PART - I
PHYSICAL SETTING OF WESTERN UTTAR PRADESH AND
A REVIEW OF LITERATURE
CHAPTER I

STRUCTURE AND RELIEF

1.0 Western Uttar Pradesh structurally forms part of the Indo-Ganga plain, which lies between the ancient southern peninsula and the recently formed Himalayan chain. This is one of the most important plains in the world. It is characterised by monotonous flat surface broken at places by small mounds and village settlements. The whole of Western Uttar Pradesh likewise has a level surface with imperceptible slope of Kilometer. This region lies at an elevation of 150-300 meters above the mean sea level. The Himalayas rise abruptly in the north of the plain and have greatly influenced the hydrology of the rivers which flow from them towards this plain. The region is composed of alluvium brought by the Himalayan rivers, Ganga, Yamuna and Ramganga. The alluvium thus deposited is of universe thickness, enormous width and of uniform character. The absence of any marked surface irregularity permit the rains to sink into the ground, which together with water percolating from major rivers and their tributaries maintain this subsoil water table at level which can be easily tapped (Williamson, 1925).

1.1 Several theories try to explain the origin of the Indo-Ganga plain. According to Suess, an Australian geologist, it was a foredeep formed in front of the resistant mass of the peninsula after the Tethyan sediments were thrust southward, and
compressed against the peninsula resulting in the uplift of Himalayan chain. The rivers rising from the Himalayas brought an immense quantity of detritus and deposited it in this foredeep. The deposition of the alluvium continued although the Pleistocene period upto the present and led to the formation of the plain.

On the other hand, on the basis of geodetic observations, S. G. Burrad found a zone of low density underlying the Indo-Ganga alluvium, and concluded that the presence of this underlying matter of low density points to a rift valley which was formed by tension in the crust leading to crustal opening\(^1\).

Another view has been put forward by Oldham, who suggests that the crust of the earth is floating upon a fluid magma, and therefore, the trough has been created by the sinking of the crust under the weight of alluvial deposit brought down from the mountain by rivers\(^2\).

A more recent theory which seems more convincing about the formation of the plain ascribes its origin to the intense mountain building movement which produced a depression or a foredeep in front of the convex side of the Himalayan arc.

2. Burrad, S.G., ibid, p. 223
Owing to the bending down of the northern edge of India, which came in opposition to central Asian masses.

1.2 As regards the thickness of the alluvium reliable information is derived from borings that have been carried out in Uttar Pradesh. Some borings have been put down in the alluvial deposits to a depth of above (2000 ft.) for tapping water. At Lucknow about 180 Km north of the south edge of the Yamuna-Ganga basin, the deepest of all the bore holes in the Gangetic alluvium was made to a depth of about 400 m (1336 ft) below sea level. The beds which were encountered during the borings were of the same character from top to bottom and consisted of sand and sandy silt with occasional beds of Kankar. The bottom of alluvium at Agra is only 1.5 m (5 ft) above sea level.

1.3 Geologically the alluvial deposits of the Western Uttar Pradesh are classified roughly into two types: (1) Khadar or newer alluvium and (2) bhangar or older alluvium. These deposits correspond in age with the Pleistocene and recent periods of geological history.


4. Krishnan, M.S., Introduction to the Geology of India, Madras, 1944, pp. 169-70

The bhangar lands occupy the higher ground and are not flooded by rivers during the rains. The area under the older deposits is much more extensive than that under the new deposits. The older deposits generally contain Kankar nodules of all sizes and shapes from small grain to big lumps. These deposits are also characterized by the patches of saline and alkaline efflorescence, which are due to the gentle slope of the land and the composition of the alluvium. The Himalayan rivers and the tributaries bring various salts in solution which percolates in the sub-soil of the area they traverse. In the areas where there is no proper surface drainage, these salts keep on accumulating by leaching from the neighbouring areas. During dry season, the soluble salts are drawn up in solution by capillary action to the surface and are deposited there in the form of a white efflorescence. The most important material in bhangar lands is clay, which at places becomes loam or sandy-loam.

The Khadar, relatively rich in plant nutrients, is a newly occupy the deposited alluvium in the narrow flood plain of the rivers. Neutral to alkaline in reaction (pH 6-8), these are deficient in organic materials specially phosphorous, and

6. Shafi, M., Land Utilization in Eastern Uttar Pradesh, Aligarh 1960, p.3
FIG. 2

WESTERN UTTAR PRADESH
CONTOURS

CONTOURS IN METRES

SOURCE: NATIONAL ATLAS OF INDIA

200
220
240
260

RIVER
YAMUNA
GANGA
are sandy to loamy in texture. Locally, as observed by Puri. The Ganga Khadar have immature profiles with sandy to silty loam texture lack of Kankar concentration, fair proportion of lime and other soluble salts and are alkaline in reaction (pH 8) with imperfect drainage while the Yamuna Khadar have sub-mature profile with pre-dominance of clay and concretion and very high lime and other soluble salt contents under ill-drained condition. (Figure 2)

CHAPTER II
DRAINAGE

2.0 Surface Water

The drainage follow the general slope of the region and rises roughly from north to south and south east in the Western Uttar Pradesh. The whole region is divided into three broad drainage basins, each commanded by the rivers Ganga, Yamuna and Ramganga together with their tributaries (Fig.3). These are perennial rivers originating from the Himalayas from where they get a continual supply of water from melting snow in late winter and summer and from rainfall during the monsoons. The rivers Yamuna and Ramganga are the tributaries of the Ganga but in view of their individual importance, these have been treated as separate systems.

2.0.1 The Ganga has a very large basin and it is the most important river of this region. After rising in Gangotary glacier in the Himalayas, it enters the upper doab plain at Haridwar through a well defined gorge in the siwaliks. The solani river joins the river Ganga in Muzaffarnagar district, the river enters the district of Meerut and separates it from the districts of Bijnor and Moradabad. Later on it forms the eastern boundary of the districts of Bulandshahr, Aligarh, Etah and Faurrukhbad and also separates the districts of Moradabad, Badaun and Shahjahanpur on to its eastern side.
FIG. 3
In the region, it roughly in a south, south-easterly direction through a long course and gathers water from its tributaries. The important tributaries that join the river Ganga in Western Uttar Pradesh are the Yamuna, Ramganga, Kali nadi, Nium Wadi, Isan nadi, Tista, Burdanar, Chhoiya, Bhainsaur and Sot. Some of these tributaries are seasonal and increase their volume during the rainy season.

2.0.2 The Yamuna, second major river of Western Uttar Pradesh rises in the region of Jumnotri at a height of 6216.9 meter. It forms the western boundary of many districts of Western Uttar Pradesh such as Muzaffarnagar, Meerut, Bulandshahr and Etawah. Generally it flows in south, south-easterly direction.

The course of river Yamuna is quite irregular along the parganas of Bidauli, Kairana and Kandhla of Muzaffarnagar district. At Madhopur, 5 Km to the north-west of Kairana, it is joined by a small stream called Katha. The banks of the river remains high in water but as the river flows towards south in the district of Meerut, the height of banks is reduced considerably. Here the Khadar deposits along the river is very small. The Hindan nadi joins the river Yamuna near Dadri in Bulandshahr district. The width of the bed of the river in Mathura is about 5 Km. It enters into Agra with a great loop, making the common boundary of the two districts only for a short distance. The average depth at Agra is about 3 m.
The course of the river becomes much wider in Mainpuri district because of the fact that it flows through soft and sandy loam which is more liable to erosion. The most prominent bends of the river in Mainpuri district are found at Punchha and Pariyar. One loop of about 14 Km length is at Horah while another has developed near Dandauli village. The river makes the boundary between Agra and Etawah districts for about 24 Km. Before receiving the waters of Chambal river, it forms the boundary of Jalaun and Etawah districts. The tributaries of the Yamuna are Hindan, Karwan, Rind, Chambal, Senger, Sirsa and Utangan. Most of these tributaries are seasonal.

2.0.3 Ramganga is another important river of this region. Though it is a perennial stream coming out from the Himalayas and has well defined course, yet the area under its course is liable to continual change owing to shifting of river bed. As a matter of fact, the surface of the land where it flows is subjected to annual inundation and deposition of fine sand and silt, similar in character to that of the river Ganga.

