
subjected to a downward pressure due to the weight of the alluvium and as a result of this downward pressure, sinking took place; but the process of sedimentation and depression kept pace, resulting in the formation of the great plains of India.

Eduard Suess has suggested that it was a "fore-deep" in front of the high crust-waves of the Himalayas as they were checked in their southward advance by the inflexible solid land-mass of the Peninsula. According to this belief this depression is a synclinorlum. Sir S.G. Burrard (formerly) surveyor - General of India), on this basis of physical and geodetic considerations, has arrived at a totally different view about the origin of the depression. He considers that the Indo-Gangetic plains occupy a deep "rift valley" which represents a portion of the earth surface sunk in a huge

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crack or fissure in the sub-crust between parallel dislocation or faults on its two sides. The formation of this great crack, 2400 kilometres (1500 miles) long and several thousand metres deep, was intimately related to the elevation of the Himalayan chain and was in fact the prime event in the whole series of physico-geographical changes that took place at this period in the earth's history. This view which is based on geodetic observations and deductions alone, has got few geological facts in its support. The geologists consider that the Indo-Gangetic depression is only of moderate-depth, and that its conversion into the flat plains is due to the process of alluviation. The rivers, rising from the mountains during a period of great gradational activity, deposited the detritus, brought down by them in their long journey and in this way the plains were formed.

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4- Ibid, p. 283.
5- Ibid, p. 289.
"A more recent view regards this region as a sag in the crust formed between the northward drifting Indian continent and comparatively soft sediments accumulated in the Tethyan basin when the latter were crumpled up into a mountain system."

Little is known about the nature of the rock that lies underneath the alluvium and the Tertiary strata in the Gangetic Plains. It is, however, known from the characteristic Gondwana rocks found on the northern rim of this alluvial tract, that its sub-stratum is an extension of the peninsular rocks namely Archean gneiss, with areas of Vindhyan and Gondwana sediments.

The thickness of the alluvium has been assessed from borings which have been carried out at various places in the plain, the deepest having a depth of 400.80 metres (1,336 ft.) from a surface level of 111 metres (370 ft.) was found at Lucknow, i.e., nearly 300 metres (1000 ft.) below sea level.

6- Krishnan, M.S., Geology of India and Burma, (Madras, 1956), p. 529
7- Wadia, D.N. and Auden, J.B., op. cit., p. 128
The beds that were encountered from top to bottom were to
the same character, alternations of sand and sandy silt, with
occasional bands of Kankar, and coarse sand near the bottom
of the bore-hole. According to S.G. Burrard, the Gangetic
alluvium occupied a narrow rift at the foot of the Himalayas,
the maximum depth of which was 32 kilometres (20 miles).
This figure has been discarded by the Survey of India, and
a rift of the type conceived by Burrard is not in conformity
with geological and geographical experience. On the basis
of geodetic data, R.D. Oldham considered that the depth of
the alluvium reached a maximum, towards its northern edge,
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5,000 ft. to 6,000 metres. (20,000 ft.).
Cowie, using the same date, adopted even higher figures and
he considers the trough to have a thickness of 6,000 metres
(20,000 ft.)

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9- Loc. cit., p. 134
10- Cowie, H.M., A Criticism of R.D. Oldham's paper on the
structure of the Himalayas and of the Gangetic
Plain is Elucidated by Geodetic Observations
in India, Memoirs of the Geological Survey of
India, Professional paper No. 18 (Dehradun,
1921) p. 6
BAREILLY DISTRICT

CLASSIFICATION OF UNDERGROUND STRATA BASED ON THE TUBEWELL BORINGS

KEY

- YELLOW SAND
- H HARD CLAY
- M MEDIUM SAND
- F FIRE SAND
- H1 HARD SAND
- S SOFT CLAY
- CK CLAY & KANKAR
- MC MEDIUM CLAY
- SK SANDSTONE & KANKAR
- C COARSE SAND WITH PEBBLES
- FS FIRE SAND WITH KANKAR
- MK MEDIUM SAND WITH KANKAR

SOURCE: DATA OBTAINED FROM TUBEWELL DEPARTMENT BAREILLY.
Later work by E.A. Glennie has revealed that the thickness of the plain is considerably less. Using the gravity results, he estimates that the depth of the alluvium is only 1950 metres (6,500 ft.). This figure, however, seems to be correct from the standpoint of geodetic data but does not conform with geological facts. This cannot therefore be taken as reliable and may well be greater.

Recently borings of similar type, have been carried out in the Bareilly district by the Tube-well department (fig. No. 2) shows the classification of underground strata to a depth of about 300 ft. The nature of the alluvium at different depth varies from clay below the surface through different strata of coarse/sand, Kankar, clay, hard clay and medium sand at the bottom. The beds that were encountered top to bottom are of the same character, alternations of sand with occasional bands of Kankar and coarse sand.

Broadly speaking the district is almost an open plain with slight undulations which are well pronounced in the south, the surface being diversified by numerous river valleys. The

11- Wadia, D.N. and Auden, J.B., op. cit., p. 135
The general slope of the area under consideration is from North to South with the exception of the tahsil of Aonla where it is from West to East. (Fig. 3) The height elevation above sea level as recorded on the Nainital Bareilly border is about 658.7 feet and the lowest in tahsil Faridpur, being 520.3 feet.

The area may be divided into three physical units. (Figure 4 A)

1- Tarai  
   (i) Mar  
   (ii) Des

2- Khadar

3- Bhangar

(i) The Mar extends in a narrow belt along with northern villages of the parganas of Chaumahla and Richa and is the continuation of the sub Himalayan forest belt which at several places advances to within a few miles of the northern border of the district. In the past it extended as far as Kabar Pargana but now there is very little forest left. Though rich in humus, tarai soils are generally ill-drained. The water-table is high and the water-logged subsoil combined with the high rainfall makes this tract unhealthy and inhospitable.

12- District Gazetteer of Bareilly, 1965
(ii) Des: This tract, comprising the central portion of tahsil Baheri, lies to the south of the tarai and is locally known as the Des which merges with the upland 'Bhangar' to the south. The soil here is fertile loam with very little admixture of sand. It slopes towards the south-east as is evident from the course followed by the rivers.

(2) Bhangar: To the south of the 'Des' lies the extensive tracts of bhangar or old alluvial upland which is much higher than the alluvial flood plain (or the Khadar) and forms the watersheds. The bhangar soils differ in composition and fertility and become light in texture towards the south and south-east, sand-hills predominating in tahsil Faridpur. In the northern part of tahsil Aonla and to the south of the Ranganga 'Khadar', the upland dwindles into a series of isolated ridges covered with light shifting soil which, under the action of the west winds, is frequently blown away to expose the hard substratum of clay.

(3) Khadar: The khadar or new alluvium of the river valleys is rather limited except that of the Ranganga, the Dooma, on
the eastern border, the Bahgul (East), in its lower courses in tahsil Faridpur, the Nakatia near Bareilly and the Bahgul (West) near Shahi. It is usually a very fertile tract and is commonly utilized for growing vegetables, wheat and sugarcane. On the whole, the flood plain of the Ramganga is 4 to 5 miles or 6.40 to 8.00 kilometres wide but is as wide as 16 miles or 25.60 kilometres in the tract between Bareilly and Aonla. It generally merges with the bhangar upland imperceptibly except near Sirauli and a few adjacent villages where the banks are well-defined, the cliffs actually over-hanging the river. The khadar of the Deoha is also very fertile and is a strip about a mile or kilometre wide which extends of 10 miles or 16 kilometres along the eastern boundary of tahsil Faridpur. The khadar in the lower reaches of the Bahgul (East) in pargana Faridpur is about a mile or 1.60 kilometres wide and is locally known as chauda. The 'khadar' of the Nakatia near Bareilly and that of the Bahgul (West) near Shahi are also extensive and fertile. (Fig. No. 4B) shows that the height of the
BAREILLY DISTRICT
DRAINAGE

BAHERI
NAWAB GANJ
BAREILLY
AONLA
FARIDPUR

SURVEY OF INDIA
SETTLEMENT
DISTRICT

Figure 5
area ranges between 300 ft. and 640 ft. above sea level.

The lowest height lies in the south western part of the area while the maximum of 640 feet is located in the north eastern part. On the whole, the area under consideration represents a flat plain and slopes from northeast to southwest.

DRAINAGE: (Fig. No. 5) shows the drainage of the area consisting of a net work of streams flowing in the north-south direction and also west east. There are five main rivers viz., the Ramganga, the Bahgul (west), (Bahgul east), Deorania, the Nakatia, and chief tributary of the Ramganga.

The other drainage lines, being seasonal in nature, are of little significance. Nonetheless during the wet monsoon months some of these streams rise in spate and inundate large areas in their vicinity and destroy the standing crops.

RAMGANGA: (i) Rising in the mountains of Garhwal, the Ramganga a great tributary of the Ganga, enters the district from district Rampur near Phinau patti, a deserted village in tahsil Bareilly. It then flows in a south-easterly direction.
past Sirauli and Sheopuri separating tahsil Aonla from the

tahsils of Bareilly and Faridpur as far as Sipahia (in tahsil
Faridpur). It then forms the boundary between the district

and that of Budaun as far as Saidpur where it again enters

the district and, running through it for about 3 miles or

4.80 kilometres, again forms the boundary between the district

and that of Budaun, finally leaving the district near Manpur.

After being fed by many streams it becomes much larger and
carves out fresh channels through the alluvium.

The banks are well defined near Sirauli and a few adjacent
villages, the cliffs actually over-hanging the river during
the floods, elsewhere they descend in little vertical steps.

In the 'khadar' of tahsil Aonla, there are numerous abandoned
old channels. To the west of Bareilly, there are 2 channels

several kilometres apart and the river keeps shifting from
one to the other and cutting into the land in between. It
can not be used for irrigation owing to the breadth of the

'khadar' and the depth of the channel below the level of the

upland and, though usually navigable by boats of small size,
becomes almost impossible at many places during the hot season.

BAEGUL (WEST)

This stream rises in the tarai area and first touches the district near Mandaigan (Fig. 4). After forming the boundary of the district for about a mile, it leaves it but retouches it at Chubakia (in pargana Chumahla) only to leave it once again. Separating the district from that of Rampur for about a mile, it enters the district near Bhairpura (Bahirpura). Near Marswa it is joined by the Barai and runs southward for about a mile and a half. It then again forms the boundary between the 2 districts till it reaches khamariya where it re-enters the district through which it flows for about 2 miles 3.80 kilometres. Then, once again separating the district from that of Rampur it re-enters the former near Dhakia (in pargana Sarsavan). It is joined by the Baraur at Rustamnagar and flowing in a south-westerly direction it is first joined by the Kichha and then by the Kali near Rakshiypur and Basai respectively. From this
point onwards it flows in a southerly direction and is
joined by the Dhora either side.

BAHUL ( EAST )

This river, an important tributary of the Ramganga, rises
in pargana Kilpuri ( district Mainital ) and after touching the
district to the north of Chitarna Malhpur ( a village on the
northern border of the district in pargana Richha ) forms the
boundary of the district for about a mile. It then runs through
the pargana past landin Sabi Buhsh, Churaila and Atarai.
From the last-named place onward it forms the boundary between
the tahsil of Sahri and Nawabganj, leaving the former at
Baraur and entering the latter tahsil in which it is crossed
by the north-Eastern Railway to the west of the Bijnor Railway
station. Running southward it leaves the tahsil at the village
of Kasman and runs through the eastern part of tahsil Bareilly
where it is crossed at Nampuriya Janki Prasad by a girder
bridge on the unstalled road leading to Bisalpur. It leaves
tahsil Bareilly at Udaipur Jaurethpur and runs through tahsil
Faridganj.
Flowing southeastward it is joined on the left ( at Faiznagar ) by the Kandu Nullah and travels southward. Further on it receives the waters of the Kailas ( from the left ) opposite Imalia and is joined by the Gundhia ( also from the left ) opposite Bhadpura. From here it forms the boundary of the district which it leaves near Fatehganj East where it is crossed by a road bridge and rail bridge of the Northern Railway leading to Shahjahanpur. It flows between narrow limits in parganas Richha and Nawabganj where the lands on its high bank ( locally known as Dhaya ) are exceptionally good. Its bed is sandy and in its lower reaches it has a highly fertile khadar area ( about a mile in width ) known as chanda. The soil above the high banks is poor in this part. Its waters are useful for irrigation and it is under the control of the irrigation department as far as Manpuriya Janki Prasad beyond which there are several earth dams. The two weirs—one at ( Churaili ) in pargana Richha and the other at Girem ( in pargana Nawabganj ) feed the channels that are on either side of the river,
DEORANIAN

This river, which rises on the borders of the district and that of Nainital, enters the district near the village of Piparia Ganesh in pargana Chaumahla and wanders south-westward through the eastern extremity of the pargana of Chaumahla and the central part of pargana Richha. Near Singra, it touches the boundary of tahsil Baheri and flows along it separating it from tahsil Nawabganj as far as Dhakiya after which it forms the boundary between the tahsil of Bareilly and Nawabganj till it reaches Maheshpur Sheo Singh where it makes a bend in tahsil Nawabganj. It then runs through tahsil Bareilly and again touches its eastern boundary near Dabora Khanjanpur, separating it from tahsil Nawabganj for about a mile. Reentering tahsil Bareilly about a mile north-east of Bhojipura, it is crossed by the line of the North-Eastern Railway and the Nainital Road of the south of the village. At Bareilly it is crossed by the Moradabad Road and the Northern Railway and joins the Ramganga in the west of the city. The river has a bed of alluvial silt with banks about 4 feet high which, during the dry weather, are stilled right down to the water's
edge producing good crops of maize and cotton. During the monsoon its volume swells by a considerable spill from the Dhora and it sometimes rises to a height of 10 feet, flooding the surrounding country. It is utilised for irrigation throughout its course, though its water is considered to be injurious to pulses.

NAGATIA

This stream rises near the village of Khamaria Gopa Dandi in the south-eastern part of tahsil Baheri and flowing southward for about 2 miles or 3.20 kilometres enters tahsil Nawabganj. After traversing the western part of the tahsil, between which and that of Bareilly it forms the boundary for about a mile, it enters the latter near Doharia Jagir. Near the village of Aspur Khub Chand it is crossed by a masonry bridge on the Bareilly Pilibhit road and further south by a ferry on the road going to Bisalpur, the metalled road and the railway line of the Northern Railway leading to Shahjahanpur crossing it by iron bridges near Saidpur Khajuria (a village to the east of Bareilly city) and at Lakhaura (a village lying to the south of the Bareilly cantonment). To the north-east of
Harsauria it again flows along the boundary of tahsil Bareilly separating it from tahsil Faridpur for about a mile and a half and comes quite close to the Ramganga (near the south of the village) where it enters tahsil Faridpur through which it runs in a south-easterly direction to join the Ramganga near Khalpur. It almost dries up during the summer but attains a considerable dimension by the spill from the Bahgul (East) in its upper course during the rains when it frequently floods a large area in tahsil Nawabganj. On the whole the banks of the river are gently sloping. Its bed consists of alluvial mud resting on a stratum of clay and there are deposits of kankar (nodular limestone) in its banks as also in the upland between it and the Deoranian. Throughout its course it is utilised for irrigation, earthen dams being built annually across it.

ARIL

This river, which is the chief tributary of the Ramganga (on its right bank), rises in district Moradabad and touches the district of Bareilly in the south-west of Gularia Aril. It then forms the southern boundary of pargana Sirauli (tahsil Asala) which it separates from the district Budaun for about
14 miles or 22.40 kilometres after reaching the village of Chakarpur Gahi at which it enters the district, it runs southeastward through tahsil Aonla. At Nau Chandpur it is crossed by the unmetalled road going from Aonla to Sirauli and near Deokla it is joined by the Parliya and further on, at Phulasi, it supplied water to the Nawab Nadi or Amis. It then flows on in the same direction as far as Lohari where it is crossed by a masonry bridge on the unmetalled road going from Bareilly to Aonla. Near Darwarpur it bifurcates to reunite near Bagarpur where it leaves the district after enclosing a large area, the road from Aonla to Bhamora crossing the right and the left branches at Sendha and Kuddha, respectively by means of ferries. Its valley is a well defined depression about half a mile in breadth in its upper reaches where the flow from the high ground on either bank is rapid but it is extensively utilised for irrigation near Aonla where it debouches on a wide and level plain of stiff clay. The villagers have dammed it at Deokola and Attar Chandi and there are also two smaller dams in the lower reaches of its course.
There are several lakes (locally) known as dabris along the Ramganga and the Bahgul (West), the largest being Lilaur Buzurg (in pargana Sirauli, tahsil Aonla) and Surla (in pargana Bareilly) each being about a hundred acres in area. Other lakes are at Ashokpur (46 acres), Jerh (19 acres) and Richha (17 acres), all of which are in tahsil Parlpur. Among other lakes which deserve mention are Ballia, Kiara Mustakil and Gauntara, and Daulatpur in tahsil Faridpur. There are others which usually dry up during the winter and none is used for irrigation purposes. Fishes are found in most of them and they are visited by water-fowl during the winter. Most of them are used for the cultivation of singhara (water-nut) and bhasenda (the stem of the lotus, part of which is edible.)
CHAPTER - II

CLIMATE

The climate of the District of Bareilly is the same as that in the other sub-Himalayan districts in the state. It is influenced by its proximity to the hills and the tefal swamps to the north. It is characterised by a rhythm of seasons which is produced by the south-west and north-east monsoons. The reversal of the prevailing winds takes place regularly twice in the course of the year. In one part of the year the winds are of continental origin and blow from north-east to south-west, while in the other part they are oceanic and blow from south-west to north-east. In view of the nature and directions of the winds the terms wet monsoon and dry monsoon are appropriate.

The winter monsoon lasts from November to February and brings a small amount of rainfall in the coastal parts of Tamil Nadu. The rest of India remains dry during this period.

The wet or the summer monsoon starts from the middle of June and lasts till October. This is commonly known as the period of rainy season. In the light of this classification, Bareilly district can be divided into the three distinct seasons.

1. the cold weather season (November to February);
2. the hot weather season (March to mid-June);
3. the season of rains (mid-June to October);

The cold weather season corresponds to the period of rabi crops, while the season of rains corresponds to that of Kharif crops.

**The Cold Weather Season:**

In the month of November a belt of high pressure develops over north-western part of the sub-continent and extends over large part of India. It influences the whole of Uttar Pradesh. The prevailing direction of winds which is from west to east is determined partly by pressure distribution and partly by the trend of the Himalayan relief.

The mean maximum daily temperature in November is 29.9°C. The days are warm, while the nights are cool; the mean daily
MEAN MAXIMUM AND MINIMUM TEMPERATURE

BAREILLY

SOURCE
DATA FROM MEMOIRS OF THE INDIAN METEOROLOGICAL DEPARTMENT

FIGURE 6
The minimum temperature for the month is 12.1°C.

The month of December registers a further decrease in the mean daily maximum temperature at Bareilly by about 5° to 7°C. The days are less warm and nights are cooler. January is the coldest month and records the lowest temperature of the year, the mean daily maximum and mean daily minimum being 26.6°C and 8.1°C respectively. (figure No. 6) In December and January, frosts are not uncommon but their intensity is not such as to damage the crop. In these months heavy mists or fog locally known as 'Kohra' often occurs at night and lasts until the early morning hours. In February the temperature records a rise, the month remains colder than November. On the whole, the cold weather seasons are characterised by clear skies, fine weather, low humidity and large diurnal range of temperature.

During the months of December, January and February a few depressions accompanied by the moderate rainfall pass through this area. It is considered that some of these depressions originate in the Mediterranean area, a few coming from as far distant as the Atlantic. The cyclonic rainfall is preceded by a warm close weather with light southerly or easterly winds.
BAREILLY DISTRICT
AVERAGE MONTHLY RAINFALL
(1922 TO 1972)

SOURCE
DATA FROM REVENUE DEPARTMENT
LUCKNOW, U.P.
RAINFALL OF SELECTED STATIONS

FIGURE 7
The cloudy weather normally lasts a day or so and is followed by clear skies. Generally, the average number of rainy days during any month of the cold weather season does not exceed more than two, but whenever the damp cloudy weather persists, it promotes various plant diseases which produce an adverse effect on the crops.