The eastern low-land of Budaun district consists of numerous lakes, small and large water channels, marshes, other land depressions and waterlogged patches of land which all are the vestiges of ancient bed of the river Ramganga and are now locally known as "bankati" in the Budaun district1. The

tributaries of the Ramganga are the April, Kadwara, Bhicha, Rapi, Dhela, Kosi, Dhando, Rajherra, Narha and the Bhagul.

2.1.0 Ground Water

Western Uttar Pradesh has a comparatively large source of ground water. The occurrence and distribution of ground water depends upon the characteristics of the underground formations. The alluvial terrain of the Ganga Plain forms one of the richest water bearing formations in the world.

Since this region has no marked surface irregularity the underground aquifers are supplemented from the rain water which sinks easily into the ground. The percolation from major rivers, their tributaries, canals, field channels, ponds and tanks also contribute to maintain ground water level.

According to latest estimates (December, 1983) the net available ground water resources of this region are of the order of 19.5 million cubic meters. Fig. 4 depicts the status of the ground water table contours (by converting the water level data to water table contours with volumes in meters above mean sea level) for the months of April and November 1983 obtained from the data collected by the Central Ground Water Board, Ministry of Irrigation and Power, Government of India. It shows that water table contours vary from 130 to 250 meters both in April and in November. A close examination reveals that the water contours vary according to geological structure, relief, drainage, edaphic and climatic conditions and follows general
WESTERN UTTAR PRADESH
GROUND WATER TABLE
1983

WATER TABLE CONTOUR
WITH VALUE IN METRE
(ABOVE M.S.L.)

---- IN APRIL
----- IN NOVEMBER

SOURCE: CENTRAL GROUND WATER BOARD

FIG. 4
south-easterly direction corresponding to the surface slope. In the northern districts lying in the tarai belt, the water table lies within 5 meters in summer but rises up during the rainy season and immediately thereafter creates swampy conditions. In the Central Ganga Plain the water table ranges in depth from 5 to 10 meters but in the interfluvial tracts of the rivers Ganga and Yamuna it may be 15 to 20 meters deep. In the canal command areas the water table lies within 2 meters because of the influence of seepage from water channels.
CHAPTER III
CLIMATE AND SOILS

3.0 India is predominantly the land of tropical monsoon climate. It is possible to grow two or more crops in a year in most parts of the country, provided adequate soil moisture could be maintained. On account of the uniformity of relief there is a remarkable uniformity of climate over large areas of Western Uttar Pradesh. As the region lies between the dry Punjab plains and the humid eastern plains of Uttar Pradesh, it experiences the climatic characteristics of both the adjoining regions. With comparatively greater incidence of winter rain, the region distinguishes itself from eastern plain. The region receives 60 to 100 centimeters of annual rainfall of which 90 per cent occurs during the rainy season.

From climatological point of view the year in Western Uttar Pradesh can be divided into three seasons:

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

3.0.1 Winter season is marked by a fall in temperature and prevalence of dry and chilly westerlies and clear skies. Occasionally the western depressions bring some well come rains and a cold wave when temperature may come down to freezing point. The maximum temperature falls from about $29^\circ$C to $23^\circ$C while minimum falls from about $12^\circ$C to $10^\circ$C in December (Fig.5).
WESTERN UTTAR PRADESH
ANNUAL TEMPERATURE
1993

SOURCE: INDIA METEOROLOGICAL DEPARTMENT

FIG. 5
The temperature shows a further decrease in January when the maximum and minimum are 21°C and 6°C. The cold waves coming from the Himalayas also bring a fall in the temperature for a short period. The direction of prevailing winds is normally from west and north-west to east and south-east. The winds are dry and light and generally blow at an average speed of about 3.2 Kilometers per hour. During the winter season specially in the months of January and February, a series of western depressions enter India through Iran, Afghanistan and Pakistan and move eastward across the Western Uttar Pradesh. These depressions cause cloudy weather and light rain accompanied by cold waves. The total rains occurring during winter season does not exceed from 4 to 5 centimeters. The precipitation decreases from west to east. The winter rains are not sufficient for rabi crops especially for the high yielding varieties of wheat which requires 5 to 6 irrigations. Under these conditions irrigation is a must for carrying successful agricultural operations. Proper irrigation also saves the crops from the loss caused by the frost. The frost, which occurs in this region during winter season is harmful for the crops like arhar, peas and mustard.

3.0.2 The hot weather period extends over the months of March, April, May and the first week of June. The rise of temperature in March and clear skies with light westerly winds of the day and relatively cool nights produce good effect on the ripening of the rabi crops. The temperature rises even more in the months of April and May. Similarly, the mean maximum and minimum temperatures also increase from west to east. The maximum and minimum temperature for April are 38°C and 21°C. In April the days are usually hot while nights remain still cool. The mean monthly relative humidity decreases to considerable extent. The months of May and June record exceptionally high temperature as high as 44°C and even more than 46°C for a few days. In hot season winds blow from west, north-west to east, south-east. In the months of May and June the hot winds known as loo originate as a result of the convective air movement produced by the heating of the surface air and rapid decrease of temperature as one goes up in the atmosphere. Dust and thunderstorms locally known as andhis usually occur in the afternoons and are accompanied by squally winds, thunder, blinding dust and sometimes rains.

3.0.3 The season of general rains commences from the second week of June and continues upto October. On account of

excessive heat, a low pressure develops in northern part of India and by the middle of June it brings a complete reversal in the air movements. The winds begin to move from the Indian Ocean to the landmass in a south easterly direction. These humid oceanic currents bring heavy downpoures which reduce the temperature of the area. The sudden arrival of monsoons transforms the whole landscape. July and August are the rainiest months of the year and about 55 per cent of the total annual rainfall occurs during these months. The average rainfall is about 75 centimeters and the amount decreases westwards as well as southwards. The maximum and minimum temperature gradually falls from 44°C to 27°C in June to about 30°C and 25°C in July. The relative humidity remains over 70 per cent throughout the rainy season. Fig.6 shows the variation in rainfall. A variability in excess of 20 per cent implies great risk in farming. In these areas therefore agriculture cannot be carried without irrigation.

3.1 SOILS

Generally the soils are so uniform and similar in their characteristics that it is often difficult to differentiate the soil of one region from that of the other. However, the soils of Western Uttar Pradesh are of alluvial origin. These soils have resulted from the deposition of the silt brought by the rivers and tributaries of the Ganga system. The alluvium has been divided into the broad geological
WESTERN UTTAR PRADESH
RAINFALL

FIG-6

SOURCE: INDIA METEOROLOGICAL DEPARTMENT
subdivisions, i.e. old alluvium and new alluvium. The newer alluvium of sandy nature, of less Kankari composition and light in colour is known as Khadar. It is in the process of building up. The older alluvium of more clayey composition, full of Kankar and of darker in colour is called bhangar. It is in the process of denudation. The Khadar occupies the flood plains of the rivers and their tributaries as a result of which the constituents of such lands are renewed every year. The bhangar soils are represented by level plains above the flood level of the rivers and the tributaries. These soils differ considerably in their texture and range from sandy bhur through loam and silt to heavy clay which are ill-drained and sometimes charged with injurious salts resulting into the formation of reh.

Broadly speaking, the soils of Western Uttar Pradesh can be divided into three groups: (1) The Khadar or newer alluvium, (2) The bhangar or older alluvium and (3) The tarai. (Fig.7).

3.1.1 Khadar or new alluvial Soils

Khadar is limited in extent and strictly confined to the terraces and the flood plains of the big rivers i.e. Ganga, Yamuna and Ramganga and their tributaries. It makes a narrow strip along both sides of the main rivers and is always exposed to floods and water-logging. Its water retention capacity is very poor. The colour of the soils varies from light grey to ash grey and the texture is sandy to silty loam. The
ground water table is usually very high and lies near the surface. The sandy soil popularly known as bhur for the most part consists of sand of whitish colour. The Khadar tract is quite precarious for agriculture. It is generally used for the production of millets and pulses in Kharif and mostly barley and gram in rabi. Salt efflorescence is quite negligible in sandy tract.

3.1.2 Bhangar or old alluvial Soils

The bhangar soils are more extensive in areal spread, occupying the interfluvial zones. The most important material in bhangar is clay which at places becomes loam or sandy loam. It generally contains Kankar and is of darkar in colour.

On the basis of texture, the bhangar soils have been further sub-divided into sandy, sandy loam, loamy, clayey, silty loam and saline and alkaline soils.

Sandy soils on bhur have an unusual geomorphic feature that adds a variety to the rather monotonous landscape. Its sandy ridges with a flat topped and gentle lateral slopes extend into the Moradabad district from northwest to southeast and are roughly parallel to river Ganga. It extends upto Budaun district only and there is no bhur area in Shahjahanpur district. It is poor in humus content. This is due to the fact that the soils has undergone several stages and degrees of
oxidation.\textsuperscript{3} It was until recently a somewhat negative tract mostly\textsuperscript{4}. But now it has partly been reclaimed through some manuring and irrigation and is being utilized for agriculture. The chief crops grown in this tract are millets and pulses among the grain crops, groundnut among other crops of Kharif and wheat, barley and peas in the rabi.

Sandy loam soils occupy a considerable portion of a generally well drained plain. The tract comprising sandy loam stretches in elongated strips along the main rivers like Ganga and Yamuna and run just in the immediate vicinity of the Khadar lands. These long patches are well defined along the river Yamuna. The greatest width of this tract is seen in Aligarh, Agra and Mathura districts. The sandy loam tract is rather broad in the upper regions of Muzaffarnagar, Meerut, Bulandshahr and in parts of Aligarh districts. It is interspersed by long patches of good quality loam chiefly in Etah and Farrukhabad districts. The sandy loam belt in Budaun and Moradabad districts stretches along both eastern and western sides of the bhur tracts as well as the north and south of it. The most

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characteristic feature of this soil is its homogeneity and level topography throughout the area. The texture of these soils is predominantly sandy and the colour ranges from yellow through brown to reddish brown. It contains humus but lesser than loamy soils. Without irrigation and manuring the soils becomes weak in crop production. The water holding capacity is generally low. The main crops grown in this soil are millets, pulses, maize, tobacco and groundnut in Kharif and barley, peas and potato in rabi. Sugar cane can also grow where irrigation facilities are available.

Loamy soils lies in disconnected patches. It is the best soil of the region which is rich in humus and organic matter. Water retention capacity of this soil is comparatively high and the underground water level is low. These soils locally known by different names in different parts of the region are generally called as matyar, domat and Kalihar. One elongated patch of loamy soils runs more or less parallel to the Kali nadi passing through Aligarh, Etah and Farrukhabad districts. Another important tract of this soil runs through Mathura and Agra districts in Western side of the river Yamuna. Third tract runs through Moradabad and Budaun districts. It also covers a considerable area in Shahjahanpur district. The colour ranges from light grey to brownish grey. The underground water table is low. The surface soils have more of sands, shows light acidic reaction while at places where the percentage of clay increase,
the reaction is mostly basic and the surface is covered with efflorescence. In many depressed areas, the percentage of clay increases towards the lower depth, with the result that Kankar pans are found in the bottom.

Clayey loam soils occur in lowlying areas where jhils and swamps are common feature and the drainage is very much restricted. One tract of this soil type is found between the Rina and Sengar nadi, another in the northwest and west of Ramganga in Budaun, Shahjahanpur and Moradabad districts. It is also found in the westernmost part of Mathura and Agra districts. The soil is darker in colour. The calcarious pans (Kankar) are also found sometimes in the sub-soil. The soil is better for transplanted rice. Millets and Kharif pulses are grown in comparatively higher and drier parts, whereas gram, peas and fodder are grown in the rabi crops.

Silty loam soil is slightly different from the loamy soil. It is more fertile. It is found dispersed in upper interfluval plain of Ganga-Yamuna doab.

The saline and alkaline soils popularly known as reh, usar or thur are found scattered in vast stretches. It is generally distributed in the lowlying and ill-drained areas. More or less it is found in every district but in Aligarh, Mainpuri and Etawah, it covers vast areas (Figure 8).

WESTERN UTTAR PRADESH
DISTRIBUTION OF
KHADAR AND BHANGAR

SOURCE I SETTLEMENT REPORT AND GAZETTEERS OF
THE MUZAFFARNAGAR, MEERUT, BULANDSHAHR
ALIGARH, MATHURA, Agra, ETAH, MAINPUR,
ETAWAH, FARRUKHABAD, BUDAUN, SHAHJAHANPUR
AND MORADABAD DISTRICTS
II SURVEY OF INDIA SHEETS OF THE DISTRICTS
OF WESTERN UTTAR PRADESH

FIG. 8
3.1.3 Tarai Soils

The tarai soils cover a small area in Moradabad district. The texture varies from clay-loam to sandy-loam. Due to excellent moisture the need of irrigation is less. The surface soils are rich in organic matters as well as nitrogen content.
CHAPTER IV

AGRICULTURAL DEVELOPMENT : A Review of Literature

4.0 Agriculture has witnessed over-all development in the world since the beginning of this century. Indian agriculture has also undergone change owing to governmental efforts and scientific utilization of land. The government has setup commissions and committees for the promotion of the welfare and prosperity of rural population in India, e.g. the Famine Commission, the Committee on Cooperation of 1915 and Royal Commission on Agriculture in 1926. These commissions and committees made many recommendations for the development of agriculture in India.

After independence the economists, geographers, agricultural planners and the government of India have all been concerned with agriculture and its development. According to Khare, due to certain inbuilt constraints of a backward area, development in certain parts could not be spread to the rest of the area. The agricultural development should be coordinated with dispersal process through a chain of agro-based industries and it is through such a decentralised strategy that one can achieve the balanced regional agricultural development in the country1.

Shafi has given a formula both to determine the agricultural productivity and to determine the productivity of a particular crop with reference to yield per hectre and the area of that crop in the district in relation to the national level\(^2\).

Tara Shukla pointed out certain problems of growth of traditional agriculture such as transformation of traditional agriculture, stages of increasing agricultural production, spread of new technology and bases of technological research\(^3\).

The optimum use of land for production as pointed out by Shafi depends to a large extent on the level of technology and the system of farming. In his opinion, there are two ways for increasing food production: a) increasing the area under cultivation, and b) increasing the output per head. He also points out that one of the major hinderance in the optimal use of the land lies in the land tenure system\(^4\).

According to Chawdhari, the farmers, in order to produce more, need to spend more on improved inputs which must be financed either out of savings or borrowing\(^5\).

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Noor Mohammad has emphasised the use of modern technology for bringing about a change in agricultural output. He pointed out that the technological factors such as fertilizers, improved seeds, pesticides and new farm implements are capable of increasing the agricultural productivity. In view of Oammen, the term technological change means all kinds of innovations and inventions which are aimed at increasing the efficiency of agricultural productivity.

The point which needs immediate attention according to Noor Mohammad is that the gestation period between the first thought technological change and putting it into practice even at low level of intensity should be reduced. Therefore, for increasing production and bringing about a remarkable result immediately after the introduction of an innovation, specific methods have to be taken to bring down this period.

Minhas and Nathan have explained the inter-state and intra-state variations in output in terms of variations in

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the extent of variable culturable area and per hectre yield\(^9\).

Bhalla has concluded that the variation in the agricultural productivity is introduced mainly by the nature of various inputs of technology\(^{10}\).

According to Kanwar, for a maximum output from land it is necessary to bring more land under irrigation, fertilizers, high-yielding varities and better agronomic technology\(^{11}\). The application of technology in agriculture as suggested by Thirumalai should be geared in a way to get immediate and long term gains. The development programmes based on technology are related to the conservation of soil resources, expansion of irrigation facilities, intensive farming through the application of modern techniques, manures, fertilizers and high-yielding varieties of seeds\(^{12}\).