The average monthly distribution of rainfall of five tahsils is shown in the map (Fig. No. V), while another map shows the average rainfall for the months from November to February. It will be seen from (Fig. No. 8) that the total amount of rainfall during the cold weather season does not exceed 2.5 millimetres. This rainfall, though small in quantity, is highly beneficial to the winter crops as it comes at a time when the plants are flowering; the effectiveness of the rainfall is further increased by the prevailing low temperatures. The cold weather depressions are sometimes accompanied by hail storms, which cause little damage to the crops if they occur in the early part of the cold weather season. But the damage to the crops is considerable when they occur late in the season, for they bruise the flowers and the immature
grains. The area affected by a hail-storm is usually small and within this area the damage is far from uniform. It may happen that the crops in one field may be seriously affected, while the crops in the others only a few yards away, may escape almost untouched. A number of examples of hail storms of great magnitude can be found in historical records of the district under study.

Winds are generally light or calm in the morning. Westerlies and north westerlies are more common from November to February. The air is very humid in the monsoon season but there is considerable decrease in humidity in the cold season. In November, it becomes about 73 percent while it increases to 81 percent in January.

The following table shows the average rainfall in cold weather season of the five rainfall stations in the Bareilly District.

| TABLE I:RAI |
| RAINFALL STATIONS ( 1971-72 ) |
|---------------|----------------|----------------|----------------|---------------|
| MONTHS        | Bareilly (58) | Babari (37)    | Amala (24)     | Bareilly (53) |
| November      | 0.3           | 0.27           | 0.25           | 0.12          | 0.85          |
BAREILLY DISTRICT

AVERAGE RAINFALL (IN mm)

NOV - FEB

CHACHEHAT 62.9
BAHERI 60.5
DAIABOJH 53.9
MANKARA 57.6
SINDHORA 58.4
PANDEHRA 57.8
KUNDRA 56.13
BAŞAHGA 58.42
RAIPURA 52.2

SHAH 51.1
BHÓJIPURA 50.8
NAWABGANJ 54.95
SARÓURA 52.24
FAJÉHGÁNJ 48.26
RlégiRA 53.34

BAREILLY 45.9
KATAIVA 45.9

AOÍLA 37.51
BHUMORA 36.00

BHUTA 41.5
FARIDPUR 40.9

SHEOPURI 39.8

SOURCE
REVENUE DEPARTMENT LUCKNOW
THE FIGURES INDICATE AVERAGE MONTHLY RAINFALL OF FIFTY YEARS

FIGURE 8
It is obvious from table No. 1 that the month of February receives maximum rainfall in the tahsils of Bareilly, Baheri, Anola, and Faridpur with 0.57, .86, .83 and 1.07 mm respectively. This rainfall is caused by the western depressions. The month of December remains dry while November also records small amount of rainfall in the various tahsils. The January/February rainfall is very beneficial for the rabi crops at a time when the plants need water for their growth.

HOT WEATHER SEASON

The hot and dry weather season includes the months of March, April, May and the first half of June. During the month of March temperature rises abruptly which can be seen from figure of mean monthly temperatures given in Fig No. 7.

Temperatures rise rapidly after February, May and early June constitute the hottest period of the year. In May, the mean daily maximum temperature is 36.7°C (103.5°F) and the
mean daily minimum $25^\circ C$ ($77^\circ F$). While the mean maximum monthly temperature in May is $42^\circ C$ and mean minimum monthly temperature $26^\circ C$.

The days are warm but the nights are cool and pleasant. The temperature continues to rise during April and May. At Bareilly, the mean maximum temperature for April, is $37^\circ C$ and May $42^\circ C$ respectively, while the mean minimum temperatures for the same months are $21^\circ C$ and $26^\circ C$ respectively. The days are hot, while the nights are warm, though the mean diurnal range of temperature is as high as in March. The sky remains cloudless, the relative humidity at Bareilly being only 22%, which is the lowest figure for the whole year. There is very little rainfall in this month as indicated by the Fig. No. 8. It may be mentioned that high temperatures, low humidity and cloudless skies of the month of April favour the ripening and harvesting of the rabi crops. The months of May records the highest temperature of the year. The mean maximum temperature during this month is $43^\circ C$ at Bareilly, while mean minimum temperature of the same station is $26^\circ C$. 
The excessive heat of this period has a desiccating influence on the vegetation and the land surface lies parched and bare of verdure under a torrid sun.

The months before the out-break of the monsoon, viz., May and June are the hottest in this district, but owing to the dryness of the atmosphere, the heat is not unbearable. Hot dry westerly winds, locally known as ' 100 ' low throughout the hot season but their intensity is greater in May and early June. These dusty westerly winds may cause heat more intense but rarely blow after sunset. Their velocities increase from 9 A.M. till noon and whenever conditions are favourable, the winds blow almost with a gale force until 2 or 3 p.m. after which they fall off very rapidly, so that during evening hours, they nearly die out. The thunderstoms usually follow dust storms in this period and bring some relief from the heat. On the days when the winds are more vigorous, the humidity between 12 noon and

2- Blanford, H.F., The climates and Weather of India, Ceylon and Burma (London 1889) p. 16
The figures indicate average monthly rainfall of fifty years from March to May, with the highest rainfall occurring in SHAHBAJPUR at 16.25 mm and the lowest in BHAMORA at 14.0 mm. The average rainfall across the district is approximately 30.9 mm. Sources of rainfall data include the Revenue Department, Lucknow.
4 p.m. may be as low as 2 to 3 percent. The hot winds usually cease by mid-June, when the advance of the southwest monsoon, day temperatures drop appreciably but nights continue to be as warm as in the summer.

The origin of winds is attributed to the convective air movement produced by heating of the surface soil and the rapid decrease of temperature as one goes up in the lowest air strata. Another significant feature of the hot weather is the occurrence of the dust storm in the late afternoon, that is, towards the end of a close hot day. These storms are locally known as 'Andhi' and their approach is heralded by strong stormy cool winds raising enormous clouds of dust which surcharged the whole lower atmosphere and reduce the visibility to ten or fifteen feet. The winds blow with a speed of thirty to forty miles or 48 to 64 kilometres per hour and can root out trees and thatched roofs. These storms are short-lived and frequently end up in light showers of rain; sometimes they are accompanied by hail and thunder-storms. (Fig. 9).
The rainfall of the hot weather season differs from that of the cold weather season in that the former is sporadic, short lived, subject to great local variations and frequently repeated about the same hours day after day for many days in succession. The barometric oscillations during a storm are rapid and considerable but are largely due to local causes.

**TABLE NO. 2**

Average rainfall in m.m. in the Hot season

<table>
<thead>
<tr>
<th>Stations</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bareilly</td>
<td>12.7</td>
<td>3.1</td>
<td>15.2</td>
<td>114.3</td>
</tr>
<tr>
<td>Baheri</td>
<td>16.5</td>
<td>10.4</td>
<td>22.3</td>
<td>147.1</td>
</tr>
<tr>
<td>Nawabganj</td>
<td>16.5</td>
<td>6.1</td>
<td>24.1</td>
<td>131.1</td>
</tr>
<tr>
<td>Acula</td>
<td>14.3</td>
<td>3.9</td>
<td>16.3</td>
<td>96.0</td>
</tr>
<tr>
<td>Faridpur</td>
<td>12.2</td>
<td>5.6</td>
<td>15.0</td>
<td>108.7</td>
</tr>
<tr>
<td>Bareilly District</td>
<td>13.8</td>
<td>9.4</td>
<td>10.8</td>
<td>123.2</td>
</tr>
</tbody>
</table>

It is obvious from table No. 2 that the rainfall during the hot weather season is usually scanty and the maximum amount

of rain during the year of record is approximately 25 mm.
which occurred in May in Navabganj. This is a premonsoon
shower which sometimes does not fall. During the same period
the minimum rainfall of 8.1 mm. was recorded at Navabganj in
April. Other stations received rainfall ranging between 13 mm.
and 23 mm.

**TABLE NO. 3**

<table>
<thead>
<tr>
<th>Stations</th>
<th>Annual rainfall in mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aonla</td>
<td>982.1 mm.</td>
</tr>
<tr>
<td>Faridpur</td>
<td>988.3 mm.</td>
</tr>
<tr>
<td>Bareilly</td>
<td>1052.5 mm.</td>
</tr>
<tr>
<td>Baheri</td>
<td>1259.7 mm.</td>
</tr>
<tr>
<td>Navabganj</td>
<td>1136.1 mm.</td>
</tr>
</tbody>
</table>

The total rainfall decreases gradually from east to west.
The reason for this is that as the distance from the sea increases,
the air becomes drier and the easterly winds are gradually
replaced by the westerly winds and precipitation accompanying
the storms diminishes. The decrease in the rainfall from north
to south is less conspicuous. (Fig. 9)
The rainfall of the hot weather season is helpful in
giving a temporary relief from the heat of the day as well as
in the preparation of fields for the sowing of early rice, but
the violent winds accompanying the rains cause immense damage
to the mangoes on the trees.

THE SEASONS OF RAINS

The wet monsoon normally commences in Bareilly district by
the 3rd week of June. The advent of the monsoon brings a
complete change in the weather. Its immediate effect is a
great fall in the day temperature, the mean maximum temperature
at Bareilly drop to 36.1 °C while the mean minimum daily tempe-

tature records 27.0 °C in June. The maximum and minimum
temperatures further drop in the month of July to 33.5 °C and
26.1 °C respectively. The much-awaited cool spells, coming
after many weeks of hot weather, bring a welcome relief.

Bursts of rain alternating with rainless intervals which last
hardly a day or two, follow in succession in the months of
July and August. Consequently these are the rainiest months
of the year and receive more than 50 percent of the total
annual rainfall as the following figure of a few selected
stations show

<table>
<thead>
<tr>
<th>Stations</th>
<th>Total annual rainfall in mm</th>
<th>Rainfall in July and August in mm</th>
<th>Percentage of the total annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aonla</td>
<td>982.1</td>
<td>388.6</td>
<td>39.5</td>
</tr>
<tr>
<td>Faridpur</td>
<td>998.3</td>
<td>406.4</td>
<td>41.0</td>
</tr>
<tr>
<td>Bareilly</td>
<td>1052.5</td>
<td>432.8</td>
<td>41.1</td>
</tr>
<tr>
<td>Nawabganj</td>
<td>1136.1</td>
<td>461.1</td>
<td>40.6</td>
</tr>
<tr>
<td>Baheri</td>
<td>1259.7</td>
<td>522.8</td>
<td>41.5</td>
</tr>
</tbody>
</table>

From table No. 4 it is obvious that Baheri receives
heaviest fall during this season as it is situated in the
northern part close to the Himalayas. Next importance is the
Nawabganj which is located to the south east of Baheri,
gets 1136-1 mm of rainfall during the year. Both these
stations also get heavy rainfall during the month of July and
August. The other three stations Bareilly, Aonla and Faridpur
get lesser amount of rainfall during the same period. It is
also clear from the table that rainfall decreases from north
BAREILLY DISTRICT

AVERAGE RAINFALL (IN mm)

JUNE - OCT

CHACHEHET 985.8
MANKARA 969.0
DUNKA 833.5
PANDEHRA 950
SINDHORA 983.0
BAHERI 975.3
BASAHGA 81.00
RAIPURA 920.25
SHAH 887.5
BHOJIPURA 833.5
NAWABGANJ 948.0
RAHARI 975.3
DAIABOJH 965.0
KUNDRA 892.5
RAIPURA 920.25
BAMORA 819.00
BAMORA 819.00
DAIABOJH 965.0
RITHORA 930.0
SARAOBA 940.5
SHAHBAJ 817.2
KATAIVA 842.5
SHEROPURA 820.1
AONLA 815.5
BHUTA 841.5
SHEOPURA 820.1
FAHIDPUR 832.9

SOURCE
REVENUE DEPARTMENT LUCKNOW

THE FIGURES INDICATE AVERAGE
MONTHLY RAINFALL OF FIFTY YEARS

0 5 10 MILE
0 16 KM
to south. This may be explained by the fact that the north region nearer to the Himalayas get more rainfall than the southern part of the district. (Fig 10)

The amount of rainfall in these months is fairly high on account of high clouds proportions; the mean maximum temperature shows a continuous decrease. The skies are heavily clouded particularly in July and August. In these months, the rain is often associated with thunderstorms. The following table shows the temperature and relative humidity in these months.

**TABLE NO. 5**

<table>
<thead>
<tr>
<th>Months</th>
<th>Mean Daily Maximum Temp. in °C</th>
<th>Mean Daily Minimum temp. in °C</th>
<th>Relative Humidity in percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>38.1</td>
<td>27.0</td>
<td>63</td>
</tr>
<tr>
<td>July</td>
<td>33.5</td>
<td>26.1</td>
<td>82</td>
</tr>
<tr>
<td>August</td>
<td>32.3</td>
<td>25.7</td>
<td>84</td>
</tr>
<tr>
<td>September</td>
<td>32.3</td>
<td>24.3</td>
<td>80</td>
</tr>
<tr>
<td>October</td>
<td>32.1</td>
<td>18.9</td>
<td>73</td>
</tr>
</tbody>
</table>

It is clear from the table No. 5 that the relative humidity increases correspondingly e.g., it is 82 percent.
BAREILLY DISTRICT

AVERAGE ANNUAL RAINFALL
(IN mm)

CHACHEHAT 1270.4
DAIABOJH 1260.3
BAHERI 1262.5
SINDHORA 1257.8
DANKA 1160.9
PANDEHRA
MANKARA 1260.5
SINDHORA 1257.8
KUNDRA 1240
BAHARA 1200 mm
RAIPURA 1050.0
NARABGANJ 1155.5
SHAHI 1039.6
RITHORA 1100.7
BHOJPURA 1065.8
NARABGANJ 1155.5
FALEHANJ 1055.8
KATAYA 996.3
BAREILLY 1025.0
AONLA 980.5
BHORMA 979.23
FARIDPUR 987.8
SHEUPURI 984.8

NOTE:
THE FIGURES BESIDE EACH STATION INDICATES
AVERAGE ANNUAL RAINFALL. THE AVERAGES FOR
MOST OF THE STATIONS ARE OF FIFTY YEARS

0 5 10 MILE
8 16 KM

FIGURE II
in July and 84 percent in August. In September the rains normally slacken and rainless intervals become longer. The day temperature begins to rise. The relative humidity in September, however, remains high (e.g. 80 percent) and the air is almost motionless. In October there is further decrease in rainfall but the mean maximum temperature remains as high as that in September, with the result that there is a drop in the relative humidity, which at Jareilly is about 60 percent. However, this humidity combined with an almost motionless air makes the months of September and October very oppressive and leads to the out-break of a number of diseases.

That 60-95 percent of the annual rainfall is received (Fig. 11) during the five months June to October. The distribution of rainfall in the wet monsoon follows the same pattern as that the annual rainfall and decreases from east to west as well as from north to south. The southward decrease, however, is more marked than the decrease towards the west. The period of the wet monsoon is not one of continual rainfall and outbursts of rain alternate with spells of the fine weather, which are very
BAREILLY DISTRICT
ANNUAL MEAN VARIABILITY

SOURCE
THE PERCENTAGES HAVE BEEN COMPUTED BY THE WRITER ON THE BASIS OF MONTHLY RAINFALL DATA FROM THE REVENUE DEPARTMENT LUCKNOW

0  5  10 MILE
0  8  16 KM
useful to the crops of the season. Incessant rains, whenever they occur, cause the crops to rot. (Figures 11-12).

If the total rainfall of the wet monsoon is divided by the number of rainy days in these months, the average fall on each rainy day comes to 16-19 mm. It should be further noted that this heavy rainfall usually takes the form of downpours, as a consequence of which the run-off is great in proportion to the quantity of rainfall. This naturally causes the flooding of the drainage channels.

VARIABILITY OF RAINFALL

Annual Variability:

It will be seen from the (Figure No. 13) that mean annual variability is lowest in the Northern part of the area and is greatest in the south western part of the area. In the former mean Annual deviation is over 20 percent while in the latter it is more than 40 percent. A comparison of average Annual Rainfall and Mean Annual Variability indicates that the tendency to deviation from the average is proportionately greater in the drier parts than in the wetter parts. Since, according to Blandford, an annual variability of 12 percent
ANNUAL RAINFALL OF SELECTED STATIONS
1943-1972

TOTAL RAINFALL: 1500 mm

Nawabganj

SOURCE: FIGURES 13-17 ARE BASED ON ANNUAL RAINFALL STATISTICS PUBLISHED BY THE GOVERNMENT OF UTTAR PRADESH LUCKNOW

FIGURE 17
or more makes an area susceptible to famine, but in the
study of this area, it does not come under this purview.

The variation in annual rainfall over a period of
thirty years for selected stations have been shown in
Figures 13-17, which indicate that, in general, the total
incidence of the rainfall at different places is subject
to great variations. In 1957, for example, the rainfall
at Mankara was 13.7" and was far below the average, while
in the same year the rainfall at Bareilly was 46.1" only
which was the average.

Similarly, in any year, the rainfall at Baheri, Bareilly
Nawabganj and Aonla is different, sometimes it is below the
average while at other time it is above the average. This
phenomenon is evident from the figures.

It can be seen, then that while all places are liable to
suffer from drought or deluge in any one given year, it may

4- The figures of the mean annual variability show the percent
of mean variations from the average, and are the difference
of the two means computed, firstly, for all the years in
which the rainfall has exceeded the average and secondly,
for all those years in which it has fallen short of the
average. The figures have been calculated by the writer on
the basis of rainfall statistics of 29 years (1942-1971).

The formula $D \times 100$, where $D = U - L$, $U$ stands for upper quar-
tile, $L$ stands for lower quartile and $M$, for the median
value of rainfall of 29 years.
also happen that dry conditions may prevail at one station but at another station, only a few miles away the annual rainfall may be greatly in excess of the average for that place.

VARIABILITY IN THE WET MONSOON MONTHS:

From the view point of agricultural operations, the variability of rainfall in the wet monsoon months is more significant than the annual variability; for even if the total rainfall of the year is below or above the average but its distribution is timely, the crops are not much affected. As a matter of fact, timely distribution is more important than the annual total. For instance, an insufficient or excessive amount of rainfall in the months of June delays the sowing of the early kharif crops and affects their outturn. The insufficiency of rainfall in July and August results in the failure of the rice crop. The rainfall of the two months, September and October, is very important to the sowing of the winter crops as well as to the quality and yield of the late kharif crops. Heavy falls in these months may lead to waterlogging while premature cessation of the rains may cause
postponement or restriction of the sowing of the rabi crops.

**TABLE NO. 6** shows the mean monthly variability of selected stations for each of the wet monsoon months.

**TABLE NO. 6**

<table>
<thead>
<tr>
<th>Stations</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pandehra</td>
<td>69.4</td>
<td>35.4</td>
<td>36.8</td>
<td>69.0</td>
<td>139.3</td>
</tr>
<tr>
<td>2. Daibigh</td>
<td>63.3</td>
<td>53.5</td>
<td>43.1</td>
<td>69.3</td>
<td>128.7</td>
</tr>
<tr>
<td>3. Kunka</td>
<td>73.1</td>
<td>47.7</td>
<td>54.38</td>
<td>94.2</td>
<td>132.5</td>
</tr>
<tr>
<td>4. Mankara</td>
<td>62.9</td>
<td>52.0</td>
<td>49.7</td>
<td>88.3</td>
<td>145.7</td>
</tr>
<tr>
<td>5. Chachebat</td>
<td>60.1</td>
<td>48.54</td>
<td>51.5</td>
<td>73.6</td>
<td>153.3</td>
</tr>
<tr>
<td>6. Sindhora</td>
<td>62.8</td>
<td>52.4</td>
<td>49.5</td>
<td>74.4</td>
<td>144.0</td>
</tr>
<tr>
<td>7. Bareilly</td>
<td>75.0</td>
<td>42.5</td>
<td>45.5</td>
<td>68.8</td>
<td>116.6</td>
</tr>
<tr>
<td>8. Kundera</td>
<td>68.0</td>
<td>38.8</td>
<td>41.8</td>
<td>57.9</td>
<td>116.0</td>
</tr>
<tr>
<td>9. Sarasara</td>
<td>75.6</td>
<td>43.3</td>
<td>39.1</td>
<td>70.0</td>
<td>115.0</td>
</tr>
<tr>
<td>10. Shahi</td>
<td>72.8</td>
<td>35.53</td>
<td>41.1</td>
<td>76.6</td>
<td>110.1</td>
</tr>
<tr>
<td>11. Nauabganj</td>
<td>71.33</td>
<td>55.6</td>
<td>56.5</td>
<td>60.5</td>
<td>125.2</td>
</tr>
<tr>
<td>12. Bhuta</td>
<td>84.2</td>
<td>49.0</td>
<td>51.04</td>
<td>54.5</td>
<td>130.0</td>
</tr>
<tr>
<td>13. Kataliya</td>
<td>80.0</td>
<td>50.1</td>
<td>55.2</td>
<td>65.3</td>
<td>132.8</td>
</tr>
<tr>
<td>14. Basangha</td>
<td>73.3</td>
<td>45.2</td>
<td>56.1</td>
<td>72.7</td>
<td>130.4</td>
</tr>
<tr>
<td>15. Bhujipura</td>
<td>72.6</td>
<td>43.4</td>
<td>55.8</td>
<td>70.4</td>
<td>133.7</td>
</tr>
<tr>
<td>16. Baiyara</td>
<td>65.0</td>
<td>40.4</td>
<td>58.4</td>
<td>84.7</td>
<td>130.9</td>
</tr>
<tr>
<td>17. Raithora</td>
<td>83.3</td>
<td>41.0</td>
<td>47.8</td>
<td>63.6</td>
<td>128.9</td>
</tr>
<tr>
<td>18. Baheri</td>
<td>62.9</td>
<td>50.3</td>
<td>58.6</td>
<td>73.3</td>
<td>125.0</td>
</tr>
<tr>
<td>19. Asula</td>
<td>85.00</td>
<td>53.4</td>
<td>58.7</td>
<td>80.7</td>
<td>140.6</td>
</tr>
<tr>
<td>20. Darispur</td>
<td>83.2</td>
<td>58.5</td>
<td>60.8</td>
<td>92.4</td>
<td>135.2</td>
</tr>
</tbody>
</table>
It will be seen from the table that the variability is very small in July and August but it is much higher in the months of June, September and October. In the first two months (July and August) it is below sixty percent at all stations and is as low as 36 percent at some stations.