In the present days what is needed to improve agriculture in all parts of the country is to conduct area-wise

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\(^{11}\) Kanwar, J.S., "Fertilizer- The Kingpin in Agriculture", *Indian Farming*, Vol.18, No.12, 1969

\(^{12}\) Thirumalai, S. *Post-war Agricultural Problems and Politics in India*, Bombay, 1954
study of the cultivators problems and evolve technology to meet specifically the problems and constraints causing low productivity in each region (Bhatia). It is because of technological innovations that the world agriculture is able to feed world's population today. The innovations came one after another in stages. At every stage, the adoption of new technique meant a great leap forward towards increase in agricultural production.

According to Pal, the irrigation alone cannot increase the required agricultural production. It is the other inputs also used with adequate water supply which can increase the agricultural production.

The immediate outcome of the green revolution was in the form of increased agricultural production but in view of Arshad, it has failed to make any appreciable difference in the overall rate of agricultural growth. According to him, the introduction of high-yielding varities along with new technology and fertilizers alone cannot balance agricultural production. An all-round production and growth in all the crops in all the regions is the only solution.

Sharma has suggested that the development of agriculture should be assessed not only by productivity levels but also with reference to inputs such as fertilizers, improved varieties of seeds and irrigation\textsuperscript{16}.

The correct use of fertilizers has been pointed out by Koakab Durry as an important step towards increasing agricultural efficiency. This can be achieved not only just by going along with general recommendations but by ascertaining the actual nutrient deficiencies of the soil that have to be taken care of by applying the appropriate quantities of nitrogen, phosphorous and potash\textsuperscript{17}.

The policies of increasing the fertilizer use as suggested by Desai should be based upon a strategy which aims at both rapidly converting the untapped potential into actual use and continuously raising the economic potential of fertilizer use through upward shifts in response functions. It has been seen that fertilizer diffusion has been most rapid on crops and varieties which respond to fertilizer use dramatically, even though they did not have best price environment\textsuperscript{18}.

\textsuperscript{16} Sharma, A.C., \textit{Mechanization of Punjab Agriculture}, New Delhi, 1976

\textsuperscript{17} Durry, K., "Improving Agricultural Efficiency through Fertilizers", \textit{The Geographer}, Vol.33, No.2, 1986, pp.13-24

According to Jaine Quizon, fertilizer is the crucial input in raising the agricultural productivity. It is because of its importance that the government intervention in the fertilizer market to encourage its more widespread production and use has been a common phenomenon. As the availability of fertilizer is limited, Arora and Sharma have proposed to increase area under pulses or other non-fertilizer using crops, where as high-yielding varieties of wheat and paddy may be raised under irrigated conditions.

Jain concludes that agriculture is now paying well on account of the availability of a wide array of high-yielding varieties of seeds and hybrid seeds. If, institutional finances are made available to the farmers, they can purchase all these costly inputs and agricultural productivity can be increased.

Burney advocates the use of pure seed as one of the cheapest input and one of the most recognised facts about


the agricultural development. Shastry has carried out a detailed assessment of the two latest high-yielding varieties of rice: Jaya and Padma.

Rege pointed out the relationship between soil, water and plant and suggested use of irrigation to get assured crop especially during drought.

It is now widely recognized that in plans for agricultural regeneration in India, irrigation has to play a catalyst role. Bhatia feels that the use of the fertilizers and high-yielding varieties of seeds requires assured water supply to the farms.

The irrigation development and improved water management are crucial to India's agricultural development. The supply of land being inelastic, accelerated growth in production is possible only through increased multiple cropping and realization of higher crop yields per unit area, both of which are heavily dependent on irrigation.


The ground water has already proved itself to be the most valuable source of water in the country for irrigation purposes. According to Vohra state ground water organisations must be responsible for giving competent technical advice to farmers regarding the kind of tube-wells and pumpsets the farmers should install in their holdings so that there is no wastage of either scarce materials and scarce energy resources. The state governments should also take up systematic programmes for the consolidation of holdings because this is one of the surest ways of encouraging ground water development\textsuperscript{27}. Vasant suggests that efficient management of the developed water resources and supply and application of all other inputs needed for irrigated agriculture can produce sufficient foodgrain for the over increasing population of India\textsuperscript{28}.\textbackslash

The importance of water management for increasing yields has also been highlighted by Destance and Patil\textsuperscript{29}.

The farm benefits from a unit of irrigated area are not consonant with the size of a farm holding. Small farmers can gain, acre for acre, as much benefits from irrigation as do large farmers. Therefore, Dhawan suggested a policy of extensive irrigated agriculture in which lightly irrigated crops would

\begin{itemize}
  \item Vasant, N.S., "Development of Irrigation and Power in India", \textit{Yojana}, Vol.31, No.6, April 1987, p.20
\end{itemize}
preponderate to be more attractive from several larger angles such as agricultural growth, its stability and interpersonal/spatial equity within the state\(^3^0\).

The cultural machinery and implements as pointed out by Bater can raise the agricultural productivity and it was therefore suggested that machinery and implements should be introduced in areas where they are not used\(^3^1\).

The Food and Agriculture Organisation has published two reports in 1953 and 1955. The report published in 1953 emphasised on machinery and stated that the machinery is more cheaper than labour. The second report published in 1955 gives an idea of progress in technology for agriculture. Another report published in 1968 deals with the problem of raising agricultural productivity by applying modern technology\(^3^2\). Jain also concluded that mechanization is highly responsible for raising the agricultural productivity\(^3^3\).


\(^3^1\). Bater, W.N., Mechanization of Tropical Agriculture, London, 1957


\(^3^3\). Jain, S.C., Technological Changes and their Diffusion in Agriculture, in S.C. Jain (ed.) Changing Indian Agriculture, Bombay, 1966, pp.57-58
In studies relating to pests, Mathur has revealed that the use of high yielding varieties and seed treatment with organomercury compound is an important step towards the control of a number of seed borne diseases. According to Pradhan, there are 62 pest species which are common to several crops and are causing damage to agricultural production.

Increasing the agricultural production is a must and their protection from pests according to Singh is as important as use of irrigation, high-yielding varieties and fertilizers. He has suggested that the farmers need to be educated about judicious use of fertilizers otherwise the boon can turn into bane.

According to Khanna and Mital, there are about 85 species of insect-pests, reducing the yield of rice in Uttar Pradesh.

In a recent study made in Uttar Pradesh the key question was raised as to how the increase in agricultural productivity is dependent on variables like irrigation by canal, 

34. Mathur, R.S., Plant Disease, New York, 1969
35. Pradhan, S., Insect-Pest of Crop, New Delhi, 1969
tubewell and from other sources, high-yielding varieties of seeds, fertilizers per 1000 hectares and tractors per 1000 hectares. Shafi pointed out that for optimum utilization of land resources, the programmes of land reform, consolidation of fragmented holdings, irrigation and drainage should be integrated and executed in proper sequence\textsuperscript{38}.

A recently published F.A.O. report emphasised the role of land system in the development of agriculture\textsuperscript{39}.

The two reports of United Nations in (1951) pointed out that there are four objectives of land reforms namely, maximization of output and productivity, increasing employment opportunities, fair and equal distribution of income and ethical order. The second report of the same year has suggested certain measures to improve the agrarian system\textsuperscript{40}.

According to Raza, the output of food per head can be raised out by increasing the yield or productivity per acre. This can be achieved through carrying out necessary land reforms. He pointed out that there are strong reasons to support


40. F.A.O., Progress in Land Reform, New York, 1951, pp.51-80
the view that there has been some casual link between the land reform and agricultural productivity\textsuperscript{41}.

According to Russell King, three motives, the political, the social and the economic are basic and govern most reforms. By fixing of 20 acre ceiling on land ownership would correspond to an egalitarian motive of enabling every farming household in India to have a minimum subsistence plot of 2 acres, but the creation of million of 2 acre plots would adversely affect food production and reduce the marketable surplus\textsuperscript{42}.

Singh and Mishra, after making a survey of land reforms in Uttar Pradesh suggested certain changes for increasing the area under cultivation including current fallow by more than 8 per cent\textsuperscript{43}.

The most important feature of backwardness of Indian agriculture as pointed out by Jather and Beri is the endless subdivision and fragmentation of holdings. In the light of their occurrence the authors have suggested remedial measures to control this problem\textsuperscript{44}.

\begin{itemize}
\item \textbf{41.} Raza, M., "Land Reform and Land Use in U.P." \textit{The Geographer}, Vol.15, 1968, pp.39-49
\item \textbf{42.} King, R., \textit{Land Reform: A world Survey}, London 1977, p.3
\item \textbf{43.} Singh, B. and Mishra, S., \textit{A Study of Land Reforms in Uttar Pradesh}, Calcutta, 1964
\item \textbf{44.} Jather, G.B. and Berims, G., \textit{Indian Farming}, Madras, 1949
\end{itemize}
Report of National Commission on Agriculture (1976) pointed out that one of the major causes of low agricultural productivity in India is the fragmentation of holdings. It suggests the consolidation of holdings as the only answer to improve the agrarian structures.\(^4^5\)

However, there has been some concern about the fragmentation of holdings and according to Jather and Beri, the areas previously uncultivated due to excessive fragmentation have now been brought under cultivation through land consolidation.\(^4^6\)

Manu has studied the scope for land consolidation and conservation and their impact on agricultural productivity, while Saxena and Sharma have focussed attention on the causes of soil erosion and various methods to control them. These methods have been applied in Etawah district in Uttar Pradesh.\(^4^7\)

Agricultural credit, according to Thirumalai is the pivotal problem in the scheme of agricultural development in India. Credit is the motive power for setting on its wheels the productive machinery in agriculture conceived and planned on the...

\(^{45}\) Report of the National Commission on Agriculture, Government of India, Ministry of Agriculture and Irrigation, New Delhi, 1976, part 15, p.184

\(^{46}\) Jather, G.B. and Beri, S.G., Indian Economics, Madras, 1949

a scientific basis\textsuperscript{48}.

Dadibhavi has conducted a micro-level study of the problems of agricultural development of backward regions and calls for urgency in rechannelising the institutional finance flows to micro-generating activities in the low per capita income regions\textsuperscript{49}.

The strategy of agricultural development in the opinion of Goud calls for extending proper financial assistance to the farmers so as to improve them from clutches of money lenders and for rapid agricultural development. He is of the view that there should be a separate agency to finance the farmers at village level. According to him, in this connection primary agricultural cooperative credit societies play immense role in transforming the traditional agriculture into a modern one\textsuperscript{50}.

In India, the first comprehensive analysis of the whole problem of agricultural credit was made by the Committee of Direction of the All Indian Rural Credit Survey appointed by the Reserve Bank of India in August, 1951. Its report suggested three important ingredients, a) the governments concern must

\textsuperscript{48} Thirumalai, S., \textit{Post-war Agricultural Problems and Policies in India}, Bombay, 1954, p.181

\textsuperscript{49} Dadibhavi, R.V., "Why these inter State Disparties", \textit{Yojana}, Vol.31, No.11, 1987, p.4

\textsuperscript{50} Goud, R.S., "Cooperative Finance and Weaker Sections", \textit{Yojana}, Vol.31, No.4, 1987, p.14
assume major responsibility for provision of funds, b) the
realisation of the intimate relationship between the
agricultural credit and marketing of agricultural produce, and
c) the agricultural credit based on the productive capacity of
the borrower is feasible and ought to replace credit based on
the security of immovable property.51

According to Sharma all agricultural productive
activities require for their sustenance some degree of credit. A
farmer who can raise only one crop a year, has to maintain
himself and his family throughout the year, therefore, needing
loan. The agricultural credit is largely responsible for the
agricultural development.52

A study published by Union Ministry of
Cooperatives and Panchayati Raj shows the importance of
cooperative in the development of agriculture providing loans
and other important inputs. Cooperatives ensure the full share
of all the farming community through balanced growth of
production.53

52. Sharma, A.N., Economic Structure of Indian Agriculture, Bombay, 1984, p.247
It has been suggested by Nath that the development of cooperatives and expansion of infrastructure will help in the development of Indian Agriculture\(^5^4\).

The Congress Agrarian Reform Committee pointed out that unless and until land is owned by tiller his incentive to production does not reach the optimum point due to his being insecure about the benefits from the land that he cultivates. Even if he is allowed to enjoy the security of tenure, will only enhance the rate of rent which he has to pay, if the improvement in land is made by him\(^5^5\).

Drawbacks of the prevailing land system are highlighted by Singh and Mishra who say that often it inhibits all initiation, stifles all efforts and prevent any enlargement of inputs due to insecurity, rack-renting, the practice of subletting and feudal or feudalistic structure of land rights\(^5^6\).

Agricultural development throughout the world is strongly motivated by the incentive of the farmers, which may take the form of pride and ownership, security of occupancy and expectation of a just division of farm income between landlords.


\(^5^5\) Report of the Congress Agrarian Reforms Committee, p.38

and tenants. These factors everywhere have the impact in improving the conditions of land.\(^{57}\)

Agricultural productivity depends on two sets of factors: technological and institutional. Those who advocate technological factors are of the view that even, if no institutional reforms are introduced, technological improvements will bring about agricultural development. On the other hand, another school of thought strongly believes that agricultural development is seriously hampered on account of certain institutional barriers. They argue that introduction of institutional reforms can release agriculture from the bondages which keep it backward and depressed. The existence of feudal or semi-feudal land relations are the biggest obstacle to agricultural development.\(^{6}\) The bulk of the income of the poor cultivators is appropriated by the land owners in the form of rent, share cropping, etc and the peasants are left with very little savings to bring improvements in land. Moreover, insecurity of tenancy rights as a further disincentive for undertaking investments in hand. In times of natural calamities like floods or droughts, the poor peasants are forced to borrow from the landlords or moneylenders. Being debtors, they are forced to sell their crops to the agriculturist moneylenders at prices much below the market prices. Thus, the institutional

\(^{57}\) U.N. Economic Bulletin for Asia and Far East, Vol.11, No.1, June, 1960, p.8
framework of ownership, tenancy and agricultural credit all work in such a fashion that they deny the cultivators the fruits of his effort\textsuperscript{58}. The exploiting classes represented by the landlord, the agriculturist, money-lenders and mechanics exploit the actual tiller of the soil. It is therefore believed that in order to reap full benefits of technological change, institutional reforms are extremely necessary.

4.1 TECHNOLOGICAL FACTORS

Technological change is one of the important forces which alter the structure of agricultural production process. The term technological change is used in a broad sense to include all kinds of inventions and innovations aimed at increasing the efficiency of agricultural production. Technological change is the key to rapid rate of growth in Indian agriculture that lies in continuous economic adjustment of town organizations to absorb technological improvements on a profitable basis. The proper combination of various technological factors i.e., ensured agricultural innovations, use of chemical fertilizers, high yielding varieties of seeds, modern agricultural machinery and improved farming techniques should enhance agricultural efficiency and yield much returns.

The technological factors throughout the history of mankind in general and during the recent years in particular have played significant role not only in overcoming various environmental constraints on agriculture but also in bringing further changes and development in existing ones. A number of methods have been developed to increase productivity by using fertilizers, better techniques of working the soil, improved breedings, development of high-yielding seeds, and the control of pests and diseases through the development and manufacture of pesticides, fungicides and herbicides. In brief, the technological change in agriculture consists of adoption of new farming techniques developed through research to bring out diversification and increase in production and greater economic return to farmers. High agricultural production greatly depends on the use of fertilizers, and new agricultural implements. The speedy and extensive development of agriculture, by and large, depends on technological change and spatial diffusion of agricultural innovations.

4.1.1 Fertilizers

The provision of sufficient fertilizers at reasonable costs and at requisite time is the most fundamental requirement for the development of agriculture under the conditions prevailing in India. In fact the level of fertilizer use per hectare of cultivated land is closely linked to the
level of crop production per hectare. The scope for increasing production by bringing more land under the plough, particularly in developing countries like India, is extremely limited and the only hope for the future lies in increasing the production per unit area\textsuperscript{59}. Fortunately, the experience with high yielding varieties of seeds has given us confidence and the scope for increasing production by breeding and utilising fertilizer responsible for it is very large.