In June the variability at all stations is between 62 percent and 84 percent, the only exception being Kataiya where it is 50 percent.

In September it ranges between 53 and 95 percent, the maximum variability occurs in the month of October at Nawabganj and the minimum at Shahi.

VARIABILITY FROM THE MEDIAN:

The variability of rainfall as determined from the average is sometimes regarded unreliable and inaccurate, and in its place median or middle value is employed. It is pointed out that average is figure which has never occurred at a station and is just an arithmetic mean, while median is the value which has been actually experienced at a particular station.
According to P.R. Grove, dispersion diagrams offer a better test of the real comparative wetness and dryness of months than do the mean monthly data. W.H. Hogg also supports this view and expresses that this method of analysis leads to a more reliable result and conveys much more information than the rainfall graphs based on mean values alone, for the dispersion diagrams clearly indicate whether the plotted values lie near to the median or far from it.

On the basis of the methods discussed by P.R. Grove, E.A. Mathews and others, an attempt has been made to study and interpret the rainfall variability from June to October with the help of dispersion diagrams located in the area under study. For an interpretation of these diagrams it would be worth while if the following points are elucidated at the very outset:


1. Where in any two months under going comparison, the interquartile band of one month is completely clear of that of an adjacent month, a 'major discontinuity' is indicated.

2. When the 'break' is less marked the median and lower quartile of one month will lie above the quartile and median respectively of an adjacent month. Such a break is known as 'minor discontinuity'.

3. When the difference between months is confined to difference in the height of medians, or where the median of the one month lay above the upper quartile of other, without the further condition in which the lower quartile lay above the median of the other month, then it is a case of 'no discontinuity'.

An attempt has, therefore, been made to analyse the variability of rainfall in the region under study from June to October by the Median Value Method. The distribution of monthly rainfall over a period of twenty nine years (1943-71)

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A- The figures have been computed by the writer on the basis of monthly rainfall statistics of twenty nine years for the selected stations. The monthly rainfall figures have been obtained from the Government of Uttar Pradesh.Indian
RAIN FALL DISPERSION DIAGRAM
JUNE TO OCTOBER
1944-72

SOURCE:
FIGURE 18 - 22 are based on statistics of monthly rain fall published by the government of Uttar Pradesh. Encircled dots represents the medium rain fall for the various months of each station.
for five tahsil stations has been shown in Figures No. 19-23.

The Rainfall Dispersion diagrams of the northern stations reveal striking similarities in variability. It will be seen from diagrams No. 19-23 that the dispersion patterns for the period July to August, though not identical, do not show any difference which is likely to be of significance to agricultural operations. The variability for June, while it is greatest in Faridpur (the most easterly of these stations), is nevertheless critical at all the remaining stations because for the small median value of the rainfall. For the month of September the inter-quartile range at all the stations is fairly long while for October, though the range is very small, it is seen that there were at least six such years in which October was completely rainless and there was an equal number of years when the rainfall was almost insignificant in that month.

It may be concluded that variation of rainfall in June is greater in the north and east and smaller in the south and west. Moreover, the June rainfall is more liable to be deficient
in the south and west. Although the inter-quartile bands as shown in Figures 19-23 indicate that the June is less variable than the months of July, August, and September. It should be noted that the higher variability of July and August as indicated by the inter-quartile bands is less significant for agricultural operations in view of the high totals of these months. The much smaller variability of June is more likely to be critical for agricultural operations because the monthly median is low and any reduction in the amount of rainfall delays the agricultural operation.

The inter-quartile bands at various stations show a fair amount of consistency in the distribution of rainfall, but if a 50 percent increase or decrease of rainfall from the median value is taken into consideration, it will be found that at almost all the stations the number of years with heavier rainfall far exceeds the number of years of deficient rainfall. This shows that July and August rainfall all over the area is more liable to be in excess of the median than to be deficient.
The September rainfall shows a higher range of variability than the June rainfall and it will be seen later that the agricultural consequences of this are quite significant.

The October rainfall is still more variable. At all the stations the number of Octobers with extremely low rainfall is greater than the number with excessive rainfall. This shows that in the month of October the rainfall is more liable to be deficient than to be in excess of the median.

Thus, a critical study of the dispersion diagrams reveals that rainfall is most variable in the month of October, the next in order being the months of September and June.

It is also obvious that the rainfall in June and October is more liable to be deficient. It remains to be added that the rainfall in Bareilly district is quite variable in these months of the year when its regularity is most needed. Such a variability cannot but lead to uncertainties in agricultural operations.
CHAPTER III

SOILS

A scientific study of the pedology of the Bareilly District has never been attempted seriously and the information regarding the soil given by various agencies are not far from arbitrary. Soil Maps of India were prepared and even those of Uttar Pradesh drawn from time to time, are based on broad categories of soils and give only a more generalized picture of the soil of the district.

The soil of the area under study is classified as one broad belt of alluvium but no further sub-classification is given.

No scientific and authentic data about the nature of the soils of the area are available. The soil map is based largely on the information available in the settlement.


2. The soil map prepared by S.P. Raychaudhury, published in the 'BULLETIN OF NATIONAL INSTITUTE OF SCIENCES OF INDIA' No. 2, 1934, 222.
Report and district Gazette of Bareilly. The Govt. of Uttar Pradesh have recently established regional soil laboratories entrusted with the task of classifying and preparing the soil maps of various parts of Uttar Pradesh based on the results of chemical analysis. During the course of his field work, the writer, made enquiries about the nature of the various soil types, their capacity to retain moisture, their general fertility and productivity. On the basis of the information thus available and the information obtained from the Settlement Reports and District Gazetteer, the soil maps of the area has been prepared.

The classification adopted in the District Gazetteer and Settlement Reports is on the basis of the rents paid in respect of each type of soil. In the year of Settlement, 1905 the soils were classified as *Bhur* (Sandy), *Chikmat* (Clayey), *Khapur* (Whitish heavy clay with traces of iron), *Matiyar* (bluish or blackish clay), *Thada* or *Shahr* (clay in lowlying areas).
deras (clayey loam), dumat (sandy loam), milaoni or bhurmilaoni (dumat containing more than 60 percent of sand), sivai (fine calcareous loam of a yellowish white colour) and Khadar (new alluvium).

Later on in 1900, the soils were classified as Domat I and II, Matiyar I and II, bhur, clay, sand and Khadar I and II. The rates for different class of soils were fixed and compared with rents actually paid which formed the basis for determining the standard rate for each kind of soil.

The last settlement was carried out in November, 1937, and December 1940. The soils were then classified as Kashiana, kashiyama Plus Gauham I and II, Domat I,II and III, Matiyar I and II, Bhur I, II, tarai dumat and tarai I,II and III.

3. District Gazetteer, Bareilly, Vol. XIII (Allahabad)

1926, p.217.

4. Kashiyama- Gauhang- Gehra - Good managed soil in immediate vicinity of village sites.
The circles were primarily formed and based on topographical features. The villages with similar soils and characteristics were grouped together in one circle. The rents for the most part were 'bilmukhta' (the rent of a holding which was let for a lump-sum at a particular rate per bigha without any direct reference to the various types of soil found in it) which were utilized to calculate the values attached to the major classes of soil in each circle.

The area occupied by each tenure-holder was expressed in terms of units, the rent per unit being calculated on the basis of the standard rent rate of each type of soil in the circle.

At the time of the tenth and the last settlement in 1937 - 1940, the consideration for determining the rent with reference to the texture of the soils was given up and the

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It should be observed that soil is classed as gauhan because its nearness to sites and not because it is good of itself. It may for instance be actually third soil instead of lean. Due to manuring it is known as good quality land.
rent was fixed on the circle basis.

There is no doubt that this simple classification of soil introduced at the time of the last settlement has now become obsolete. In the modern days when the determination and collection of rent is controlled directly by the state Government, it is necessary to have a comprehensive classification of the soils.

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Domat I, II, III

(1) The best class of loam. (11) A lower class of loam, rice is grown. (111) Inferior Loam, it is usually found in broken ground and at the extremities of village lands. It is often affected by user and reh.

Matyar- I Clay in which rice of good quality is usually sown.

Matyar- II Inferior clay which grows usually sathi rice and is mainly single cropped, though in good seasons attempts are made to grow a rabi crop also.

Bhur-1 Sandy soil in which Sugar Cane is very often grown which is generally known as thanda ret.

Bhur-II Inferior soil in which crops like bagra, moong & moth are usually grown.

CLASSIFICATION OF SOILS ON THE BASIS OF FERTILITY.

In addition to the classification of soils discussed above the villagers also recognize an alternative system of classifying their cultivated lands on the basis of their location with regard to the Village site. The basis of this classification is the varying degree of soil fertility. This method is, however, conventional and takes into consideration the location of the field from the village site or the amount of organic matter which is applied to the soils.

The fields adjoining the rural dwellings receive most of the village refuse as well as a good deal of night soil. Moreover, these same fields receive most of the manures which the villagers can afford to put into their fields for the simple reason that it is more expensive to carry the manure to distant fields as well as time consuming. Thus, the fields which are nearest to the dwelling are frequently manured, while those lying a little farther away are manured occasionally, and those situated
at long distances from the village site get little manure.
Actually each group of houses forms a centre from which the
fertility gradually diminishes towards the outskirts of
the village and as a general rule, the most remunerative
or cash crops are found near the settlements, while the
inferior and less remunerative crops are found farther
away. As far as the nomenclature of these lands is con-
cerned, the manured land around the village site is known
as gauhar or bara. These lands near the village site are
also known by the name (Kachiana). Such lands are usually
earmarked for crops like turmeric, tobacco, ginger, onions,
many varieties of green vegetables and plants which yield
spices. These patches of land are constantly manured and
watered and are never free from crops. Generally Kachia
or Murag (a class of people who specialize in cultiva-
tion of vegetable and tobacco) raise in such fields most
of the vegetables and spices that the villagers require.
The outlying unamnured land is known as male
and intermediate land is known as manjhar or miana. It
would be worth while to mention here that the point at
which one class passes into another is a matter of opinion.
A line of demarcation between two groups can not possibly
be drawn.

The writer has, however, visited a number of
villages from different parts of the district during the
course of his field work and collected informations from
the cultivators about the soil characteristics, availability
of water, soil, drainage, fertility and use of fertilizers,
level of the land and potentiality of soil in terms of net
crop return from different types of lands. On the basis of
these informations and personal observations, an attempt
has been made by the writer to classify the soils of the
Bareilly district and to depict their areal distribution
in Fig. . . . . 43
The soil of this district has been formed by the action of rivers viz., Ramganga, Naktiya, Bahgul, Deorenia & other rivers. This is generally alluvium in nature. This alluvium has been very much affected by the local climatic and vegetative conditions and topography. The proximity of the sub-Himalayan ranges has also greatly shaped the nature of the soils from where the parent rock material are brought down by the rivers and deposited in the plain. The zonal differentiation in the parent rock material has in turn, given a distinct characteristic to each type of soils.

Geologically the district forms a part of the Indo-gangetic alluvium, which can be put into two divisions. However one more can be added to these two divisions (1) Khadar or new alluvium, is generally light in colour owing to higher amount of sand present in its composition. (ii) bhangar or old alluvium having more clayey and silty compositions, is generally grey to dark in colour, and (iii) tarai, dark to dark grey in colour and rich in clay content.
Deposits of the upland consist of older alluvium
or the bhangar which belong to the Middle and upper
pleistocene. These deposits are dark-coloured and generally rich in concretions and nodules of impure calcium
carbonate known as Kankar. The deposits of the low lands
consist of new alluvium or the Khadar. These deposits are
light coloured and rich in calcareous matter and belong to
the upper pleistocene. Both these deposits are pervious
and the rain water percolates into them without any difficulty.

(iii) Tarai -- These soils are known as 'Man', a name
commonly applied to the dark-coloured forest soils of the
sub-Himalayan areas. These soils are found very unhealthy
owing to their proximity to the forest and have a high water-
table, heavy rainfall and imperfect drainage.

Casual distinction between these three is somewhat
difficult but usually old alluvium are spread over the
higher ground and the newer ones occupy the lower ground in
the vicinity of the rivers, while Tarai area lies in Brahmaputra
river system.
and Navabganj tahsil which is identical with that of
the Nainital Tarai.

Khadar:- The Khadar or new alluvium soil is found on
either banks of rivers Ramganga, the Deoha (on the eastern
border), the Bahgul (east in its lower courses in tahsil
Faridpur) in the Nakatia near Bareilly and the Bahgul (West)
near Shahi. The dominant features of the soil are clay and
sand. It is believed that when the river is in spate, it
carries with it large quantities of materials of all sizes
from coarse sand having 2 mm to 0.2 mm diameter, to fine
silt and when flood water spreads over a wide stretch of
land, its speed is retarded and thus coarser sand is
deposited; further on where the speed decreases consider-
ably, the finer mud is deposited. This process ultimately
results in the formation of patches of coarse sand and fine
clay in the Khadar lands. Khadar lands are found in all
the tahsils. Developed from fresh alluvial material and

G. Hall, A.D., revised by Robinson, O.B.E., THE
Introduction to the Scientific study of the
growth of crops. (London, 1936), p. 59
deposited during the floods by the rivers in their courses, these soils are found as parallel strips along the rivers and rivulets. Except for the flood-plains of the Ranganga which at certain places are 4 to 5 miles in width, the khadar lands are of small extent, being sometimes no more than narrow strips. The old Khadar lands are fairly fertile except where fresh sandy material is deposited by heavy floods or high winds. In colour, the soils are generally ash-grey to brownish grey on the surface and their texture is sometimes silty loamy sand and sometimes sandy, the clay contents being low. The better type of these soils is capable of yielding good crops of Jewar, bajra, wheat and barley during favourable seasons.

The Khadar of the Ranganga has different layers of soils. The surface soil varies from the richest alluvial earth to more sand. Successive deposits of alluvial silt,
known as Karn, gradually raise the level till land becomes almost or entirely free from inundation. In such places the khadar is extremely productive, the fertility of the soil remaining unimpaired till the river changes its course. Here the settlements are generally temporary as they are subjected to frequent inundation. However the sandy soil produces melons, water melons and pumpkins. Kharif crops can be grown easily but it is difficult to grow Rabi crops because irrigation facilities are not available and the construction of mason-ry wells or tube-wells involves considerable expenditure which is beyond the means of the villagers.

Bhangar soil :-

These soils occur in upland tracts located at a height varying from 3 to 6 metres above the khadar. The soil profile is generally mature, showing good development and illuviation of clay and sesquioxides. It has several

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7. No mechanical analysis of the soil has been done by the writer. The classification is based on the information obtained by the writer about the different types of soil found in villages (a) in the course of field work, (b) the inspection of soil samples.
topographical and textural sub-types:

1. Sandy (Bhur)
2. Loamy Soil (Domat)
3. Clayey Loam

Sandy Soil

This soil is also called bhur and is the poorest of all, being too porous to retain moisture. This type of soil is found in Faridpur tahsil. Natural to slightly acidic in reaction, the sandy soils of the uplands are brown to yellowish brown in colour, the lower layers showing a more yellowish tinge. Tracts made up of this soil are capable of yielding crops but only when there is favourable distribution of rainfall or when adequate irrigation facilities are available. This region does not provide facility for the construction of wells since the water-table is very low and sub-soil is sandy. Kans (Saccharum spontaneum) grows extensively and the chief crop is ground absence of a complete soil survey is, therefore, limited. It is a kind of weed which grows wild.
nut, which does well on these soils.

2. **Loamy soils** :-

This soil is grey to greyish brown in colour, mature in profile development and loamy in texture, the soils of the lower layers being heavier than those on the surface. There is illuviation of clay and sesquioxides, both showing accumulation in the lower layers. Lime contents are low but there is a high proportion of magnesia. Neutral to slightly alkaline in reaction, they are well drained except in depressions. These are very fertile if adequate irrigation facilities are available because its water retention capacity is very low. Patches of clay loam to clay are also common. Clay is known as **Dhamkar**. It is found in flat shaped depression and low-lying areas located far away from any significant channel. This soil is best suited to paddy crops.

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9. Dhamkar as the name derived from the Hindi word 'dham' meaning paddy.
These soils have average plant nutrient status and respond well to all manurial treatments, usually loam which is not susceptible to frost as the sandy soil and is devoted to the cultivation of wheat either as a sole crop or in combination with barley, gram and peas. Fig.15. indicates that a large portion of Aonla tahsil, central part of tahsil Bareilly and also in tahsil Faridpur is covered with loamy soil, while it is also scattered in small patches in southern part of Baheri tahsil.

Clayey Loam:

This group of soil is characterized by low land content, both coarse and fine which gives to this type an unusually high water holding capacity. It is also some what poorly drained.

Clayey loam is locally known as matiyar and usually devoted to the cultivation of Kharif crops. In the northern portion of Bareilly tahsil, in the southern portion of Navabgunj tahsil and one third portion of Faridpur


11. During the course of his field work, the writer obtained this information from the village people.
lying in the north is covered with this type of soil. The soil is mature in profile. It has illuviation of clay and sesquioxides and is neutral to slightly acid in reaction. These soils contain calcium which predominates in the upper layers and have a high magnesium saturation in the lower. The soil has grey or yellowish grey colour at the surface which in the lower horizon deepens to a dark grey colour. At depth varying from two to four feet calcareous pans of (kankar) may occur. The calcium from the surface is leached and accumulates at various depths in the form of kankar nodules. The presence of kankar pan impedes the drainage with the result that during the rainy season bodies of water at places are held up and stagnate. It may be mentioned that sany soil responds well to transplanted rice. In hot weather the clay dries up and splits into deep cracks, the soil being so hard as quite impervious to the plough, until soften by rain. A greasy, sticky clay is called chiknut and the heavy grey clay with traces of iron is called kuman. This is very unproductive variety.
3. Tarai soils:

This type of soil is found in the northern portion of tahsil Bahārī and Nawabgunj. Fine in texture and rich in organic matter and plant nutrients, these possess the capacity of retaining moisture for long periods. Plants can therefore thrive in them for a long period without irrigation. Locally these soils are known as 'mañ', a name commonly applied to the dark-coloured forest soils of the sub-Himalayan areas. The tracts where these soils are found are very un-healthy owing to their proximity to the forest and have high water-table, heavy rainfall and imperfect drainage. These soils are dark to dark-grey in colour and rich in clay content, especially in the upper layers, the lower layers being lighter in texture. They are calcareous in nature frequently having small kaal kar nodules in the lower depths. The magnesia content is lower than that of lime and the exchange complex is highly saturated with calcium. The soil is rather immature in
profile and the symptoms of an anaerobic condition are in
evidence in the lower depths in the form of yellow and brown
mottlings and concretions. Bareilly type I or Tarai soil
is subclassified as Bareilly type I(A) (clayey mar) and
Bareilly type I(B) (clay loam des). The former is found in
the Northern parts of tahsil Baheri, and the soil of
Banjaria is representative of this type. The latter occurs
mostly in the western parts of tahsil Baheri, the represen-
tative soil being at Shisgarh. Type I(A) of clayey mar is
deeper and with better moisture and nutrients. Clay loam
(desh type I(B)) is much lighter in texture (specially
in the lower depths) and is rich in plant nutrients.