Fertilizers are often regarded as substitutes for animal manure, but that is not correct. Animal manure improve soil conditions and supply nutrients. Animal excreta and green manure contribute directly to the soil organic matter. Fertilizers do so indirectly by increasing the quantity of crop residues available for incorporation into the ploughed lands\textsuperscript{60}. Nitrogen, phosphorus and potassium are required by the plant in large and are known as primary nutrients; while calcium, magnesium and sulphur are secondary nutrients. The requirement of these nutrients is generally supplied by the use of common nitrogen, phosphorus and potassium fertilizers.


\textsuperscript{60} Ignatieff, V., \textit{Efficient use of Fertilizers}, F.A.O., Agricultural Studies, Italy, No.43, 1958, p.2
The quantity of fertilizers to be applied to each crop depends upon the level of the nutrients in the soil and the crop requirements. Lack of nitrogen results in poor growth of plant, and a uniform yellowing of the leaves. Indian soils are deficient mainly in nitrogen. The source from which the required nitrogen can be used are farmyard manure like cowdung, compositing of night soil and vegetable refuse, etc, oil cake, green manure like Saun and dhencha, bonemeal and chemical fertilizers. The most beneficial method whereby this essential element of nitrogen can be applied is through the roots of leguminous plants carrying out a natural process of nitrogen fixation. Lack of phosphate is often associated with a purple leaf colour, particularly at the edges, but in certain crops such as cotton and tobacco the leaves become dark green. Insufficient potash causes a swelling of the leaf edges of many plants including tobacco, cotton, maize, groundnuts and many fruit trees. The effect of potash on sugarcane varies with the soil and rainfall. The sugar content of the cane is frequently increased by the use of potash.

Thus an important step towards increasing the efficiency of agriculture is to ensure the correct use of fertilizers and this can be done not only by just going

along with general recommendations but by ascertaining the actual nutrient deficiencies of the soil that have to be taken care of by applying the appropriate quantities of nitrogen, phosphorus and potash. In fact, fertilizers and manures constitute a crucial input in agricultural production.

4.1.2 High Yielding Varieties of Seeds

Almost every cultivator knows the potentiality of high yielding varieties of seeds for raising the level of return from the crop. The country has attained self-sufficiency in seeds of high yielding varieties and is in position even to export these seeds to other countries. The HYVs of crops offer an unprecedented opportunity for a breakthrough in agricultural productivity. If used with suitable combinations with other inputs in particular, fertilizers, water and crop protection chemicals, they are capable under favourable conditions of raising yields severalfolds compared with those of local varieties. The new varieties may be superior to the old ones in three different ways; yield capacity, cultural reliability, and quality of product.


The phenomena of any improved variety must be considered in relation to a given ecological and agricultural environment. The yield potential of the new cereal varieties can be achieved only if they are used in conjunction with adequate inputs of fertilizers and water, careful attention of crop production and generally high standards of farming.

In 1960-61, a pilot project in seven intensive Area Development Programme (IADP) districts was tried. These areas were such which had an assured supply of irrigation and were free from natural hazards. The project decided to introduce high yielding varieties with recommended dose of chemical fertilizers. The IADP districts showed 25.53 per cent higher yield per acre than the non-IADP districts. In some cases, the difference of yield was of the order of 50 per cent.

For most traditional varieties of wheat and rice, fertilizer responses fall off at about 40 to 50 Kg of nitrogen per hectare. For high yielding varieties, the response increases upto 100 Kg or more. In India, recommended fertilizer doses for the Mexican wheat are 80 to 120 Kg N, 40 to 60 Kg P₂O₅ and about 40 Kg K₂O per hectare⁶⁴. In 1966-67, two purely Mexican varieties of wheat seed named Larna and Sonara-64 were adopted for cultivation in irrigated areas. About 1800 million tonnes of high yielding varieties of wheat seed were imported from Mexico.

⁶⁴. Ibid., p.17
which facilitated the cultivation over large area in India at that time, there was great doubt about the wisdom of importing such large quantities of seeds. Later on, some of these Mexican varieties were improved upon by Indian scientists and new Indian varieties like Kalyan Sona, Sonalika, Safed Larna, Chhoti Larna have been evolved. Water availability and management are particularly important. Mexican varieties of wheat should receive at least two or more irrigations than the local ones. In some areas of rice fields the problem is an excess rather than a deficiency of water. For example, because of deep flooding the new short-strawed varieties cannot be introduced without improved water control. Pests and diseases are another problem.

So the application of the package of inputs of high yielding varieties and recommended doses of fertilizers have resulted in increase in yield per hectre\textsuperscript{65}. However, in such crops where distinctly superior high yielding varieties were available, the rise in yields has been spectacular. This is clearly noticed in the wheat revolution in Punjab, Harayana, Rajasthan and Western Uttar Pradesh. The new Mexican varieties like Lerma Rojo, Sonara-64, Kalyan and P.V.-18 became so popular that the government was unable to meet the demand of farmers for better seeds and it also could not supply adequate quantities of fertilizers against the rapidly rising demand. However, some

\textsuperscript{65.} Dutt, Ruddar, op. cit., p.242
breakthrough has been achieved in rice areas. Better high yielding varieties are being developed in rice and other areas.

The art of plant breeding, reinforced by the science of genetics, has revealed possibilities of increasing yield of crops, through new varieties, sometimes based on hybrid vigour. It is essential that normally five to ten years is the time required for placing the entire area of a crop under improved varieties in most of the areas through organised multiplication and distribution of seeds\textsuperscript{66}.

4.1.3 Irrigation

Alongwith good seeds and fertilizers, there is also the need for timely supply of water in adequate quantities. In India, farmers are most dependent on rainfall for the supply of water to their fields. But monsoons are highly uncertain and irregular. The capriciousness of rainfall in India manifests itself in a variety of ways. In any particular year, the rains may not arrive at all, or it may come in torrents. Again, the monsoons may start too early or too late, or yet again the rains may not be sufficiently prolonged and well distributed. All this upsets agricultural work, resulting in partial or complete failure of crops. And the tragedy is that the uncertainties or

\textsuperscript{66} Thirumalai, S., op. cit. p.171
abnormalities of rainfall in India are the general rule, rather
than the exception. As such the harm caused by them is a normal
feature of Indian agriculture. Therefore, irrigation can afford
security against the vagaries of monsoon\textsuperscript{67}.

The most effective way of increasing agricultural
production in India is to control the sources of water supply
and increase the maximum possible limit of irrigational
facilities to provide assured, adequate and regular water to the
fields throughout the crop-calender year, according to the needs
of the crop pattern that may be determined as necessary to
fulfil the objective of increase in production\textsuperscript{68}.

Because of unfavourable rainfall, farmers could
cultivate only one crop without irrigation in the limited
period. Therefore, irrigation development and improved water
management are crucial to India's agricultural development. The
supply of land being inelastic, accelerated growth in production
is possible only through increased multiple cropping and
realization of higher crop yields per unit area, both of which
are heavily dependent on irrigation\textsuperscript{69}.

\textsuperscript{67} Agrawal, A.N., \textit{Indian Agriculture and its problems}, Delhi, 1953, p.14

\textsuperscript{68} Thirumalai, S., \textit{Post-war Agricultural Problems and Policies in India}, Bombay, 1953, p.60

\textsuperscript{69} Roy, Shyamal, "Irrigation Development under India's New Plan (1978-84)- An Apprasial", \textit{Agricultural Situation in India}, Vol.26, No.5, August, 1979, p.303
It has recently been suggested that India can be divided into three broad groups of areas according to the character of the water supply and the stability of production and that different policies are required for each of these areas. The first area lies where there is an assured water supply both in volume and in spread either from assured rainfall or from sources of irrigation, e.g. tube-wells, deep bore wells, canals from snowfed rivers or storage dams which are not unduly dependent on the vagaries of the monsoon. In these areas the irrigation policy should be intensive and productivity oriented, aiming to maximize yields per hectare. In the second group areas, where the water supply is largely dependent on the monsoon, the policy should be mainly protective. In the third group of areas, where, there is no dependable irrigation, policy should be on contour bunding and contour cropping, so as to maximize returns per unit of water.

During the first decade of planning (1950-51 and 1960-61), the main emphasis was on extention of irrigation so that more land could be brought under cultivation and better crops could be substituted for inferior crops. It is well established fact that the agricultural development lies in the extension of irrigation. Once this basic input, i.e. water, was

made available, production would increase because other inputs such as better seeds and fertilizer could be more effectively applied. The main sources of irrigation in India are (a) canals (b) local streams, ponds and tanks and (c) wells.

Extension in the irrigation facilities and bringing more area under irrigation has its own importance in increasing agricultural productivity but farmers can get much by increasing yields on land already irrigated. Increasing yields on land already irrigated, contribute to maximizing the returns from costs that have already been incurred.

For getting the maximum benefit from irrigation, a planned system of irrigation has to take into account: a) the supply of necessary water to the crops in season, b) the damage and disposal of excess water, c) prevention of flood damages, d) conservation or stocking of water for release in dry season, e) conservation of soil in higher elevations and f) the prevention of erosion by sea in coastal tracts.

Bringing new land under irrigation is usually both time consuming and costly. Although the reason for low utilization of water resources available in India, mainly is the technical difficulties. The Command Area Development Programme (CADP) was introduced during Fifth Plan period. The programme envisages development of irrigation by the construction of field channels and access roads, land levelling and land shaping, introduction of the rotational water supply system and
promulgation of integrated crop-soil-water management practices. The programme stresses to equitable distribution of water to small and marginal farmers.

A number of analytical studies have proved that India can increase its agricultural production to a large extent, if adequate and assured irrigation facilities are available\textsuperscript{71}.

Much of the disparity among the productivity performance of the three sources is found to be due to the intersource differences in crop pattern. As one moves from tanks to canals, and onto dugwells and tubewells, the irrigated crop pattern shifts more and more in favour of rice crop that otherwise attracts a large chunk of irrigated acreage once farmers get access to irrigation facility. Productivity of groundwater irrigated land has risen much faster than that of surface irrigated lands mainly due to the fact that high yielding varieties technology has been biased in favour of farmers having access to private means of irrigation.

Irrigation is indeed the surest way in which agricultural production can be increased. Irrigation would not only include the major schemes specifically planned for bringing in the possibility agricultural production in arid regions but

\textsuperscript{71} Mohammad, N., "Technological Change and spatial Diffusion of Agricultural Innovations", Perspectives in Agricultural Geography, New Delhi, Vol.5, 1981, pp. 317-18
also schemes to ensure the supply additional water in all regions which are dependent on rainfall. On the basis of studies made in India, one acre of good irrigated farmland at the current level of technology is able to support one person\textsuperscript{72}.

4.1.4 Mechanization

Mechanization means the introduction of tools, implements and machines which substitute human labour and animal labour. For instance, the use of a tractor in place of the plough is one example which acts as a substitute for both bullock power and human labour. There is power which is used to draw underground water for purposes of cultivation and similarly, there are sowing and threshing machines. There are harvesters which enable the speeding reaping of the crop. So the whole range of machines and appliances which can be used from ploughing to harvesting are covered by the term mechanization\textsuperscript{73}.

Mechanization is a most conspicuous weapon that can revolutionise Indian agriculture. The electric power and diesel play significant role in the development of agriculture especially in the mechanization and rationalization of farm operation. The modernization of agriculture, through the process of mechanization, has played a very significant part in bringing


\textsuperscript{73} Dutt, R., op. cit. p.245
prosperity to cultivators by ensuring them better crops at reduced costs. Its part has been equally great in the reclamation of the new land, covering wastes and barren lands into flourishing agricultural colonies.

Indian agriculture in the past has been inefficient not because of the farmers but because of the nature and society. The system of agriculture followed by farmers is the result of farming techniques or practices achieved through ages and in many places the system attained a very high standard e.g., the cultivation of rice in deltas. The Royal Commission on Agriculture of India (1928) has pointed out two opinions.

1. The ploughs are light which bullocks can draw and farmer can carry it on his shoulder to and from his often scattered fields.

2. Deep ploughing is essential for some crops but it may not pay the cultivators in all kharif conditions. On the contrary, it may lead to loss of moisture in the areas of light rainfall and in areas of heavy rainfall, in either case jeopardizing germination.

However, there is a great scope for improvement in tools used by farmers, e.g. seed drills, cheap threshing and winnowing appliances, better water lifts etc. Great economy could be effected by improving the bullock carts by replacing the solid wooden wheels by rubber tyres. The weight of the cart is ridiculously large compared with its capacity.
The use of tractors is increasing in India. A tractor, unlike a bullock, does not derive its motive power from the produce of the soil. As such its use will lighten on land and release a certain area for the growing of food crops. Tractor makes it possible for a farmer to do his field and farmyard operations well in time. But the efficiency of a tractor decreases where, there is small size of holdings 75.

In the beginning of course, tractors were essentially built for very large holdings. But now the position has considerably changed. The manufactures of agricultural machinery have persistently, and with success, explored the possibility of making small tractors and other machines suitable for work on small holdings. Now small, all purpose tractors of very low horse-power are available. They have been especially designed to meet the economic and technical needs of lower acreages.

The agricultural operations can be performed much more quickly by the use of machinery than by human or animal labour. The importance of speed as a factor in agricultural efficiency is not to be minimized. Where as, for instance, an unfavourable change in the weather frequently follows harvesting time, speedy harvesting, threshing and storing of the crops may save it from much damage. The margin of the time during which

75. Agarwal, A.N., op. cit. p.124
the various operations for the preparation of the soil and for sowing must be performed may also be narrow, for each agricultural operation must be adjusted to changing weather and moisture in the soil and delay may spoil the growth of crops. For India, where weather conditions are so uncertain, machines have a special significance. Mechanization of agriculture will help in stepping up the economy to the higher level.

Nobody can ignore the importance of mechanical irrigation in the determination of agricultural efficiency. Mechanical irrigation will not only provide adequate water to our fields at the proper time but will also help, besides generating power, in the solution of different problems connected with control of flood water, soil erosion, afforestation, etc. Modern agricultural machines are very powerful tools which can bring great benefit by appropriate and timely use. Mechanization has increased the yield of crops, in cases by permitting more timely preparation of the ground, seeding, cultivation and harvesting.

4.1.5 Pesticides and Fungicides

Crop pests, insects and diseases play havoc with crops and are a constant source of worry to farmers everywhere. In India, their depredations destroy as much as one-tenth of the

76. Ibid, p.126

total production. Crops and the cropping pattern and the variable climatic conditions provide an ideal environment for the multiplication and thriving of insects, disease organisms and weeds. Therefore, there is a continuous activity of pests, diseases and weeds throughout the year posing a perennial threat to agriculture\textsuperscript{78}. The analysis of various pesticides is done by several institutions including the Central Food Technological Research Institute, Mysore and the Indian Agricultural Research Institute, New Delhi. About 250 pesticides are used in agriculture, of which a hundred are insecticides, 50 herbicides, 50 fungicides, 20 nemacides and 20 other chemicals. Dichlorodiphenyltrichloroethane has improved the economic, social and health status of developing countries\textsuperscript{79}.

Agricultural scientists are trying their best to raise more food to satisfy the needs of an ever increasing population. The task of increasing food production has many problems, one of the most important is the control of pests and weeds\textsuperscript{80}.

Insects and pests are the most important groups of

\textsuperscript{78} Reddy, D.B., \textit{Plant Protection in India}, 1968, p.2


\textsuperscript{80} Rao, V.P., "Biological Control of Insect, Pest and Weeds", \textit{Everyman's Science}, Vol.6, No.2, 1971, p.90
organisms which damage and cause loss to agriculture. These insects and pests also cause many diseases to the plants. The animal pests largely belong to insects but crabs, snails, earthworms, monkeys, hares and rabbits can also be pests. There are other large animals such as jackal, deers, tortoise, blue bulls or 'neel gai' and sambar who also destroy the crops.  

Fungi are the second most important group of organism affecting crop production. They are microscopic in size except a few species which can be seen with a naked eye. Fungi obtain their nourishment from their hosts, either living or dead. Parasitic fungi are the ones which causes diseases in plants. Fungi respond sharply to climatic conditions and often the environment determines the severity and the extent of the spread of fungus diseases. The fungi are the disseminated through wind, water, soil, plant materials, insects and man and animals.