Rab Soils:

The total area covered by such soils in the
district Bareilly is not large. These soils are found
scattered in small patches in different parts of the
Bareilly district and hence it is not possible to
demarcate areas of rab soils on the soil map.
The patches of reh soils are found mainly in the southern and eastern parts of the district.

The efflorescences of sodium carbonate and sulphate which are found in abundant quantities in the alluvial soils of the Indo-Gangetic plain, give rise to barren lands known as Usar. In such places the concentration of alkali, is too great to allow the growth of plants. The salty crusts on the alluvium are known as reh.

The mechanical breakdown, chemical decomposition, and solution of mineral particles in the alluvium leads to the formation of reh soils. In some cases sodium salts are introduced into the lower layers of the alluvium as a consequence of percolation of canal water containing particles of the sodium. The reh salts are present in solution in all ground water, and during the rainy season, solutions are washed down towards the water table. In the intervening dry weather periods, extensive evaporation takes place, and this exerts a strong capillary pull, upwards against gravity, on
the water which is present in the pore spaces of the soil. As soon as the water reaches the surface, it begins to evaporate and the salts crystallise out as a white incrustation. These are known as *reh* salts. The occurrence of small quantities of alkali salts in the soil does not have any marked injurious effects on the crops. It is only when their proportion increases beyond a certain limit that they begin to interfere with the growth of the crops which in some cases may be prevented altogether. The salts produce a physical action, which increases correspondingly with the increased amount of dissolved substances. For, water to pass readily from the soil into the root of plants, the osmotic pressure of the cells of the roots must be considerably greater than that of the solution. In other words when the pressure of the soil solution becomes stronger than that of the cells, water passes from the roots to the soil and the crop withers away. This actually happens when the

soil becomes charged with alkali salts beyond a critical point. The crops are then unable to take up water and consequently perish.

Saline and Alkali soils:

In Uttar Pradesh vast stretches of saline and alkali lands popularly known as Usar or reh are lying waste and uncultivated. The total area of the Usar in the State was estimated at 2.2 million acres in 1938, but a more recent survey made in 1957 placed the figure 3.1 million acres. There is an increase of 50 percent within a period of less than 20 years. At this rate the State is about to lose five million acres of land within the next 100 years.

The situation is indeed alarming and calls for immediate attention both in regard to the reclamation of the area under usar land as well as to check further spread of alkalinity to cultivable lands. Dr. Leathur (1876) showed that these salts are the decomposition products of igneous rocks under natural weathering.

13. Ray Chaudri, S.P., soils of India, p. 366
process, and are present in the soil profile itself. They become evident on the surface layers under certain prede-
sposing conditions. He included the saline and alkali soils of the Punjab, U.P., Gujrat, Bombay and Deccan under common term 'Usar' derived from Sanskrit word ushtra meaning barren or sterile.

Reclamation of Usar lands:

Now at this juncture when the country is facing an acute problem of food shortage in the country, such Usar lands should be reclaimed. Efforts should be made to bring every inch of cultivable land under plough. So that the problem of food shortage should be eased to a certain extent.

Several methods have been suggested from time to time. They are (1) The use of organic material (2) the improvement in the drainage of the area (3) the application of lime and gypsum (4) cultivation of salt-resistant crops like rice, sugar-cane which can grow and survive even under some what adverse conditions (5) scraping.

14. Ibid  p. 360
The above noted methods, where practised have been
given very satisfactory results so far as the reclamation
of Usar lands is concerned. The most important of all
these methods is the improvement of drainage: leads to water
logging and, in turn, it results in the formation of white
incrustation on the surface of land. It is, therefore, nece-
ssary that the drainage should be improved so that water
logging could be avoided. Higher water table is one of the
chief causes of reh formation and hence to remove the effect
produced by high water table, fields should be divided into
small plots having high mends (embankment) round them so
that they could hold water for some time. The mends should
not be less than 4 feet at the base, 2 feet at the top and
2 feet high. The plots thus made should be kept under
occasional cultivation as a result of which the salt will

15. Khan A.D., Diagnosis and reclamation of Usar soils,

16. Chaudri, S.P., Soils of India, Indian Council of Agri-
more downward to greater depth. In this way the land will be free of any incrustation of white material and at the same time the molecules of soil will be fertilized. The second step is to provide drains to take out excess water and to see that, as far as possible, no water collects in the vicinity for any length of time.

During the summer, specially in April and May, when the water table goes down, it is possible to bring about leaching of soil in Ugar land with the help of irrigation water. This process will also help in eradicating evils of red formation.

The use of organic materials, application of lime or gypsum and salt resistant crops have shown very useful results in the reclamation of Ugar infested soils. In case of badly damaged alkali patches, treatment with sulphur or gypsum accompanied by adequate watering has led to steady improvement in the soil and crops have been raised with success.

Removal by scraping off the incrustation of 

sometimes resorted to but it is not very effective since

large quantities of salts are left in the soil.

The use of bulky organic manures is also very effective in improving the condition of the soil. In fact,

they improve the permeability of the soil, bring about better structure conditions and produce various organic acids

which partially neutralize some of the harmful salts. The following bulky manures are specially useful.

1. Green manuring with ganai (Crotolaria juncea) and dhauncha (Sesbania aculesta) is very useful. Green manuring crop should be sown in kharif season following the leaching operations and turned into the soil at the proper time.

2. Press mud and molasses in heavy quantities (at 10-15 tons

per acre) applied for a number of years continuously will

also improve the soil condition.

3. Raw cow-dung applied in huge quantities like 20 cart-loads or more per acre gives good results.

4. Application of heavy doses of compost over a number of years also proves useful.

Experiments on the reclamation of Usar soils with the help of green manuring and gypsum have produced encouraging results in Uttar Pradesh. In such experiments, the fields according to their soil properties are treated with specific quantities of well powdered gypsum, and water is allowed to stand in them for the completion of the reaction. The water is thereafter flushed out and a crop of 'Dhamsha' is sown as a green manure at the rate of one quintal of dhamsha seed per hectare. After about six weeks, the crop is ploughed, and the field is ready for the sowing of transplanted variety of paddy.

It is desirable to have complete reclamation that the all methods described above and a liberal use of artificial fertilizers may be put into practice.
UNDERGROUND WATER AND ITS EFFECT ON CROPS

Physiographically, the area under study is essentially a featureless plain, sloping very gently in an approximately north to south direction, the average slope being less than 0.66 metre per 1.60 kilometres. However the monotony of the plain is broken by the slightly elevated tracts or interfluves between adjoining drainage basins or slightly lower ground along the streams. From a geological study of the region it has been found that the alluvium is one continuous series of fluvial and sub-aerial deposits mainly composed of, unconsolidated beds of clay, sand, gravel and their mixture is in varying proportions. The thickness and the succession of the strata are found to be directly related to the changing physical condition under which the deposition of the alluvium occurred. There is, however, a general uniformity in the geological structure of the underlying formation. It does not reveal any marked spatial variations.
Significance of the Water Table

The ground water in the alluvium, at least up to the depths ordinarily reached by tube-wells in this area (i.e., about 300 feet), is not confined under pressure but occurs under water table conditions. The position of the water table is indicated by the state level of wells tapping free ground water.

As regards its significance, the water table is an indicator of the hydraulic conditions prevailing in the upper part of the zone of saturation. It registers fluctuations due to variations in addition to or with draws from ground water storage. Further, the slope of the water table gives the hydraulic gradient of free ground water. In fact, the water table slope is a graphical expression of the influence on the water table, of geological structure, topographical features and hydrologic characteristics of the formation.

20. The water table is a physical surface defining the upper limit of the zone of saturation.
21. Free ground water occurs in the opening of capillary and supercapillary sizes where as fixed ground water occurs in the subcapillary openings of finer materials, as for instance silt, clay and shale.
BAREILLY DISTRICT
AVERAGE WATER LEVEL
MAY

KEY

SOURCE

[Diagram showing map of Bareilly District with water levels indicated by lines and numbers.]

FIG. 24
BAREILLY DISTRICT
AVERAGE WATER LEVEL
OCTOBER 1971

THE FIGURES INDICATE AVERAGE WATER LEVEL IN FEET ABOVE SEA LEVEL

FIG. 25
Location Wells And Their Water Level Depth Records

There are in all 64 wells in Bareilly district situated along different well lines. The water level depth in these wells is being measured and recorded by the Irrigation Department of the U.P. Government. Each well is measured twice a year, once in May preceding the onset of the monsoon rains, and again in October following the cessation of the rainy season. The position of the wells and their corresponding May and October water levels are shown in Figure no. 24 and 25.

Variation In The Position Of Water Table

The areal variations have been studied. The factors which might cause these variations would obviously be those which at any place, do not themselves change so readily with time, as for instance, surface relief, geological structure and hydrologic characteristics of the formation. For this study, the average May and October water table depth figures (measured from the ground surface) for the period 1951 to 1971 have been considered. (Figure no. Table no. 7)
Showing the water level depths in feet below ground level.}

It becomes obvious from the figure and table no.
that the depth of ground water below the ground level was
less than 10 feet in the line no. 1 or in the upper portion
of Baheri tahsil which is close to Himalayan area.

There are canals in Baheri, Nawabganj and Bareilly and
Faridpur tahsils. These canals are used for irrigating the
fields. So there is less pressure on existing wells where
these canal pass. In canal irrigated tracts of the area indeed,
with the continuous loss of water through surface, the water
table nearby area rises up. Hard clay pans and indurated
calcariourous layers in certain areas prevent down ward movement
of water, thereby bringing a considerable rise in under ground
water table.

It is seen from the survey of wells situated near the
canal or tanks that the water table is higher. In the month
of October the water sometimes flows out of the wells. In the
month of October it was only 1.75 feet below the surface. On
the other hand, in the wells which are more than a kilometre
away from the canals and water tanks, the water table was 5.56 feet below the surface. The remarkable rise in water table of wells around the canals was partly due to percolation of canal waters. The significance of canal in bringing up the water table nearby all the wells can be well judged from the data.

The water table in the district falls from 10 to 25 feet depth. However in Baheri and Nawabganj the range lies between 10 and 12 feet while in Bareilly tahsil it ranges between 15 to 18 feet. Figure reveals after the study of water level depth data of the district are:

1. Water level depths of less than 10 feet occur mainly in the tarai area of the district especially in the upper portion of Baheri tahsil where there are small rivers.

2. Water level depths are higher near the river or canal while it is lower in these wells which are away.

3. From north to south the water table decreases but near the river Ramganga it increases.
SOURCE

THE PROFILE SECTION HAS BEEN DRAWN BY THE WRITER ON THE BASIS OF DATA OBTAINED FROM THE IRRIGATION DEPARTMENT, BAREILLY

BAREILLY DISTRICT

SURFACE PROFILES & GENERALIZED WATER TABLE MAY 1971-72

ALTITUDE ABOVE SEA LEVEL (FEET)
Figure 26 B

Source

Basis of data contained herein is that the profile section has been drawn by the writer.

Surface Profiles & Generalized Water Table Oct

Parelli District

1971-72
These features are even more clearly brought out by Figure no. 26 A where in the east west water table profile sections and the corresponding surface profile sections have been drawn along the lines passing through the District, figure no. 26 B.

Further it is clear that factors like geological structure and hydrological characteristics of the underlying formation exhibit but little variations from one place to the other. Hence it may be inferred that these two factors would not cause significant areal variations in the portion of the water table.

As regards variation in its position with respect to time, the water table surface does not show any sign of either a progressive rise or decline during the period under consideration. In fact the general position of water table has remained unchanged during this long term period. (Figures 24 /)

This inference is in conformity with the results of another allied investigation wherein it was found that long term position of the water table surface has not affected by
factors like canal seepage, tube well pumping and other factors.

However, such influences do become apparent over short term periods as for instance, the occurrence of water table declines in heavy pumping areas in a low rainfall year or during a drought period. (Figure 25)

But the short term influences almost completely neutralize each other over a long term period and the net result is that the position of the water table remains unchanged.

Form Of Water Table

The water table is rarely a level surface. In fact, it exhibits district relief features. As shown above, the relief of the water table surface over the District is mainly influenced by the surface relief features. This fact is once again, brought out by comparison of the surface and the water table contour maps of the district Figures 3.

Thus ground water ridges underlie the drainage divides marked by the courses of the three main canals of the District and ground water valley under lie the streams of the district.
Conclusions

The variation in the position of the water table surface in the District are only of relatively minor nature and clearly reflect the influence of surface relief. Moreover, signs of either progressive rise or decline in the water table surface have not been observed.

The water table surface is mainly influenced by surface relief. Infact, the usual north to south water table gradients become apparent.

Soil is the medium of plant growth. Under normal conditions one half of pore space is occupied by water and the rest by air. There exists an inverse relation between these two. As the soil moisture increases, the air decreases and the Carbon-dioxide content of the soil increases, the oxygen content decreases. The free exchange and flow of air and water is of extreme biological significance. Restricted drainage is inimical to root growth. Rice is an exception, which has differently constructed roots with internal air passages which allow oxygen to pass down from the leaves. It harms
the soil and crop in many ways e.g., arhar (pulse) is a
tender crop and dries up in the area where the drainage is
restricted.

Poor drainage also affects the accumulation of soluble
salts, because when the water moves upward and saturate the
upper soil, the injurious salts come up to the surface. As
evaporation proceeds these salts remain in the surface and
make the soil saline. It has been found on inquiry that
many hectares of lands, in tahsil Baheri and Nawabganj
have become saline, and in course of time converted into
reh soil because of the continuance of salinization and
alkalinization processes. This is more conspicuous in the
north part of tahsil Baheri and north east part of Nawabganj
where the water table becomes up high and about near the
surface during the rainy season.

It is quite true to say that rising subsoil water table
does have in impact. On the general characteristics of soils,
and its fertility. The productivity and productivity functions
of the soil have been studied in the area under study in
relation to sub soil water table in the area, where a large
part of the productive land has been turned into saline and
or alkaline land.

The slope of the area is from North to South, and west
to east as shown in Figure no. 3. The low lying areas
of the area remains water logged during rainy season. As it
is obvious from the Figure no. 3 that the slope is quite
nominal and is oriented to-wards south.

The ground water table in the area under study rises
during the rainy season. It has created some problems to
agriculture and public health. The land of Baheri and
Nawabganj tahsils, has been effected since the water table
is just below the land surface during the rainy season
(Table no. 7).
<table>
<thead>
<tr>
<th>Name of the water bodies</th>
<th>Number given on the village map</th>
<th>Height above scale level in feet</th>
<th>Depth of water in the well below natural surface in feet</th>
<th>May</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kichha Nadi</td>
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CHAPTER IV
GENERAL LAND USE

Bareilly district is an area where about 90 per cent of the total population is directly or indirectly engaged in agricultural pursuits and depends entirely for its livelihood upon agriculture. Agriculture is an old occupation of the people who have now taken it as a tradition and way of life. An attempt has, therefore, been made to study the agricultural land use patterns of the whole region on the basis of tahsil statistics of general land use as well as the land use of the different cropping seasons during the year 1971-72. The significance of agriculture in the district is important by the fact that about 79 per cent of the total area is directly under cultivation and 3.37 per cent is under groves, forest, pastures, and culturable waste which may be brought under cultivation if the facilities are available. Thus about 87.12 per cent of the total area is culturable of the remaining area, approximately 3.21 per cent is waste land and 9.55 per cent is under nonagricultural uses, e.g. as settlement roads, railways, ponds, river channels and
A very small percentage of the area under non-agricultural uses is covered with reh.

There are two main agricultural seasons in the region i.e., the kharif or the season of summer crops and the rabi, the season of winter crops. The sowing of kharif crops commences generally with the onset of the monsoon rains in the third week of June. The crops grown in this season are rice (broadcast and transplanted), sugarcane, maize, small millets (Single or mixed with pulses and arhar (Cajanus indicus). All these crops except sugarcane are not irrigated and depend for their growth entirely on monsoon rains.

The rabi crops are usually sown in the second week of October and harvested in March or April. The principal crops of this season are wheat, wheat mixed with barley, barley gram, peas and lentil. All these crops need irrigation except in those parts where the soil is highly retentive of moisture.

It will be clear from the table No. 8 that cultivated land in the district is 78.25 percent which can be increased
if the culturable waste is brought under plough. The waste land can be reclaimed which will increase the acreage of cultivated land. It will, thus increase per capita land and yield.

In tahsil Baheri, the cultivated land is 76806 hectares or 81.06 per cent. This tahsil lies in Tarai area. Here it is well drained plain. There are several rivers and small rivelets here and irrigation facilities are available. Cultivated land can be increased by reclaiming the waste land and culturable waste i.e. 7.41 per cent. In the tahsil Bareilly, 73.37 per cent of the total area is cultivated, the land not available for cultivation is 9.71 per cent which can be easily cultivated. The soil is clayey and it is upland area. The area under forest is only 0.1 per cent. The other uncultivated land in this tahsil is about 18473 hectares or 14.83 per cent, under this area the land can be also utilized under cultivation which will increase the yield of the tahsil. There is a close relationship between quality of land and the size of fields. The fields of the good
quality land are mostly small in size while fields of the medium quality land are relatively large. If we reorganise the field boundaries there is enough scope for the increase of cultivated acreage. The rainfall in the kharif season is well distributed and is sufficient for the growth of kharif crop. There are enough facilities for irrigation in this tahsil and there is also great scope for the extension of irrigation. Irrigation is needed in rabi season because there is not sufficient rainfall for the growth of rabi crops. In case the area is brought under irrigation, the yield is likely to go up in all the tahsils of the district.

In Nawabganj tahsil, the cultivated land is 81.65 per cent. This area under cultivation can be increased by addition 8.17 per cent of land which can easily be cultivated, if water facilities are available. The land under groves can be increased which is only 1.39 per cent. In case the area under groves is increased in this tahsil, it will beneficial because more wood might be available for fuel to the villagers which could cover the loss caused as a result of cow dung being used for
fuel. Thus more cowdung could be made available for manure.

The utilization of the waste land for growing trees for fuel can also be considered. Dhak and babul trees survive well in the useless lands and grow easily. Another tree which can be propagated usefully is casurina which matures quickly, reaching a height of 15 feet in three or four years. It yields excellent fire wood and according to some authorities, helps in the fixation of nitrogen in the soils.

The daily production of fresh cowdung per adult cow and buffalo has been estimated by Burns at 40 and 50 maund respectively. If the dung together with cattle shed sweepings is preserved carefully it may prove adequate to replenish the annual loss in the fertility of the cultivated land in the village.

In tahsil Anila, the cultivated land is 78.18 per cent. There is enough scope for cultivating the culturable land amounting to about 10.46 per cent of the total land.

1. Burns, W., Technological Possibilities of Agricultural Department in India (Allahabad, 1944) pp. 116 Statement IV.
This culturable land includes permanent pasture, groves, forest and other miscellaneous trees. The area can easily be brought under cultivation if irrigation facilities are available. The area under forest is very small. In the tahsil, irrigation by tube well is available and area of 1418 hectares is irrigated by Government tube wells. There is enough scope for the increase of tube wells. So that more land can be cultivated and total production of the tahsil as well as of the district can be stepped up.

In Faridpur tahsil, the cultivated land is 50985 hectares or 79.78 per cent of the total area of the tahsil. The land not available for agricultural purposes is 11.58 per cent. The waste land which has been included under this category can be reclaimed by the method discussed in the chapter on soil. The other uncultivated land is 5511 hectares or 8.62 per cent of the total area in the tahsil.

In the light of the earlier discussion, it is clear that there is enough scope for increase in the cultivated land. In the opinion of the writer the cultivated land can
be increased by reclaiming the waste land and extending the irrigation facilities in such areas.

**TABLE NO. 8**

<table>
<thead>
<tr>
<th>Total area of the District</th>
<th>... 407450 hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use of land</strong></td>
<td><strong>Area in hectares</strong></td>
</tr>
<tr>
<td>Cultivated land</td>
<td>319021</td>
</tr>
<tr>
<td>Forest</td>
<td>553</td>
</tr>
<tr>
<td>Land not available for cultivation</td>
<td></td>
</tr>
<tr>
<td>(a) Under water</td>
<td>15527</td>
</tr>
<tr>
<td>(b) Settlement</td>
<td>21764</td>
</tr>
<tr>
<td>(c) Cemetery</td>
<td>852</td>
</tr>
<tr>
<td>(d) Reh</td>
<td>696</td>
</tr>
<tr>
<td>(e) Other uncultivated land</td>
<td>13069</td>
</tr>
<tr>
<td>Culturable land</td>
<td></td>
</tr>
<tr>
<td>(a) Groves</td>
<td>5054</td>
</tr>
<tr>
<td>(b) Pastures</td>
<td>624</td>
</tr>
<tr>
<td>(c) Culturable waste</td>
<td>7654</td>
</tr>
<tr>
<td>(d) Old fallow</td>
<td>896</td>
</tr>
<tr>
<td>(e) Current fallow</td>
<td>11960</td>
</tr>
<tr>
<td>(f) Pandra</td>
<td>9840</td>
</tr>
</tbody>
</table>

| Total                    | 407450               | 100.00 |

It is obvious from table no. 8 that about 87.26 per
sent of the total area of the district is suitable for cultivation but as 78.29 per cent is under cultivation at the present moment. Culturable land can be brought under plough provided that some more irrigational facilities are made available to the district.

Out of the net cropped area of 319021 hectares, about 10381 or (25.49 per cent) are double cropped lands which yield two crops during the year. This category of land can be increased if the area is provided with more irrigation.

It is desirable to study the characteristic features of the present land use pattern in the five tahils of Bareilly district. The details of the existing landuse at the tahsil level have been depicted in table no. VIII (6) under different categories of land use. It will be seen from this table no. VIII that the cultivated land in these tahils ranges from 73.37 per cent to 81.65 per cent. Although in each tahsil the percentage of cultivated land is appreciably high, nevertheless in each case some amount of cultivable land lies unproductive because of the presence of a high proportion of injurious salts at or near the
surface or owing to poor sandy soil. The percentage of unproductive land is, however, greater in the ill-drained clayey soil and submontane tract. In the ill-drained clayey tract the main course of their occurrence is water-loggings, while in the submontane tract the presence of shrubs and soil erosion render the land unproductive. In order to fulfil the food requirements of the increasing population the cultivators have already pushed the limits of cultivation.

The table further reveals that in each tahsil a substantial acreage of arable land is left fallow in either of the seasons.

<table>
<thead>
<tr>
<th>Tahsil</th>
<th>Total Culti</th>
<th>Unculti</th>
<th>Cultu Fallow</th>
<th>Fallow in land in cropped</th>
<th>Double of the land</th>
<th>Cultivat</th>
<th>double area per</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>area</td>
<td>vated</td>
<td>vated land</td>
<td>land in land in cropped</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aounla</td>
<td>81940</td>
<td>70.18</td>
<td>11.35</td>
<td>10.48</td>
<td>23.89</td>
<td>36.55</td>
<td>18.29</td>
</tr>
<tr>
<td>Bareilly</td>
<td>109711</td>
<td>73.37</td>
<td>16.93</td>
<td>9.71</td>
<td>17.42</td>
<td>30.49</td>
<td>26.04</td>
</tr>
<tr>
<td>Faridpur</td>
<td>63002</td>
<td>79.78</td>
<td>11.88</td>
<td>8.62</td>
<td>29.36</td>
<td>34.98</td>
<td>15.40</td>
</tr>
<tr>
<td>Nawabganj</td>
<td>57152</td>
<td>81.45</td>
<td>10.16</td>
<td>8.17</td>
<td>13.95</td>
<td>36.45</td>
<td>31.13</td>
</tr>
</tbody>
</table>
The practice of fallowing in the kharif season is practiced in the area under study to regain fertility on account of rain water, light and air to which the fields are exposed. The practice of raising some early maturing legumes and green manure crops from these lands is more useful as this practice would enrich the soil and protect from erosion. The fallow land ranges in the kharif season between 11.52 per cent to 29.36 per cent. This area can be reduced by growing leguminous crops. (Table No. VIII)

In rabi season the area of fallow land ranges between 30.49 per cent to 36.65 per cent which can also be reduced if new varieties of crops are cultivated.

It is remarkable to analyze that in this district double cropping is a common feature of land use. The percentage of double crop varies from 15.49 per cent to
Agriculture in each village is mostly practised on a family basis and can be said to be intensive subsistence type, based on the cultivation of high yielding varieties as far as possible within the limits of geographical environment and socio-economic conditions of the cultivators. It therefore, appears that a combination of improved practices of cultivation will significantly increase the per hectare yield of the crops. More and better irrigational manure and implements, none of these by itself will be more than slightly effective, but each combined will yield high returns.
TABLE NO. 10 A

The total area occupied by different crops and their percentages to the net area sown and total cultivated land of the district have been shown in Table No. 10A.

Gross cultivated land in **District Bareilly** - 319021 hectares

Net cropped area in the kharif season - 212672 hectares

<table>
<thead>
<tr>
<th>Crops</th>
<th>Area in hectares</th>
<th>Percentage of gross cultivated land</th>
<th>Percentage of net cultivated land</th>
<th>Total % of Total net cultivated land</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BRAIN CROPS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birmillet</td>
<td>15 5609 5624</td>
<td>1.76</td>
<td>2.31</td>
<td>47.56</td>
</tr>
<tr>
<td>Bulrush millet</td>
<td>9 9231 9240</td>
<td>2.90</td>
<td>3.80</td>
<td></td>
</tr>
<tr>
<td>Birmillet pigeon pea</td>
<td>14 17136 17150</td>
<td>5.37</td>
<td>7.06</td>
<td></td>
</tr>
<tr>
<td>Bulrush millet &amp; pigeon pea</td>
<td>22 11811 11833</td>
<td>3.71</td>
<td>4.77</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>45575 41043 86623</td>
<td>27.16</td>
<td>36.18</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>116 13479 17535</td>
<td>5.51</td>
<td>7.24</td>
<td></td>
</tr>
<tr>
<td>Small millets</td>
<td>3 1614 1617</td>
<td>0.50</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>3 903 903</td>
<td>0.23</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Urd</td>
<td>1 1105 1105</td>
<td>0.34</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Moong</td>
<td>55 55</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Other pulses</td>
<td>54 54</td>
<td>0.01</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td><strong>OTHER CROPS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td>21177 19666 40843</td>
<td>12.30</td>
<td>16.82</td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>27 255 282</td>
<td>0.08</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>326 633 1519</td>
<td>0.47</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Other food material</td>
<td>11 26 37</td>
<td>0.01</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Jute</td>
<td>1 5 6</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Sandal</td>
<td>10 566 576</td>
<td>0.18</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Sun</td>
<td>57 57</td>
<td>0.01</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1</td>
<td>Fig</td>
<td>11</td>
<td>11</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>Groundnut</td>
<td>280</td>
<td>2028</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>Chillies</td>
<td>250</td>
<td>330</td>
<td>1.1</td>
</tr>
<tr>
<td>4</td>
<td>Other spices</td>
<td>350</td>
<td>210</td>
<td>2.0</td>
</tr>
<tr>
<td>5</td>
<td>Fodder</td>
<td>1.5</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>6</td>
<td>Other food</td>
<td>45</td>
<td>5.3</td>
<td>0.0</td>
</tr>
<tr>
<td>7</td>
<td>Material</td>
<td>76949</td>
<td>23.0</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>Fallow</td>
<td>76949</td>
<td>23.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Grand total: 76949

Total plan: 26.3
LAND UTILIZATION IN THE KHARIF SEASON

The table no. 10 A depicts the total area occupied by different crops and their percentages to the net area sown. The importance of kharif season in the agricultural cycle of the district can hardly be over-emphasized, for about 47.86 per cent of the gross cultivated land is in this season.

The spatial distribution of kharif crops may be appreciated by the percentages of different crops to the total cultivated land in each tahsil. It will be seen from the table no. IX that cereals hold the most important place in the kharif crops. Grain crops occupy about 62.78 per cent of the net cropped land where as the remaining 37.02 is covered by other crops including sugarcane, fodder, vegetable and oil seeds. Of the grain crops, the principal crops in order of importance are rice (broadcast) and transplanted, big millets mixed with akhar, maize, pulses and small millets. Of the kharif pulses including akhar (pigeon pea), and moong, akhar is by far the most important crop. It will be
desirable to describe the physical condition and methods of farming under which the principal *kharif* crops are grown, so that the distributional patterns of these crops can easily be analysed. Rice broadcast and transplanted taken together is by far the most important cereal of the *kharif* season. It occupies 86625 hectares or 36.18 per cent of the net cultivated land in season. It is needless to emphasize that rice is the main staple food for the major population of the district. Rice supplies the bulk of the protein and fat amongst its different food constituents. The use of rice as human food is perhaps the easiest as it is generally eaten after being boiled. The straw of rice plant is used as fodder for cattle which is rather poor from the view point of nutrition. Of the two principal varieties of rice, the broadcast rice covers 45005 hectares of land or 19.04 per cent of the net cropped land in the district. This variety is locally known as bhadoi or kunwari, named after the Hindi months i.e., Bhadon or Kunwar in which it is harvested.
The best lands for the cultivation of broadcast rice are those which consist of clayey loam soils. Rice predominates in Nawabganj, Baheri, and Bareilly tahsils where soil is clayey or clayey loam. This rice broadcast is generally sown on the best quality lands which grows two crops a year and as such two varieties of rice are followed by remunerative crops like wheat, barley, peas and gram in the rabi season.

To secure against the pulsatory nature of rainfall, broadcast is often sown in combination with such crops as kodon (Paspalum scrobiculatum) and arhar (Cajanus indicus) which may resist against the variations in time and incidence of rainfall. In case the required amount of rainfall for rice does not occur or the rainfall is late or the gap between the rainy days is prolonged, rice crops is liable to damage while kodon or arhar may be harvested. There is a close relationship between the cultivation of rice and the type of soil and the amount of rainfall. Its cultivat predominates northern part of the district in tahsil Baheri,
and Nawabganj where the rainfall is high and soil is heavy.

But on the other hand, its intensity diminishes in the southern parts where the amounts of rainfall is relatively low and the soil becomes lighter.

The transplanted rice covering an area of 41618 hectares or nearly 17.14 per cent of the net kharif crops is the second most important cereal area. Transplanted rice is a late maturing variety which is sown in late July and harvested in late November and early December. Early planting of the seedlings is, however conducive to higher yield of late maturing rice crop. Clayey soil which is found in natural shallow depression in the northern part of the tarai region is best suited to the cultivation of late maturing rice. Since this variety of rice needs almost stagnant water in the fields till the end of September, the fields are surrounded by small earthen embankments (meinds). Clayey soil by virtue of its cementing characteristics assist much on making these small meinds permanent. Moreover this soil has a high water retaining capacity on its surface.

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The area and intensity of the transplanted rice, is therefore, highest in those tahsils where clayey soil predominates. That the highest percentage of this variety of rice occurs in *tarai* tahsils Baheri and northern part of Nawabganj. These places have more than 20 per cent of their total cultivated land under transplanted rice. The lowest percentage is in Faridpur tahsil where the soil is sandy.

The yield of the late maturing rice is very much decided by the climo-edaphic factors. In the *tarai* parts where the rainfall is highest and the clayey soil dominates, the per acre yield is as high as 450 kg., but it decreases in the southern portions. The yield of transplanted rice is in each case higher than that of early maturing variety. The yield of transplanted rice may be enhanced substantially by the Japanese method of cultivation which is gaining importance during the current years. Japanese method includes improved cultural practices with proper manuring and crop protection measures. The salient features of this method are the selection of good and healthy seeds for sowing in the nursery, preparation of well pulverised and raised seed
beds, application of adequate organic and inorganic fertilizers

to the nursery and the rice plots, weeding of nursery beds,
careful up-rooting of the seedling, frequent interculturing
of crops for nitrogen fixation and preventing the crops
against the spread of various pest and diseases. The per acre
yield by Japanese method may be increased by about 50 per
cent. It has been observed that the transplanted rice is
harvested from the same field for years in succession without
any crop rotation. This leads to a deterioration in the level
of fertility and deficiency of nitrogen in the soil of the
rice fields is not uncommon. It is more important in rice
cultivation to preserve and to recuperate the fertility of
the rice fields. If, however, the rice fields are covered
with leguminous crops like lentil in the following *rabi*
season, nitrogen deficiency may to a large extent be made up.

3 Singh, A. C., & Singh, B. Japanese Agricultural Demonstration
Farm, show the way to Higher yield *in Paddy, Indian Farming* vol. XVIII,
No. 7 (New Delhi, 1968) pp. 11-15
Maize ( Zea mays )

Maize, known as the Indian Corn, is one of the main staple food crops of the people. Due to its early maturity, maize becomes important among the kharif crops. Green crops of maize generally become ready for use within a short period of 10 weeks. It supplies food to the farmers when the reserves of rabi grain are exhausting. Maize ripens in the month of September, the green cobs are ready for use about one month earlier. In the absence of adequate supply of food, green cobs are roasted for use as a supplement food.

Maize requires well drained loamy soil. It requires adequate amounts of moisture. A continuous supply of rainfall with a short gap of three to four days encourages its cultivation. A long break in the rainfall or excessive rainfall is much injurious for the crop. Water logging and floods are equally harmful because the crop of maize may not withstand excessive water. Loamy or sandy loam soil is well suited to this crop. It is never sown in lowlying areas where water remains stagnant. Soils having an adequate amount of nitrogen
compost gives a better yield of maize. It has been found at the Agricultural Research Institute, Pusa that about 15 kilograms of nitrogen per acre in the form of rapeseed cakes was most suitable manure for its better yield which was even superior to 8000 of farmyard manure per acre. A mixed crop of maize with leguminous crop: like urd and moong will perhaps serve the same purpose. A crop rotation of maize with lentil (a rabi pulse), may also give a better yield of maize on the same field on which other rotations are practised because lentil supplies adequate amount of nitrogen to the soil.

The cultivation of maize is controlled by the climosedaphic factors. It will be seen from the table no. 10A that maize covers an area 17595 hectares or 7.24 per cent of net cropped area of kharif season. The area under maize decreases from north to south and east to west according to the decreasing amount of rainfall and richer quality of soil.

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It has gained much importance in the recent years because of its improved varieties which have been introduced by the Pant Nagar University and other agricultural institutes. In most of the irrigated areas and in the loamy soil two crops of maize are now harvested by sowing in the month of February and harvesting in the month of May, and then again sowing the second crop in the month of June and harvesting in the month of September. In such land where these two crops of maize are taken, one crop of potato is also taken. Improved varieties of maize e.g. ganga type I, II jhawar kishan, yield just the double of desi type. These yield better type of maize than desi.

Small Millets

Mixed cropping of small millets with pulses is a common practice in the district. It covers an area of 1617 hectares or about 0.66 per cent of the kharif crops. Small millets mixed with pulses constitute the second important grain crop after rice. Small millets include locally known species of
**savan** (Paniceum frumentaceum), **koden** (Paspalum serobiculatum) and **mandua** or **kakun** the greater area being devoted to **savan**. Pulses include **arhar**, **urd** and **moong** but **arhar** occupies a greater area in combination with small millets. All these crops thrive best with scanty rainfall lighter soils. Mixed cropping of **small millets** with pulses is practiced in the region owing to the difference in their harvesting periods and for the maintenance of the soil fertility. The crop of the small millets matures early and becomes ready for harvesting within three months. It supplies food to the farmers at the crucial stage when their store of **ragi** grains is almost exhausting. **Arhar** (Pigeon pea) on the other hand, matures very late and takes about 9 to 10 months for its harvest. The seed of small millet and **arhar** is broadcast soon after the rain breaks at the rate of 6 to 8 kilogrammes per hectare. The crop of small millet is harvested in the last week of August or first week of September. Mixed cropping of small millets with pulses help in nitrogen fixation of the soil and in maintaining the soil fertility. These crops
may flourish on a variety of soils but light loamy soil seems
to be best suited for their cultivation. They suffer
severely in the higher rainfall or by the accumulation of
water in their roots. This is perhaps one of the important
reasons that these are sown in the areas of low rainfall
and on higher level ground. The maximum acreage under these
crops occurs in Faridpur and Aonla. These two tahsils show
the evidence of comparatively low rainfall and light loamy
soil of bhangar. The percentage of mixed crops of small
millets and arhar in these tahsils ranges between 9 and 16.
It has been discovered by the Maize Research Institute
Chindwara (M.P.) that the application of about 5 kilogramme
nitrogen per acre gives better yield of *kodon* 5. Liberal use
of nitrogen however, will give an increased amount of yield
of small millet. The main aim behind the sowing of the small
millets in combination with the pulses is that the latter
supplies good deal of nitrogen to the soil which in turn helps
in the better harvest of small millets.

5 Madholia, J.K., & Tivari, P.K., Kodon responds to nitrogen, Indian Farming
Among the kharif pulses, the most important are arhar, urd and moong which together occupy about 0.84 per cent of the net cropped land in this season. The pulses are soil building crops and supply with adequate nitrogen to the soil and thus they are usually sown in combination with those crops which require high amount of nitrogen. These are usually sown as mixed crop with broadcast rice, small millets, sugarcane and maize. Its combination with sugarcane is limited since both of them are exhaustive crops and effect the soil adversely on account of extraction of moisture and soil minerals. It may be grown in any type of soil but lighter soils seem best suited to its cultivation in which its long roots easily penetrate and develop freely. In deficient rainfall it survives well here as excessive rainfall and waterlogging retard its growth very much. It is most sensitive to frost and a succession of frost for days may completely destroy the crop. During the period of its growth it requires moist and warm weather with high relative humidity.
but during the flowering and reining period, it needs cool
dry and light sunny weather. Cloudy weather during its
flowering period encourages several plant pest and
diseases which may nip the crop in the bud.

The pods of whether green or dry are commonly used
for preparation of dal. The outer husk of the grain as well
as pods are used as a nutritive food for milching animals.

Variations in the per acre yield of **arhar** in the region
are mainly to climo-edaphic factors. Its per acre yield
ranges between 200 kg. in heavy, illdrained and very damp
soil to 350 kg. in the **bhanger** areas having well drained,
highlya aarated and light soils. There is close relationship
between climate and soil for the cultivation of **arhar** in
the district. It is mostly grown in loamy or sandy loam soils
where the rainfall is comparatively low. Other pulses like
**urad** and **moong** which are leguminous crops, occupy collect-
ively an area of 1160 hectares or 0.47 per cent of the net
**kharif** crops. All these pulses are sown in June and harvested
in September. These pulses again require low amount of
rainfall and lighter soils. Their, per hectare yield varies from 250 kg. to 450 kg. This variation is due to the difference in the suitability of soil and field preparation. The yield is higher on the well-drained fertile loamy soils. Water logging and excessive rainfall during the sowing period destroy seeds and the crop is destroyed at the initial stage of its growth. At present the area under these soil building crops is very limited in the district but an extension of these crops is essential to increase the fertility of the soil as these crops help in nitrogen fixation of the soil.

Sugarcane

Sugarcane is the most important cash crop of the area under study which supplies the bulk of the cash to the farmers with which they fulfil their agricultural and non-agricultural needs.

Their social needs, and other amenities of life like clothes and medicine are met with cash received from sugarcane.
Sugar cane cultivation is also encouraged by the sugar mills. There are several crushers in the district and two sugar mills. More money is fetched than the grain crops. Above all, the same field producing grain crops, supplies about thrice the amount of cost if it is covered by a crop of sugarcane.

Keeping in view the heavy cost of production, strenuous field preparations often discourage the sugarcane cultivators but the handsome profit encourages them to cultivate. Sugar cane is grown in those areas where climo-edaphic factors are congenial to its cultivation.

It is a tropical plant and requires high temperature ranging between 25°C to 27°C during its germination and growth but at the time of maturity it needs only about 20°C. This is not the limiting factor, as a number of new varieties have been developed by Pant Nagar University to be adjusted in different temperature conditions. For cane cultivation an area should have an average monthly temperature above 20°C for about four to six months. Along with high temperature

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conditions, adequate water supply is indispensable for its
growth. Rainfall is abundant in the area and about 90 per
cent of the total rainfall is received in the wet monsoon
months, e.g., June to October, when sugarcane requires it
most.

In the district paddy (Ratoon cropping) is left for a
some of
second crop, in the coming season others/the farmers save
expenditure on account of purchase of sugarcane cuttings,
but they have to spend on manures because soil fertility
has diminished appreciably. It may not be very fruitful if
the soil is not heavily manured and fields are not thoroughly
prepared. In almost all types of soils, sugarcane is irrigated.
It is irrigated in the months of April & May when there is
little soil moisture in the top layer of the soil. Sugarcane
is quite adaptable to varying soil groups in the area.

Sugarcane is very useful because every part of the cane
plants is utilized in one way or the other. The juice is
extracted from sugarcane by a press (locally known as kahlon)
or by crushers and is used for preparing raw sugar ('gur') or
sugar, sugar gaggery and thick syrup (rah). The molasses are used for poultry and live-stock feeding and may be fermented and converted into alcohol. The bagasses are used as fuel or may be converted into compost. The tender green leafy part of the plant is used as a nutritive fodder for milching animals.

Sugarcane covers an area of 40843 hectares or 16.82 per cent of the net cropped land. It is concentrated in loamy soils.

Sugarcane is not, however, the first ranking crop in any of the tahsil because rice and wheat constitute the bulk of the crop. It is a second ranking crop in Baheri tahsil while in Bareilly, its rank is third.

Yield of the sugarcane differs. It may be easily increased with the liberal application of oil cakes, green manuring like sanai and nitrogenous fertilizers to the lands. Molasses as fertilizers are highly beneficial for higher yield on the light soils like 'deh' soil of tarai. The artificial manure potash and lime applied to the loamy and clayey loams can give a better yield of sugarcane.

7 Pendi - This is the local name of the left part of the sugarcane plants after the crop has been harvested. It then gives new off shoots which become sugarcane plants in due course of time.
Other Crops

Fodder, vegetables, oil seeds are other minor crops. Fodder is the most important in this category of crops which covers 26690 hectares or 10.99 per cent of net cropped land in the *kharif* season. It is followed by vegetables with 1519 hectares or 0.25 per cent, oil seeds with 0.47 per cent other fruits 0.11 per cent of the net *kharif* crops. It is surprising that through a large percentage of the population in this area is vegetarian, yet the area under vegetables is too small to meet the local requirements.

The area under fodder is also very small in view of the huge population of live-stock. The byproducts of the grain crops and sugarcane are used for the feeding of the cattle and provide substitute for fodder.

Fallowing

The lands are left fallow in the *kharif* season with a view to region fertility for the crops to be grown in the *rabi* season. It will be seen from table No. IX that 76349

$\text{The fact that the population is vegetarian only means that they do not eat meat ordinarily, their diet consists of rice, wheat, pulses and vegetables.}$
hectares or 20.78 per cent of the total cultivated land is left fallow in the season. This is mostly used for the cultivation of wheat, wheat mixed with barley and peas. All these crops require high degree of fertility of soil and may not give a better yield if sown in the same field from which kharif crop is harvested.

Fallowing in the kharif season is less practiced in those parts of the district where clayey loam soil predominates and are exclusively meant for rice cultivation.

Land Utilization In Rabi Season

Table No. 10B reveals that only 56.1 per cent of the total cultivated land is devoted to the rabi crops and about 13.9 per cent is covered with continual kharif crops. The remaining area is left fallow owing to the lower fertility of the soil. The lands under rabi fallow, which is 30.00 per cent, include all those fields which have produced a

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9 Table No. 10B has been computed by writer on the basis of data collected from the district headquarter, 1971-72.

10 Continual kharif crops include sugarcane and pulses like arhar (pigeon-pea) which are sown with the rabi crops.
The area along with percentages occupied by each crop is given table no. 10 B during 1971-72.

Gross cultivated land in Bareilly district...
Net cropped land in rabi season...

<table>
<thead>
<tr>
<th>Crops</th>
<th>Area in hectares</th>
<th>Percentage of gross cultivated land</th>
<th>Percentage of net cropped land</th>
<th>Total percentage of gross cultivated land</th>
<th>Total percentage of net cropped land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>irrigated</td>
<td>unirrigated</td>
<td>total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRAIN CROPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>75181</td>
<td>37361</td>
<td>112542</td>
<td>35.26</td>
<td>62.86</td>
</tr>
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<td>Wheat Gram</td>
<td>6630</td>
<td>15986</td>
<td>22616</td>
<td>7.09</td>
<td>12.68</td>
</tr>
<tr>
<td>Wheat mixed with barley</td>
<td>39</td>
<td>229</td>
<td>259</td>
<td>0.08</td>
<td>0.14</td>
</tr>
<tr>
<td>Barley</td>
<td>230</td>
<td>1481</td>
<td>1761</td>
<td>0.55</td>
<td>0.98</td>
</tr>
<tr>
<td>Wheat mixed with peas or gram</td>
<td>145</td>
<td>535</td>
<td>680</td>
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</tr>
<tr>
<td>Gram</td>
<td>810</td>
<td>12656</td>
<td>13566</td>
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<td>Pea</td>
<td>2327</td>
<td>4383</td>
<td>6710</td>
<td>2.10</td>
<td>3.80</td>
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<tr>
<td>Lentil</td>
<td>226</td>
<td>8876</td>
<td>9102</td>
<td>2.85</td>
<td>5.87</td>
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<td>OTHERS CROPS</td>
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<td></td>
</tr>
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<td>Fruit mango</td>
<td>24</td>
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<td>1521</td>
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<td>0.80</td>
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<tr>
<td>Potato</td>
<td>2061</td>
<td>131</td>
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<td>Onion</td>
<td>214</td>
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<td>223</td>
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<td>664</td>
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<td>0.37</td>
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<td>Other food</td>
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<td>15</td>
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<tr>
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<td>3242</td>
<td>1.01</td>
<td>1.81</td>
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<td></td>
<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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<td>----</td>
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<td>------</td>
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<td>Tobacco</td>
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<td>145</td>
<td>1182</td>
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<td>0.24</td>
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<td>1463</td>
<td>2243</td>
<td>0.70</td>
<td>1.25</td>
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<td>Berseem</td>
<td>60</td>
<td>42</td>
<td>102</td>
<td>0.03</td>
<td>0.04</td>
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<td>FALLOW</td>
<td></td>
<td></td>
<td>98252</td>
<td>32.07</td>
<td>32.07</td>
</tr>
<tr>
<td>CONTINUAL KHARIF CROP</td>
<td></td>
<td></td>
<td>41746</td>
<td>13.90</td>
<td>13.90</td>
</tr>
<tr>
<td>Grand Total</td>
<td>91297</td>
<td>87726</td>
<td>179023</td>
<td>56.12</td>
<td>100.00</td>
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</tbody>
</table>
kharif crop and are not capable to produce a second crop in
the following rabi season.

Out of the net area sown in the rabi season, 92.19 per -
cent is devoted to cereals, nearly 17.25 per cent to the
rabi pulses including peas, gram and lentil and about 6.70
per cent is covered by other crops like oilseeds, vegetables,
spices and fodder. The principal cereals of this season are
wheat, wheat mixed with barley, barley, barley mixed with
gram and wheat mixed with gram.

Wheat (Triticum aestivum)

Wheat is the most important rabi crop of the district
and occupies an area of 112542 hectares or about 62.86
per cent of the net cropped area in the season. It is the
next important cereal of the region after rice and occupies
35.25 per cent of the total cultivated land. Wheat is used
for the preparation of bread after being converted into
flour. The crop is sown in the month of October, and takes
about 5 months to mature and as such it is harvested in
March or early April. Wheat requires atleast two watering
after its germination but in case the soil is retentive of
moisture. It will need only one watering. Two fifths of the
total acreage under wheat is produced in the area having
irrigation facilities. Wheat area is irrigated by ponds,
and non-masonry wells, canal and tube wells. Threshing is
done with the help of cattle and winnowing is completed by
dropping the trampled grain from a height of about 6 to 7
feet and the chaff is than separated from the grain.

Wheat occupies usually the best going lands of the
district and is grown on those fields which have remained
fallow in the preceding kharif season. In some cases, it
is sown on the fields which were occupied in the preceding
kharif season by broadcast rice, maize or small millets.
As the wheat cultivation requires thorough field
preparations, the fields are ploughed several times, weeds
are removed and several harrowing is given. In case wheat
occupies the fallow lands of the preceding kharif season,
a good preparation of the field becomes possible. During
the wet monsoon months the fields are frequently ploughed
and harrowed and good seed beds are prepared, but, if the
fields are occupied during the kharif season the time for
preparation of the fields is limited as the time interval
between the kharif harvest and the rabi sowing is very
small. In this case, the average yield per acre (per hectare)
decrease to an appreciable extent. The method of sowing the
seed is easy because it is either broadcast or sown in
deep furrows made by ploughs. In each case the seed is
covered under a thin sheet of soil by the method of harrowing.

Winter rainfall, if it occurs during the flowering period
of wheat, is much conducive to higher yield. Frost may
adversely affect the crop but a minor frost which occurs
in the region seldom damages the wheat crop. During the
ripening period of wheat, bright sun-shine and high
temperature are very conducive.

Wheat is generally grown on the loamy and silty loam
soils of the region. The dominance of wheat in the rabi
season specially in the loamy soil or silty loam soils of
the khadar is a marked feature of the agriculture of the
region.
The average yield of wheat varies in the district from place to place due to variation in the soil characteristics, irrigation facilities and field preparation.

About one fourth of the area under wheat is covered by the improved variety of wheat which matures in a short time & gives a high yield. The extension of improved variety of wheat seems desirable in the area.

The per acre yield ranges between 275 kilograms per acre in silty loamy soil to more than 400 kilograms in loamy soils. The yield of the new varieties which have been imported from abroad and their seeds developed in India (especially at Pant Nagar University) give a better yield some times twice as much as the production of old varieties.

The new varieties of wheat with high yield need several waterings and appreciable quantity of artificial fertilizers per acre, which a poor farmer of the area can not afford. Hence a good many farmers do not like to introduce new varieties in the district.
Wheat and Barley (mixed): (Triticum sativum & Hordeum vulgare)

The mixed crop of the wheat and barley, locally known as goiśi, covers 259 hectares of land or about 0.14 per cent of the net sown area in the rabi season. The climatic conditions required for its growth are similar to those of wheat except that barley plant may withstand frosty conditions and severe cold where as wheat may not. The crop grows at a temperature of 16 C. during its growth and 25 C. during its maturity. Since the rainfall during the month of November and December amounts to almost negligible, this crop is generally not liable to the destroyed.

The method of sowing and cultivation of goiśi is similar to that of wheat. It is sown on the medium quality lands which are manured with organic as well as inorganic fertilisers. The fields are given several ploughing and harrowing so that a very good seed bed may be prepared and proper tilth of the soil be maintained. The seed is either broadcast in the field or it is sown by furrows method.

Per hectare yield of goiśi again varies from one place
to the other depending upon the climo-edaphic factors. On the loamy and sandy soils, the yield is comparatively higher than the clayey or clayey loam soils only because the good preparations of the fields are possible in the loamy and sandy soil where as in the clayey soils there is natural hinderance. The average yield per hectare ranges between 300 kilogramme and 350 kilogramme. It may be observed from Figure no. 30 that the highest concentration of this crop is found in those portions where the lighter soil prevails.

Barley mixed with Gram: (Hordeum vulgare & Cicer arietinum)

The practice of mixed cropping in this season is again against an insurance the uncertainties of the climo-edaphic factors. One of the most common combinations of grain crops in the rabi season is barley and gram which together occupies 680 hectares or 0.37 per cent of the net cropped land. The general climatic requirements of this crop is almost similar

11 A combination of different rabi grains are known as haihar. The most prevalent combination in the region is barley and gram or peas and barley. This combination may vary from one place to other according to the suitability of the soil.
to that of barley. The crop, however, grows well in the khadar areas. Loamy soils give a better yield of this crop seen in the month of October, the crop becomes ready for harvest by the last week of March.

Raihar flourishes well in different soil groups as it is evident from its distribution. The percentage of the total cultivated area is however, small.

Peas (Pisum sativum)

Peas constitutes as one of the most important rabi pulses, of the region and occupy 6710 hectares of land or about 3.86 per cent of the net cropped land. Peas holds fourth position among the different rabi crops. The green peas is used for the preparation of vegetables and the green seeds provide one of the most nutritive diet to the people. The green pods which are usually ready for use by the month of January are sold on high rates and provide a good amount of cash to the farmers. Peas are used for the preparation of vegetables usually in combination with
potatoes or roasted alone just to be used as a delicious dish. In this way, peas are not only a substitute for the staple food when dry but serve best as vegetable when they are taken fresh and green.

Peas flourish well on clayey or clayey loam soils which contain adequate amount of humus and nitrogen. The ideal soil for peas is that which is well drained, well manured, highly aerated. The cultivation of peas is generally similar to that of wheat or barley. As a leguminous crop, peas are a soil building crop and their rotation with the rice maintains the soil fertility. The crop leaves behind a good amount of nitrogen which helps in increasing the yield per hectare of rice. The rice crop is generally grown on those fields which have produced rice in the preceding kharif season though its rotation with small millet and maize is not uncommon in the region. After the harvest of the kharif crops, the fields are frequently ploughed and harrowed and moderate doses of phosphatic fertilizers are applied. Then the crop of peas flourishes best and gives best return.
The seed is sown broadcast at the rate of 35 kilogramme per acre in the last week of October and the crop matures by the end of February, when the crop attain a height of about 20 cm., the end of the stem is nipped off so that its vegetative growth may be luxuriant and the crop may give a higher yield. In the bhanger areas of the region the crop of peas requires at least one watering whereas in other soil groups it is not irrigated because soil so retains enough moisture to support its satisfactory growth. Peas cannot withstand the severe cold and frosty conditions specially during the flowering period. Since severe frosty conditions seldom appear in the region, the crop is far from vulnerable.

The crop is cultivated in varying soil but its highest concentration lies in the tahsil of Baheri and Bareilly.

Depending upon the climate-edaphic factors, field preparation and irrigation facilities, the yield of peas varies from place to place. It ranges between 600 kilogramme per hectare in khadar areas to 650 kilogramme in the rich loam or clayey loam soils.

12 Horse, H.T., Grams and Gramineae (London, 1944), p. 68.
Gram (Cicer arietinum)

Gram occupies a small percentage of the net sown area in the rabi season. It is grown in medium quality land and usually this crop is unirrigated. It is sown in October and harvested in March.

Gram is sown very often alone but sometimes it is mixed with barley and wheat. Heavy soils suit it best. It is a subsidiary crop of the village. Its yields in the year of inquiry were approximately 327 kilogramme per acre.

The area under gram is 13466 hectares or 7.57 percent of which 810 hectares is irrigated in the district. It is very popular for its many uses. The green tender leaves of the plant are used as vegetable and green grains are roasted for a delicious dish. In the dry state, gram is either used as a pulse or is converted into flour from which breads are prepared. Gram was like barley also the main staple food for the poor people. It is grown on a variety of soils but sandy loam or loamy soils seem to be best suited to its cultivation. Climatic conditions for the growth of gram are...
almost similar to those of peas except that it is much sensitive to rainfall. It is sown in the middle of October and if the rainfall occurs abundantly after it has been sown, the seeds are liable to be damaged. Gram can not withstand the chilly weather and frost at any stage of its growth. A light shower during the month of January is quite beneficial for its cultivation but it should not be accompanied with cold waves. Instead fairly bright sunny weather should follow the rains. Frosty weather and cloudy atmosphere not only retard the development of flowers but also destroy the grains inside the pods.

Gram generally occupies those fields which have produced broadcast rice or small millets in the preceding kharif season. The best quality lands are usually not devoted to its cultivation. Gram requires thorough field preparation. The fields are ploughed and harrowed for three to four times before sowing the seed. The seeds are broadcast at the rate of 10 to 15 kilograms per acre and when the plant attains the height of 10 centimeters, weeding is done and the crop
is irrigated if the soil is not able to restore and supply sufficient moisture. At the same time the upper stem of the plant are nipped off so that they may give way to several off shoots and luxuriant growth. Khadar areas are specially suited for its cultivation where it needs no irrigation.

Natural aeration of the soil is an essential factor in its cultivation. Sandy loam soils of the area fulfill this requirement and give a better yield.

The yield of gram varies from 200 kilograms per acre to 325 kilogram depending upon the soil and climatic factors. The yield is comparatively greater in the porous light soils where natural aeration is high. It has been observed that wherever, the roots of gram obtain an abundant air supply, yield increases. Most of the blocks consisting of high concentration of gram are wholly or partially in the sandy loam or loamy soil tract where it thrives well and gives a better yield. The yield of gram may further be increased if organic manures are applied.

Oil Seeds: (Mustard, Linseed & Alsi)

Occupying an area of 3295 hectares or 1.84 per cent of the net rabi crops, oil seeds constitute the major source of fat and oil supply to the people of the area. Besides being important as a source of human diet, they supply a large amount of oilcakes after the extraction of the oil which have immense value as fertilizers and food for milk animals and poultry. The principal oil seeds of the rabi season are mustard and linseed (Brassica campestris) & Alsi (rapeseed). Oil seeds are generally grown as a single crop. More than fifty per cent of the oilseeds in the region are grown in combination with wheat, barley and gram. Climatic conditions are similar to all rabi crops, these seeds are sown in the month of October and harvested in February or March often before the harvest of rabi grains. The seeds require the most fertile lands which are highly manured and maintain good tilth. They need at least one watering during their flowering period if the soil is not adequately moist.
Other Crops

Among the category of 'other crops' oilseeds, and vegetable, opium and ground nut are included. Vegetables include potatoes, tomatoes and other vegetables which are most important in the area. The vegetables are sown in small fertile fields and require painstaking agricultural labour. It is only after thorough spading, ploughing, harrowing and weeding that the vegetables give high production. Potatoes (solanum - tuberosum) require intensive field preparation, manuring and irrigation. It is very much sensitive to frost and a succession of three to four days of frosty weather may completely mar the crop. Such a weather appears only infrequently in the area. Since potato is a deep rooted crop, it requires porous soil with good natural aeration. Loamy soils or sandy loam soils with perfect drainage system are ideal to its cultivation. Precaution against pest and diseases is also necessary. Tomato is also much sensitive to diseases and frosty weather.

In 1971-72, the total area under vegetable was only
664 hectares or 0.37 per cent of the net **rabi** area which seems too small an acreage in view of the heavy vegetarian population. The vegetables are sown generally on 'gaumana' soils of the area which due to the nearness of village settlements enjoy adequate supply of manure.

**Lentil (Lens esculenta)**

With an area of 9108 hectares or about 5.88 per cent of the net **rabi** crops, lentil ranks first in importance among the **rabi** pulses. It is grown on a variety of soil ranging from light loam to heavy clay. Its cultivation needs no painstaking field preparations. Being usually a cover crop, it is sown on those fields from which rice has been harvested in the preceding **kharif** season. After ploughing the fields once or twice the seed is broadcast at a rate of 12 kg/ per hectare. No attention is being paid to its cultivation in the region since it is treated as a cover crop which saves the fields, if left fallow, from erosion. Everywhere lentil is a non-irrigated pulse. As a creeping pulse its importance is great because it enriches the soil heavily with the
nitrogen after decomposition of its decayed leaves. It matures within four months. The great benefit that accrues from this crop is not the pulse seeds that are obtained but the supplies of nitrogenous material to the rice field. Rice always gives better yield if sown in rotation with lentil because the heavy extraction of nitrogen from the fields by rice is compensated by the lentil crop. The yield of lentil varies from place to place according to the suitability of the soil and attention paid to its cultivation by the farmers. The per hectare yield ranges from 350 kilogram in khadar or light loamy soil to 400 kilogram in the clayey loam soil.

Barely : (Hordeum Vulgare)

Barley covers an area of 1761 hectares of land or about 0.98 per cent of the net cropped area in the rabi season. The plant of barley is adaptable to a wider range of climatic conditions and it may be grown on poor and rough soil groups. Barley constitutes the staple diet of the poor people. During the period of growth it requires
adequate amount of soil moisture and is usually irrigated in those group of soils where enough moisture is not present.

As the barley plant may easily withstand the severe cold and frosty conditions, its cultivation has no serious difficulty. During the ripening period, however, it requires plenty of sun-shine and high temperature.

Barley is, no doubt, adaptable to various soils but it gives satisfactory return in sandy loam and loamy soils. It is generally grown in rotation with the kharif crops of rice (broadcast), maize and small millets. For a good yield of barley, the fields are thoroughly prepared and farm yard manure is supplied to the field at the rate of two to three bullock cart load per acre. After several ploughing and harrowing a good seed bed is prepared and the seed is sown either broadcast or in furrows at the rate of 40 kilogramme per acre. When the seeds germinate the fields are irrigated at least one in the loamy soil group whereas in other type of soils it needs no irrigation. The crop of barley usually ripens by the middle of March and harvested towards the end of the month or early in April.
Fallow

98,252 hectares or 30.00 per cent of the gross cultivated land is left fallow because such lands are not capable to produce a *rabi* crop after the harvest of a *kharif* crop. It will be seen from the table No. that a considerable area has been left without crop which can be utilized to cultivate crops. It is also clear that fallow lands fall in those areas where the clay or clayey loam predominates and also where the transplanted rice is the major crop in the *kharif* season. The greatest drawback with these soils is that they attain such hardness during *rabi* season that ploughing becomes very difficult if not impossible.

The practice of fallowing may, however, be checked with the extension of leguminous crops like lentil and peas which may be scattered in the fields during the month of October when the soil is sufficiently moist and may be ploughed with little difficulty. This will check the soil erosion besides providing some subsistence to the farmers and the yield will also be fruitful to the population.
Vegetables and Potatoes

Vegetables are grown in the district as a cash crop. Its cultivation is mostly in the hands of Kachis and Maraos who are supposed to be the professional vegetable cultivators and sellers. However, there are some farmers, too, who own a small holding, proper to grow vegetables and potatoes during the *rabi* season and earn more cash than what they can get from grain crops. The same land in the *kharif* season is put under maize which is also more or less a cash crop.

Potatoes are planted in ridges in fields after they have been given several ploughings and also very heavy dressing of manure have been applied. Sowing season starts from October and lasts till middle of November. The crop is ready in January if sown in early October.

Potatoes are liable to potato blight, but here no damage has yet been caused by the fungus.

The potatoes crops in the district covers an area of 2192 hectares of which 2061 hectares are irrigated and rest 131 hectares unirrigated.
Mixed Crops

It will be seen from figure No. 31 that in some fields two or more crops differing in their water requirements are sown in the same season. There are several reasons for such a mixing of crops.

Firstly, the mixing of crops like millets and pulses, rice and pulses, barley and gram, barley and peas is a kind of insurance against the vicissitudes of weather. If the season is wet, rice flourishes well and if it is dry, the millets thrive, so that in either cases the cultivation has a reasonable prospect of getting some return. Similarly in the rabi season mixing of crops also provides a safeguard against climatic vicissitudes.

Secondly, by sowing two crops which mature at different time (such as millets and pulses), the cultivator maintains his meagre reserves of food. In our country the monsoon is such which can not be depended upon because of its vagaries. Sometimes it so happens that there is rain but the time and the quantity is not certain. This is the
greatest consideration in the minds of the cultivator while sowing the crops. If one crop has been destroyed by the failure of rain or by excessive rain, he will get some produce from the other crop. As a result of mixing, the cultivator is ensured about some yield for his livelihood. No doubt irrigation facilities have been developed in the district yet more than 40 per cent of the net cropped land is still unirrigated. In case irrigation water is available in a region, people will not depend wholly on rain water.

Thirdly, with the help of these mixtures, the cultivator unconsciously maintains the supply of nitrogen in a convenient way on very small holdings. The crops, which encourage bacteria action in the soil, are the kharif and rabi pulses. They build up soil fertility and ensure some return.
Crop ranking is the simplest method which denotes the relative position of strength among the different crops shown in the region. The strength of each crop is evaluated by the per cent held by the crops from the total cropped land of each Block. The highest per cent of a crop of a Block is kept under first rank and the second highest rank and so on. Intensity of crops in different blocks may be appreciated with the ranking method but variable position of the individual crop within the different cropping situation is best revealed by crop-combination analysis.

For a better and intensive study of the geography of crops, the study of ranks and crop-combination is indispensable and therefore, they are included in the present study.

RANKING OF CROPS

To assess the relative strength of the different crops in the district, the crops ranking first, second and third
in the year 1971-72 have been worked out on the basis of
Blockwise statistics and mapped in Figures 27, 28, 29.

Figure 29 shows that rice (broadcast and transplanted
taken together) is major crop of the entire area. In five
blocks out of ten rice predominates. It may easily be
correlated with the climoedaphic factors. The prevalence
of humid climate with abundant rainfall and high temperature
during the cropping season and the dominance of clayey soil
best suited to transplanted rice, determines largely the
rice cultivation. In the southern tahsils or blocks with a
little less rainfall and loamy and silty khadar soils and
climoedaphic factors go in favour of broadcast rice above
all as a staple foodcrop of the area. Rice is given priority
over other crops. Average rainfall during the wet monsoon
months in the area under study and average monthly tempera-
ture during the growing period of rice are the factors
which have made rice a principal crop of the area.

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Block: It is a smaller administrative unit than a tahsil. Since the crop dated was not available tahsilwise, they have been collected blockwise.
BAREILLY DISTRICT
1ST RANKING CROPS 1971-72
BASED ON THE PERCENTAGE TO TOTAL HARVESTED CROPS IN EACH BLOCK

SOURCE
BASED ON UNPUBLISHED DATA OBTAINED FROM THE REVENUE DEPARTMENT BAREILLY
BAREILLY DISTRICT
2ND RANKING CROPS 1971-72

BASED ON THE PERCENTAGE TO TOTAL HARVESTED CROPS IN EACH BLOCK

SOURCE
BASED ON UNPUBLISHED DATA OBTAINED FROM THE REVENUE DEPARTMENT BAREILLY

FIGURE 28
BAREILLY DISTRICT
3RD RANKING CROPS 1971-72
BASED ON THE PERCENTAGE TO TOTAL HARVESTED CROPS IN EACH BLOCK

SOURCE
BASED ON UNPUBLISHED DATA OBTAINED FROM THE REVENUE DEPARTMENT BAREILLY

FIGURE 29
Wheat is the next crop of the area. That is due to the soil and climatic conditions. Sugarcane is also grown in Bithrichainpur block. Here the soil owing to its high retentive capacity of moisture and adequate amount of lime and potash encourages its cultivation. Sugarcane could not hold first rank in other block only because of the preference given to rice as a staple crop which involves less labour and expenditure in its cultivation when compared to sugarcane.

A little diversified pattern of crops is revealed by the figure 29 of second ranking crops:

In 6 blocks, wheat is as a second ranking crop, while rice in four blocks is a second ranking crop. The dominance of wheat as a second ranking crop in the area may be explained by the fact that climate and soils of the area favour its cultivation in the *rabi* season. Wheat being a remunerative crop and holding second position as a staple food for the general population, is grown extensively on all varieties of soils ranking from silty loam to clay through its yield is poor in the areas of clayey soil. Wheat attains next
important position after rice. Taking as a whole, the region may be agriculturally called as a rice and wheat area.

A more complicated and diversified distribution of crops may be seen on the map showing third ranking crops. (Fig. 30) A variety of crops appear on the agricultural landscape when they have been ranked third. Here maize is the main third ranking crop. It is in four blocks – Shergarh, Bahari, Bhojipua and Fatahaganj. This is due to irrigation facilities and also new varieties of maize which have been developed by the Pand Nagar University. In some blocks two crops of maize are harvested. In Ramnagar block, rice holds third ranking crop. Other important third ranking crops are wheat, wheat and gram, and gram in Bithrichainpur, Mirganj and Nawabganj respectively.

The fragmentation of areal distribution becomes intensely diversified if an attempt is made to map out the fourth and fifth ranking crops. An analysis of this diversification will therefore, be of little use.
CROP COMBINATION REGIONS

The importance of combinational analysis of different elements in a study of crop land use can hardly be over-emphasized. To know and to analyze variable positions of the individual crop within themselves as their integral complex, the study of crop-combination regions becomes indispensable. It seems necessary to highlight the most important elements that govern the other smaller elements in the whole complex system. This type of study helps in the interpretation of socio-economic aspects of land use besides being much valuable aspects for an adequate understanding of individual crop geography. As an integrated reality crop-combination requires definition and distributional analysis and the regions demarcated on this basis largely decide the make-up of the still more complex structure of valid agricultural regions.

To demarcate the crop-combination regions, various statistical procedures have been evolved and used. In the present study, Doi's method has been adopted which seems to

be a good improvement over that of Weaver. Weaver's formula for crop combination i.e., \( \frac{d^2}{n} \) has been substituted by Doi with \( \leq d^2 \) or sum of the squared differences. Weaver's method to determine the minimum deviation at the very outset, seems to be quite simple, but in practice it requires much calculations work. Occasionally it also tends to produce highly generalised results in the areas of large number of variants. Doi's formula, given a little different result from that of Weaver, still it is easily adoptable since it

References may be made here to the following studies.

(a) Weaver, J.C., ibid., pp. 175-200.

In all the studies of combinations, references to Weaver's method, inevitable since his is the first credit in evolving and applying the formula. For the determination of minimum deviation Weaver calculated of real per cent of all the possible combinations in the unit considered against a
avoids much of the calculations work involved in Weaver's method, because of the combinations having the smallest \( d^2 \)
can be found by consulting only one sheet table which presents critical values for different elements at various accumulated percentages. More over in the region where the number of variants is so large, Doi's formula does not give such a generalized and unwieldy result as is given by Weaver's formula. The results found with Doi's method are more realistic since the formula is equally suitable in regions of high specialization. In view of such merits, Doi's formula has been used by the writer to assess the most accurate crop-combination in the area under study.

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theoretical standard, which was 100 per cent in one crop, fifty per cent in each of two crops, 33.3 per cent for each of three crops and so on. For a detail discription of this method a reference has already been made.

\( d \) denotes the difference between the actual crop per cent in a given unit and a appropriate per cent in the theoretical curve; an is the number of element in the combination.
It seems, however, unnecessary to reproduce the whole
method of Doi, for he has elaborated it most clearly and
intensively in his paper. An illustration of the crop-
combination region, the area may be given here, which will
indicate the similarities between the methods.


18. The case of block Fatehganj may be taken to illustrate
the statistical procedure involved. The individual crop
percentages in Fatehganj are given below.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>40.3</td>
</tr>
<tr>
<td>Rice</td>
<td>33.5</td>
</tr>
<tr>
<td>Maize</td>
<td>16.0</td>
</tr>
<tr>
<td>Big millet and Pigeon Pea</td>
<td>9.00</td>
</tr>
<tr>
<td>Other crops</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Monoculture crop combination = \( \frac{(100 - 40.3)^2}{2} \) = 356.0

2-crop combination \( \frac{(50 - 40.3)^2 (50 - 33.5)^2}{2} \) = 356 = 188.0

3-crop combination \( \frac{348.4}{3} \) = 116.1

4-crop combination \( \frac{842}{4} \) = 108.0

5-crop combination \( \frac{842}{5} \) = 168.4

Thus according to Weaver's as well as Doi's formula
four crop combination is assigned to the block because
it has the minimum deviation in each case whether
divided by the total number of crops considered or
not.
Based on Doi's method, an attempt has been made to calculate the crop combination patterns of the area. Block has been taken as a unit area. 4 crop association region emerge which have been shown in Figure 31. It may be pointed out that these combinations have emerged from 13 major crops of the area (rice, wheat, sugarcane, maize, peas, gram, small millets mixed with pulses, bulrush millet, pigeon pea, barley and oil seeds).

The most salient features of the crop-combination region is the absence of monoculture. Figure 31 shows the number and variety of crops falling in each block. The clusters and similarity of a particular crop associations is not an uncommon features. The largest group is formed by 3-crop combination of rice; wheat; maize; sugarcane; and groundnut.

The other marked cluster is formed by 2 crop-combination rice-wheat. The former includes blocks Baheri, Fatehganj, Ram Nagar, Bithri Chainpur, Faridpur, whereas the latter cluster comprises Shergarh, Nawabganj, Bhejipura and Alampur-
Zafarabad. Elsewhere the area is characterised by diversified combinations. The relative dominance of a particular combination such as rice and wheat is also striking (Figure 31). This is due to the most favourable climo- edaphic conditions. Rice is the dominant crop and as such it falls in most combination of the area.

Crop Combination Region : (Two crops - wheat & rice)

It is evident from the figure 31 that there is a great diversity in crops. This diversification is due to geographical conditions which ultimately decide the selection and growth of certain crops. There are four blocks viz., Shergarh, Nawabganj, Bhojipura and Alampur Zafarabad where two crop combination of rice and wheat emerges. In these blocks the dominance of clayey and clayey loam soils and favourable climatic conditions give way to rice cultivation in the kharif season. It occupies by far the largest percentage of the total sown area followed by wheat. Cultivation of wheat is given preference. It is a remunerative crop. It is given preference over all the rabi crops and as such its percentage is the second highest.
Crop Combination Region: (Three crops)

In this cluster falls the blocks of Baheri, Fatehganj, Ram Nagar, Bithri Chainpur, and Faridpur. Rice, wheat and sugarcane are the crops in Baheri and Fatehganj in two blocks, wheat, rice, and sugarcane in Bithri Chainpur block, in Faridpur wheat, rice, and groundnut, in this way wheat, rice, sugarcane, maize, and groundnut constitute the combination, rice being the first ranking crop and wheat is the second ranking crop in most of these blocks. In other blocks, rice is the first ranking crop and wheat is the second ranking crop while third ranking crop differs from one block to another. Taking as a whole three crop combination region constitutes the largest part of the different combinations found in this area.

Crop Combination Region: (Four crops)

The combination of a large number of crop is an example of increasing diversity of crops resulting from the variable geographical conditions. There is the only block, Mirganj having four combinations of crops; there again rice and wheat are the first and second-ranking crop respectively while wheat
and gram and big millet and pigeon pea are the third and fourth ranking crops.

Figure 3D shows that the greatest diversity of crops is found in the western and southern portions of the area where the poverty of soils, lesser degree of irrigation facilities and comparatively uncertain climatic conditions result in the large number of crop associations. In the loamy or clayey areas the remunerative and staple food crop dominate and no large diversity exists only because the soil is much fertile and productive to grow the major crops of the area without large fluctuations in their yields. Rice is by far the most important crop of the area which is followed by wheat and maize. It is evident that all the important crops dominate in this area. It is safe to assume that, on the whole, the area is satisfactorily fertile and productive. The change in crops largely depends upon the quality of the soil, seasonal distribution of rainfall and its variability, annual temperature conditions and irrigation facilities. It may be added that the farmer decides the selection of the crops.
He may consider several factors such as the cost of production, net gain etc. There are also human and economic factors which do play an important role besides the geographical conditions.
IRRIGATION

The problem of irrigation in the development of agriculture is of foremost importance. In fact it is the most important means to increase the yield as well as the area under cultivation. The intensity of cultivation is no doubt raised with irrigation facilities. It not only facilitates the growth of a second crop but also helps in increasing the crop yields to the fullest extent. This necessity is particularly felt in the case of vegetables and cash crops. Such crops can not be grown in those areas where the provision of irrigation is not adequate. Moreover, in the absence of sufficient irrigation facilities, large areas are exclusively dependent upon rainfall which is often deficient and unevenly distributed and thus produce only one crop.

In an area with an annual rainfall of 1083 mm. and a maximum of 522 mm. in the two months of July and August, the question of irrigation by canals and tube wells has been a matter of controversy. The masonry and spring wells suffice the needs to a large extent in the winter months when rad
crops required irrigation but during the years when there is a failure of monsoon the rice crop is ruined totally in some parts of the area and partially in others.

There is however, a substantial area covered by canal irrigation in the district. It is done by two methods flow and lift. The table no. 11 shows the details of the area under both methods. The area under canal irrigation is 66339 hectares or 49.0 per cent of the irrigated land in the district. The largest area covered by canal irrigation in tahsil Baheri is 23228 hectares or 84.7 per cent of the total irrigated land by canal in the tahsil. In other tahsils, the irrigated area by canal is 16702 hectares or 67.1 per cent in Nawabganj, 14120 hectares or 35.5 per cent in Bareilly and 12339 hectares or 56.6 per cent in Faridpur. There is no irrigation by canal in tahsil Aonla. Table no. 11 illustrates the details of acreage in each tahsil covered by various means of irrigation in 1971-72. It will be seen from table that Aonla is greatly benefited by tube well irrigation both Govt. and private. The highest number
of Government tube wells in Aonla is 1813. It is followed by Bareilly with tube wells 702. In other three tahsils irrigation is carried on by other sources. It is also evident from table no. 12 that highest percentage of irrigated land lies in the tahsil Aonla 26.6 per cent by tube wells.

**TABLE NO. 11**

Irrigation by Different Sources in Tahsils of Bareilly

<table>
<thead>
<tr>
<th>Sources</th>
<th>Baheri</th>
<th>Nawabganj</th>
<th>Bareilly</th>
<th>Aonla</th>
<th>Faridpur</th>
<th>Bareilly dist.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canal</strong></td>
<td>23226</td>
<td>16702</td>
<td>14420</td>
<td>-</td>
<td>12339</td>
<td>65389</td>
</tr>
<tr>
<td><strong>Tubewell(personal)</strong></td>
<td>807</td>
<td>1718</td>
<td>2834</td>
<td>5271</td>
<td>2394</td>
<td>13574</td>
</tr>
<tr>
<td><strong>Tube well(Govt.)</strong></td>
<td>196</td>
<td>26</td>
<td>7938</td>
<td>5718</td>
<td>57</td>
<td>13965</td>
</tr>
<tr>
<td><strong>Masonry well</strong></td>
<td>530</td>
<td>4196</td>
<td>9042</td>
<td>9308</td>
<td>5374</td>
<td>28452</td>
</tr>
<tr>
<td><strong>Non-masonry well</strong></td>
<td>418</td>
<td>35</td>
<td>-</td>
<td>127</td>
<td>84</td>
<td>644</td>
</tr>
<tr>
<td><strong>Lakes and Ponds</strong></td>
<td>136</td>
<td>306</td>
<td>2501</td>
<td>706</td>
<td>348</td>
<td>3999</td>
</tr>
<tr>
<td><strong>Other sources</strong></td>
<td>2110</td>
<td>1912</td>
<td>3200</td>
<td>417</td>
<td>656</td>
<td>8295</td>
</tr>
<tr>
<td><strong>Total area irrigated</strong></td>
<td>27425</td>
<td>24899</td>
<td>39715</td>
<td>21547</td>
<td>21752</td>
<td>135338</td>
</tr>
<tr>
<td><strong>Total area unirrigated</strong></td>
<td>39381</td>
<td>21767</td>
<td>43986</td>
<td>42516</td>
<td>29233</td>
<td>186983</td>
</tr>
<tr>
<td><strong>Percentage of irrigated to net area sown</strong></td>
<td>35.7</td>
<td>53.6</td>
<td>47.4</td>
<td>33.6</td>
<td>42.6</td>
<td>42.0</td>
</tr>
</tbody>
</table>

An examination of table no. 11 further reveals that, though canal and tube wells are dependable sources of
irrigation, the area irrigated by these means was 49.0 per cent and 20.3 per cent respectively in 1971-72. In tahsil Aonla there is no canal irrigation. However there is provision for tube well irrigation which is expensive than canal irrigation.

**TABLE NO. 12**

Table shows percentage of different sources of irrigation in the tahsil and district.

<table>
<thead>
<tr>
<th>Sources</th>
<th>Bahri</th>
<th>Aonla</th>
<th>Nawabganj</th>
<th>Faridpur</th>
<th>Bareilly</th>
<th>Bareilly district</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canal</td>
<td>84.7</td>
<td>-</td>
<td>67.1</td>
<td>56.6</td>
<td>35.5</td>
<td>49.0</td>
</tr>
<tr>
<td><strong>Tubewell</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal</td>
<td>2.9</td>
<td>24.5</td>
<td>6.9</td>
<td>13.3</td>
<td>7.3</td>
<td>10.0</td>
</tr>
<tr>
<td>Tube well Govt.</td>
<td>0.7</td>
<td>26.6</td>
<td>0.1</td>
<td>0.3</td>
<td>20.1</td>
<td>10.3</td>
</tr>
<tr>
<td>Masonry well</td>
<td>1.9</td>
<td>43.1</td>
<td>15.9</td>
<td>24.8</td>
<td>22.7</td>
<td>21.1</td>
</tr>
<tr>
<td>Non-masonry well</td>
<td>11.6</td>
<td>0.6</td>
<td>0.1</td>
<td>0.4</td>
<td>4.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Lakes &amp; Ponds</td>
<td>0.5</td>
<td>3.3</td>
<td>1.3</td>
<td>1.6</td>
<td>6.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Other sources</td>
<td>7.7</td>
<td>1.9</td>
<td>7.6</td>
<td>3.0</td>
<td>8.1</td>
<td>6.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

It is evident from the table that in tahsil Baheri, there is 84.7 per cent canal irrigation, the highest percentage in the district while in Aonla there is no irrigation by canal. Canal irrigation can be developed in Anola which can bring more land under cultivation. It is a cheaper means of irrigation than tube well. In tahsil Nawabganj Government tubewell
should be developed. By analysing the table no. 12 it is
gathered that the two dependable sources of irrigation canal
& tube well require much attention of the Govt. so that the
farmers may be assured of adequate water supplies for
their crops.

\footnote{Data obtained from District Headquarters Bareilly.}
A CRITICAL ESTIMATE OF CANAL IRRIGATION FACILITIES IN THE DISTRICT.

Canal irrigation is, by far, the most reliable source of irrigation. It provides security against seasonal odds. Even during the year when monsoon fails, canal can come to the rescue of the farmers and, to some extent, crop failure can be avoided.

It is very often said that canals can help to convert the unproductive lands into a fertile one but sometimes the reverse case is also true. The canals with their distributaries running over different parts of the country come across various strata of the earth and thus its water is mixed with numerous salts which are soluble in it. As soon as these salts become in excess, the canal water does harm to the crops. In due course of time, areas receiving constant supply of canal water might be turned into a waste land.

Besides this, there is one more danger from which the area is likely to suffer in due course of time. The badly designed water distributing might land to water-logging and the water-
logged spots, in turn, would provide suitable conditions for
the breeding of mosquitoes which constitute a source of
malaria.

Balancing the merits and demerits of the canal irrigation,
it can, however, be said that this has greatly improved the
economy of the area by stepping up the crop yield per acre.
Where such facilities are available moreover extension in
the acreage of different crops has also been made possible
owing to the canal irrigation facilities.

There are eight canal systems in the district, a brief
account of each being given below:

Upper Bahgul Canal System

The canals of this particular system take off from the
Bahgul river and serve a large part of the tarai area of the
district. Before 1909, only earthen bunds were constructed
every year and it was only in that part year that permanent
weirs came into existence at Rudpur and Garhi. The left and
right Ogamur canals (with their minor branches) irrigate
the land on the eastern side of the river almost as far
south as the road running from Richha to Pilibhit. The average area irrigated annually in 1971 15021 acres.

Kichha Canal

In the past earthen bunds used to be constructed from year to year for purposes of irrigation. A masonry weir was built in 1885 but as it was swept away by the floods in 1891, earthen bunds had to be resorted to again till 1904, then another masonry weir with a length of 297 feet was built. As this structure was subject to leakage (because of having wooden gates), in 1902 eight steel gates were installed which made possible the full utilization of the water released from the Dhora dam through the Kichha canal system and the Kichha Paha feeder. The Kichha canal enters the Bareilly district from the Nainital district near the village Amda. There was an acute shortage of water in this system before the construction of the Dhora reservoir project which has a storage capacity of 1840 million cubic feet and augments the supplies of water to the Kichha, Paha, Dhora, Baraur and Balli canal systems and also feeds thirty-four miles of channels constructed under the Dhora reservoir project. The
project has led to considerable expansion of irrigation in the district and enables the Kichha canal system to serve through its channels. The area irrigated by the canal in 1971, 1520 hectares.

Paha System

Earthen bunds were also constructed every year for procuring water for irrigation from the Paha river which enters the district from tahsil Kichha (in the Nainital district) at Nagla. A masonry weir was built in 1907 but the water shortage continued to be acute (specially for the sugarcane and rice crops) and relief came only with the completion of the Dhora reservoir project by which water was procured through its sluice channel and the Kichha Paha feeder. The system has been remodelled and the standard of irrigation raised to the level of the Sarda Canal system.

The area irrigated by Paha system in 1971 was 12325 hectares.

B-arsaur Canal System

The system had an earthen bund till 1906 when a masonry regulator was installed and it now irrigates the
area between Baraur and the Western Bahgul. The area irrigated annually was 4578 acres. A cut made from the Paha canal to the Baraur increased the supply of water considerably. The system was also remodelled, in order to carry the additional discharge to water and to convey water down stream to the Balli and Kuli canal systems.

Balli Canal System

The Balli dam was built on the Western Bahgul and till 1908 irrigated only the lands in the Rampur district when a masonry regulator was set up near the village of Pipra for feeding the canals serving the areas in the districts of Bareilly and Rampur between the Western Bahgul and the Kuli and to divert the surplus water into the latter. Its masonry regulator was swept away by a flood in 1926, necessitating the putting up of earthen bund every year till an acqueduct over the Western Bahgul was made in 1968-69 by carrying water from the Dhora reservoir, the additional supplies of water being sufficient to meet the high demand for irrigation from the Balli canal system. The area irrigated was 2165 acres.
Kuli Canal System

Before 1903 the river Kuli was dammed with earthen bunds by the cultivators themselves but in that year a masonry weir was built by the government to feed the Kuli canal system. The area irrigated annually in 1971 was 5930 acres between Kuli and Bhakra.

Dhora Canal System

Till 1908 earthen bunds were constructed annually near the village of Jasainagar but that year saw the construction of a masonry weir which, proving inadequate, was replaced by the existing weir in 1928. The entire canal system operates within the district and is fed sufficiently by the Dhora reservoir and area irrigated was 12192 acres.

Sankha Bund

A small earthen bund was built by government at Rasula, about 10 miles west of Bareilly, (on the Moradabad road) which has small masonry escapes. It feeds the Rukampur minor canal, the average area irrigated annually in 1971 being 486 acres.
Sarda Canals System

The lower Bahgul canals, which run entirely in the district, were formerly completely dependent upon the precarios supplies of water from the east Bahgul and the old right and left Churaili canals were taken off from the churaili dam which stands 3 miles north of the Richha Pilibhit road near the village of Churaili in tahsil Baheri where the river is dammed with a masonry weir (with falling shutters) the old Girem distributaries start at this dam near Girem and irrigate an area covering 10 miles on both sides of the river.

Direct irrigation from these systems was formerly insignificant, the extension of enormous facilities for irrigation in tahsils Bareilly, Nawabganj and Faridpur being the result of the emergence of the sarda canal in December, 1928.

A barrage was constructed at Duni on the river Desha to raise the water of the Sarda which came down through the Sarda Desha feeder and the rivers Pafewain and Lehia.
The Deoha Bahgul feeder has been constructed from the river Deoha at the Duni barrage and goes to the East Bahgul (upstream of the Churaili dam) making available sufficient water for overcoming the acute shortage.

The Richha branch, taken the Churaili dam, feeds the Right Churaili distributary system. The channels of the Bareilly distributary system have a length of 56 miles and 5 furlongs. The Shahi distributary system's channels are 41 miles, 3 furlongs and 365 yards in length and the channels of the Daulatpur distributary system have a length of 29 miles 5 furlongs and 527 yards. In addition to the remodelled Girem distributary system with channels of the length of 84 miles and 2 furlongs and the right Girem distributary system with the channel of the length of 18 miles and a furlong on the Girem dam, the Faridpur branch system with its channels covering a length of 152 miles and 7 furlongs has been responsible for the great development in irrigation in tahsils Nawabganj and Faridpur.

Only the terminal sections of the Kailas and Abora
canals (which once used to draw up the rivers Kailas and Absara) are also now fed by the Sarda (the river) and lie inside the district. The Kailas distributary with its minor channels covering a length of 18 miles and 4 furlongs irrigated an annual average area of 4629 acres from 1951-52 to 1962-63 and the Absara canal, with a length of 31 miles 3 furlongs and 637 yards, irrigated and annual average area of the 7057 acres in that year.

The total length of the irrigating channels of the Sarda canal system in the district is 427 miles 5 furlongs and 407 yards, the average area irrigated annually being 223181 acres.

The utility of tube well irrigation can not be underestimated in the district where the canal irrigation facilities are not available. Tube well should be provided so that the crops might not be damaged during famine time. From table no. 12 it is clear that in tahsils there is much scope for extension in the tube well irrigation.
facility. Since the construction of tube well is manageable by individual, its construction in those areas where existing irrigation facilities are not adequate, should be taken up by individuals as private tube wells. This will go along way insolving the problem of irrigation in the district to a large extent.

Method of Lifting Water

The question of lifting water for irrigating crops is also very important in an area like Bareilly district. The methods differ from one part to the other. In fact, these are determined, to a great extent, by the local conditions on the one hand and by the suitability of water level and the height at which this water is to be raised on the other.

Based on the considerations method earlier, five methods are employed for lifting water in the different parts of the Bareilly district.

(1) Rahat or Persion Wheel
(2) Basket
(3) Dhenkli
(4) Charkhi
Rahat or Persian Wheel

The method of lifting water is popular in some part of the district where tube well facilities are not available. It is worked by one pair of bullocks which moves round and round the well. The bullocks are attached to one end of the frame and the other end is fitted at the mouth of the well. The portion of the frame is attached with numerous metal buckets which go round into the well and raise water as the bullocks turn the drum on which these buckets rest. This method is generally employed by relatively rich peasants for the simple reason that it involves an initial expenditure to the tune of Rs 2000/-, excluding the cost of one pair of bullocks. It is a convenient method but its use is confined to such wells which contain sufficient quantity of water and do not dry up during the period of operation.

The writer made inquiries about the cost of the Persian Wheel while he was collecting information regarding the irrigation in the district.
This method of lifting water is practised in the upland region between the rivers of Nakatia and east Bahgul and west Bahgul where water is available at great depths ranging between and 10.5 metres.

Basket

It is the simplest device for lifting water from ponds, lakes and seasonal streams. While in operation, a closely woven basket is held by means of strings at the two ends by two persons at a time who swing the basket into the water and then empty it into a broad but shallow channel called bordra, constructed at the site where water is to be lifted. This broad channel works as a storage for supplying water into the narrow channels leading to the fields. In this case water can be lifted upto a height of approximately 1.2 metres. If the height is greater than this water is raised in two stages, the first stage being at a lower level than the second stage. Two persons and sometimes four working at two baskets lift water and store in a pit or depression from where people of the second stage lift the water and
finally it is passed into narrow channels leading to the
fields.

The above method is followed by poor farmers who can
not afford to employ other costlier methods. It is a cheaper
device of irrigation but requires much labour and time since
the process is very slow. The other demerits of the method
lie in the fact that a good deal of water falls back every
time the basket is raised. Further the device is operative
only for a limited period of time in the beginning of the
rabi season when water is available in lakes, ponds and
seasonal streams. This method prevalent in some parts of
Bareilly and Faridpur tahsils.

Dhenkli

This method is followed in the area where the soil is
loose and the water table is high. The farmers dig Kachcha
or unprotected wells in which water is available at a low
depth, approximately 2.4 to 3.6 metres. During the pre-
monsoon period when water is needed for sugarcane fields,
these wells contain very little water and therefore only one
A medium size of two forked pole is fixed into the ground near the well and then a long thin pole is placed cross-wise on the forked edge. A rope is attached to the other end of the thin pole and an earthen bucket is tied to the end which is hanging freely from the thin pole. This rope with the bucket fastened to it goes into the well and raises water. Three persons are generally needed for this work, two persons working on the dhankli by turn which lasts for about half an hour or so and one person in the field for sprinkling water. This device is usually practised in the loamy areas to the south of the Ramganga in tahsil Aonla and Faridpur.

There are some demerits of the method, e.g., (1) the irrigating capacity of this indigenous method is very low. (2) such wells last for a short period (3) much time is wasted by this device. Inspite of these drawbacks, this method is followed even today in the Bareilly districts.

Charkhi

It is an indigenous method used for lifting water from such protected wells which have high water level. It is also
known as 'pot and pully system'. The area irrigated by this
device in a day is much smaller than in the case of *pur* but
obviously the work is far lighter and each well requires
only two persons by turn. It has been estimated than two
persons working on a 'charkhi', with a third man to distribute
water in the field will irrigate one-tenth of an acre each
day during the hot weather months, while one-eighth of an
acre in the same interval of time during the cold weather
months.

This method is generally followed by very poor farmers
who cannot afford to use costlier methods and moreover who do
the job themselves. Middle class farmers who get the work
done by employing labour, do not usually adopt this device
since it consumes sufficient time and therefore a large
amount on irrigating an acre of land. This method is usually
followed in tarai area.

Irrigation in the Kharif season

The *kharif* crops are sown when the south west monsoon
has set in and therefore, no artificial watering is needed. However, in the year when the south-west monsoon is late or it has failed, irrigation becomes essential. The main crops of the kharif season are rice, transplanted rice, sugarcane, maize and fodder. These crops grow well if the rainfall during the monsoon is adequate and well-distributed. Sugarcane, however, needs at least four waterings prior to the setting in of the monsoon and at least one watering for sowing the crops in case there has been no rainfall in late March or early April. Successful cultivation of transplanted rice is also dependent upon irrigation.

Out of a total irrigation area of 135338 hectares in the district, 68448 hectares are irrigated in kharif and 91297 hectares are irrigated in kabi. In kharif 28.2 per cent land is irrigated while 71.8 per cent land is unirrigated. In kabi 50.9 per cent land is irrigated while 49.1 is unirrigated. In zaib 38.5 land is irrigated while 61.5 per cent unirrigated. The table no. 13 indicates the detailed data of irrigated and unirrigated land.
<table>
<thead>
<tr>
<th>Crops</th>
<th>Irrigated</th>
<th>Percentage of irrigated land</th>
<th>Unirrigated</th>
<th>Percentage of unirrigated land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>68448</td>
<td>28.2</td>
<td>174224</td>
<td>71.8</td>
</tr>
<tr>
<td>Rabi</td>
<td>91297</td>
<td>50.9</td>
<td>87726</td>
<td>49.1</td>
</tr>
<tr>
<td>Zaid</td>
<td>469</td>
<td>38.5</td>
<td>748</td>
<td>61.5</td>
</tr>
<tr>
<td>Total</td>
<td>160214</td>
<td></td>
<td>262898</td>
<td></td>
</tr>
</tbody>
</table>

It is evident from table no. 13 that 45575 hectares of rice was irrigated in the district on account of deficient rainfall at the time of sowing. Transplanted rice cultivated in low lying areas also required supply of water. As regards fodder, the fields were irrigated prior to the sowing of the seeds in the month of June. Sugarcane is entirely dependent on irrigation facilities except in the catchment area of the rivers where the soil retains moisture throughout the year and where sugarcane can be produced without irrigation.
Table shows the irrigated acreage under some important of the kharif crops in the year 1971-72.

<table>
<thead>
<tr>
<th>Tahsil</th>
<th>Rice</th>
<th>Sugarcane</th>
<th>Fodder</th>
<th>Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baheri</td>
<td>14669</td>
<td>5666</td>
<td>4792</td>
<td>5</td>
</tr>
<tr>
<td>Aonla</td>
<td>1676</td>
<td>3471</td>
<td>1564</td>
<td>6</td>
</tr>
<tr>
<td>Nawabganj</td>
<td>12134</td>
<td>5638</td>
<td>3919</td>
<td>3</td>
</tr>
<tr>
<td>Faridpur</td>
<td>5874</td>
<td>2040</td>
<td>2264</td>
<td></td>
</tr>
<tr>
<td>Bareilly</td>
<td>11222</td>
<td>4362</td>
<td>4098</td>
<td>63</td>
</tr>
<tr>
<td>District</td>
<td>45575</td>
<td>17557</td>
<td>16634</td>
<td>116</td>
</tr>
</tbody>
</table>

In the district the irrigated acreage under sugarcane is 16.8 per cent of the net cultivated land. Other crops which are irrigated in kharif season, are maize, bulrush millet and vegetables. The area of these crops is very small.

IRRIGATION IN THE RABI SEASON

The rabi season crops cannot be successfully grown without irrigation facilities. The amount of rainfall during the winter months is scanty and the rabi crops requiring more than one watering, cannot grow without irrigation.
However, gram and linseed can grow even without irrigation facilities, though the yield per hectare is very low.

Vegetables, potatoes, tobacco and other cash crops need regular supply of water which can be ensured only where irrigation facilities are available near at hand.

In the year 1972, the total area under rabi crops was recorded as 179023 hectares out of which 91297 hectares or 50.9 per cent were irrigated from different sources (table no. 13). The high percentage of irrigated area in the rabi season as indicated by the figures referred to earlier might lead one to conclude that the area is well served by irrigation facilities, but this position is somewhat misleading. About 50.9 per cent of the net irrigated area in the rabi season is irrigated from all sources. Any serious deficiency in the average amount of rainfall during the wet monsoon months adversely affect the position and some of the rabi crops would be damaged.

It will be clear from the table no. XVI that only a small proportions of the total area sown under wheat mixed
with gram and gram alone was irrigated in the district and
the substantial area was left unirrigated.

It is customary in the area to grow gram as a sole
crop or mixed with either wheat or barley in the fields
which are released by the rice crops. Since these fields retain
sufficient moisture for a long time, the crops like gram or
barley may be cultivated in such fields even without
irrigation, but when they are grown in fields which were
left fallow during the kharif season, they need irrigation
without which the crops would be damaged.

Further, it is evident from the table no. 15 that
a substantial area in the rabi season is devoted to wheat
and next in respect of acreage comes peas, while third
position is occupied by wheat mixed with gram in Bareilly
district. Wheat is largely grown for sale, while barley or
wheat mixed with barley or with gram provides bread to a
majority of rural population and peas and gram are consumed
as pulses.
### TABLE NO. 15

Table shows the irrigated acreage under some of the *rabi* crops in the year 1971-72.

(Area in hectares)

<table>
<thead>
<tr>
<th>Crops</th>
<th>Aonla</th>
<th>Nawabganj</th>
<th>Faridpur</th>
<th>Bahera</th>
<th>Bareilly</th>
<th>Bareilly district</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>11183</td>
<td>12171</td>
<td>15674</td>
<td>13187</td>
<td>22964</td>
<td>75181</td>
</tr>
<tr>
<td>Wheat &amp; gram</td>
<td>4294</td>
<td>332</td>
<td>443</td>
<td>363</td>
<td>1198</td>
<td>6630</td>
</tr>
<tr>
<td>Wheat mixed with Barley</td>
<td>22</td>
<td>1</td>
<td>9</td>
<td>--</td>
<td>7</td>
<td>39</td>
</tr>
<tr>
<td>Barley</td>
<td>101</td>
<td>26</td>
<td>106</td>
<td>9</td>
<td>38</td>
<td>280</td>
</tr>
<tr>
<td>Gram</td>
<td>419</td>
<td>83</td>
<td>182</td>
<td>41</td>
<td>85</td>
<td>810</td>
</tr>
<tr>
<td>Pea</td>
<td>981</td>
<td>155</td>
<td>960</td>
<td>28</td>
<td>203</td>
<td>2327</td>
</tr>
<tr>
<td>Lentil</td>
<td>107</td>
<td>31</td>
<td>32</td>
<td>16</td>
<td>40</td>
<td>226</td>
</tr>
<tr>
<td>Wheat mixed with peas or pulses</td>
<td>19</td>
<td>17</td>
<td>40</td>
<td>23</td>
<td>41</td>
<td>145</td>
</tr>
</tbody>
</table>

An inquiry about the irrigation facilities available in the *rabi* season reveals that almost all the crops received only one watering owing to lack of water in the ponds. In some cases, paucity of funds proved a hindrance. Wheat, peas, tobacco and poppy require more than one and at least two waterings, while potatoes and vegetables require regular supply of water at intervals from the beginnings to the period of maturity of the crops. But in many cases, the required quantity of water is not available to such crops with the result that
the average yield is low.

The overall picture that emerges from this study of irrigation facilities available in the kharif and rabi seasons, is not satisfactory. This may be explained by the fact that the farmers have to depend mostly upon ponds, seasonal lakes and streams. In the case of canals, tube wells and masonry wells, a regular supply of water to the fields can be ensured at all times but in the other case, the supply is dependent upon the south-west monsoon, and a failure of this upsets the irrigation facilities of the area to a large extent.