A large number of weeds both monocots and dicots infest agricultural lands and depress yields considerably. Some like 'kans' and water hyacinth have occupied thousands of hectares of cultivable land. The parasitic flowering plants limit the production of certain crops. A weed is a plant which grows in places where it is not wanted. The weeds compete with

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82. Reddy, D.B., op., cit., p.11
crop plants and fruit trees for nutrition, moisture, light, space, etc and affect the growth and reduce or suppress yields considerably. There are large number of weeds which grow in the fields, orchards and gardens and effectively reduce the yields.

Among the control measures used for containing insects, diseases and pests and weeds for preventing or limiting their damage and reduction in yields, mechanical and physical, cultural, biological and legal methods of control have played a very significant role. Cultural practices such as crop rotation, mixed cropping, adjustment in date of sowing, depth of sowing and field sanitation through removal of diseased debris and weeds play a great part in the control of plant diseases. A virus diseases cannot be prevented or cured by chemicals, the use of disease free seed goes a long way in reducing rejection. For this it is necessary to establish disease free nurseries at isolated places where rigorous rogging eliminates all diseased material.

The use of chemical for controlling the diseases and pests are widespread in the world today. The chemical method of control is the only one which achieves immediate results and is most feasible under the existing farming conditions.

83. Handbook of Agriculture, Indian Council of Agricultural Research, New Delhi, 1961, p.366
4.2 INSTITUTIONAL FACTORS

Rapid growth of agriculture lies in continuous economic adjustment of farm organisation by absorbing improved technological innovations and institutional cooperation on a profitable basis. The process of agricultural development has already begun and the recently introduced institutional reforms are paving way for a largescale application of modern technology. The efficiency of institutional and technological factors is appealing only when the land and people are in proper condition. A simple word 'land reform' is used to increase the productive efficiency of land.

In the traditional and generally accepted sense of the term, land reform means the improvement of agricultural institutions, for example, agricultural land, or income from land and also agricultural credit producing market. Land reforms in India are intended to achieve two objectives. From the point of view of social justice, land reforms aim at redistributing ownership of land and improving in terms of land conditions of tenancy so that the share of the actual tiller of the soil improves in the value added in agriculture. In other words, the purpose of land reforms is to end exploitation of tenants, small peasants, marginal farmers and share croppers by the landlords. The second aim of the land

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84 U.N., Progress in Land Reforms, New York, 1954, p.6
reform is to recognise the unit of cultivation so that holdings become economic and there is no waste of labour and capital in cultivation.

The factors which are considered for the study are land consolidation, credit supply, role of cooperative societies, land holdings, land tenure and land revenue and size of holdings. These factors play an important role in raising the agricultural productivity

4.2.1 Land Holdings

One of the important factors responsible for the backwardness of Indian agriculture is the very small size of holdings. This is accompanied by the fact that these small holdings are scattered into small fragments. The average size of holding in India is 2.3 hectares.

Obviously, the average size of holdings in India is low as compared with advanced countries of the world. There are two reasons for this: firstly, the land man ratio is not favourable in India. In other words, as compared with the amount of land available, the population of India is quite high. Secondly the proportion of population dependent on agriculture is about 70 per cent of the total population.

The endless sub-division and fragmentation of holdings is one of the many causes responsible for the slow growth of agriculture in India. The process of sub-division and fragmentation is not of recent origin but its history can be
treated back even before Hindu period. The Hindu and Muslim laws of inheritance also accentuated this tendency as they conferred equal rights to property among the heirs.

The fragmentation and scatteredness of land holdings is one of the main obstacles in increasing agricultural production in plains as well as on hills.

Due to small size of holdings, recommended improved methods of farming cannot be adopted which otherwise would have brought higher output.

4.2.2 Land Consolidation

One of the major causes of low agricultural productivity in India is the fragmentation of holdings. It involves two processes of sub-division and fragmentation. Once the process of fragmentation begins, it is accentuated with each succeeding generation. In other words, excessive fragmentation is the result of influence of the social structure that creates too great a demand for the limited area of land by population largely dependent on it. This is due to the system of private law and custom which encouraged progressive sub-division. Land consolidation in its broadest sense always plays an important role in any programme of increasing agricultural productivity. Consolidation of holdings is today of major interest in India, which is engaged in efforts to improve its agrarian structure.

Land consolidation has been considered as the best measure to face the evil of sub-division and fragmentation. The
Planning Commission of India is also of the same view and has suggested that the programmes of consolidation of holdings should be followed with full vigour by all the states in India. Land consolidation is a process of substituting the fields of the farmers in any area in such a way as to make the holdings held by each of them more compact. Land consolidation may also be defined as the amalgamation and redistribution of fields constituting individual holdings so as to reduce the number of fragments in the holdings. Consolidation of holdings has been regarded as an aspect of an integrated programme of village reconstruction and besides regrouping of fragmented holdings included connected work of land improvement. Consolidation of holdings aims at giving every farmer a compact area equivalent in value, and as far as possible in area to the area held by him previously.

Land consolidation not only facilitates cultivation but also reduces the cost of cultivation.

The cooperative consolidation of holdings, legislation for compulsory consolidation of holdings was passed in 1928. The Government of Uttar Pradesh passed land


consolidation Act in 1909. The provision of the Uttar Pradesh Act came into force in January 1940 and the scheme of consolidation was introduced in 12 districts. The consolidation Act of Uttar Pradesh was amended in 1958 in order to accelerate the pace of consolidation by removing the obstacles which cause delay in this work.

Consolidation of holdings has a number of advantages. It saves both time and labour, supervision and management of land become easy and efficient operational efficiency is promoted. There is much greater scope for irrigation and conservation practices. Consolidation of holdings provides an opportunity for replanning the entire village community. It encourages adoption of modern farming practices.

The consolidation of holdings will have direct effect on the productivity of land. Agricultural operations are carried out on the entire area of the holding at the most favourable time.

In brief, a correct procedure in colsolidation ensures the allotment of fields to the farmer on the basis of variations in soil, topography, location etc., to enable him to grow the major crops of the area.

4.2.3 Effect of Consolidation of Holdings on Cultivation

Consolidation of holdings effects the cultivation in many ways are as follows:
a) Increase of agricultural efficiency.
b) Development of soil condition.
c) Development in the extension of cultivation.
d) Better management.
e) Increase in social condition.

When the land is compact in a single plot the cultivator has to devote his full time in it. In this way this scheme saves the time, labour and energy and has helped the cultivators to be quick and careful to supervise their fields. With consolidation of holdings, the cultivation becomes easier and it also reduces the cost of cultivation. The land which is wasted in boundaries, farms etc., can be brought under cultivation by land consolidation and thus the cultivation can be increased.

By the land consolidation, the soil condition can also be improved. When the land is consolidated, the manure can be conserved and more intensive cultivation is possible. It is observed that the acreage in irrigated lands has increased after consolidation. The scheme of land consolidation has brought a great change in the attitude and tendency of peasants in cultivation of crops. Because of good irrigation facilities, the cultivation of many crops has comparatively increased. Recommended and improved methods of cultivation can be adopted which would have brought higher output by the land consolidation. The scheme of land consolidation effects the
social structure very much.

4.2.4 Credit Supply

Rapid growth in agricultural production in the short run requires a rapid and radical change in the use of agricultural technology which is reflected in the use of high yielding varieties of seeds, intensive use of fertilizers and plant protection measures. The new technology is highly productive but at the same time, more costly and unless proper credit facilities in conjunction with careful extension advice and other necessary institutional infrastructure are provided to a majority of cultivators, no substantial gains can be achieved. Agricultural credit in terms of crop loans is a variable resource and is meant for meeting the costs of some of these critical costly inputs apart from providing sustenance to the farm family during the period preceding the harvest.

Credit supply is one of the most important economic determinants and life blood for agricultural development. In order to produce more, farmers need to spend more on improved inputs which must be financed either out of savings or by borrowing.

It is said that if adequate and timely credit supply is provided to the farmers with lower interest rate, they can develop their agriculture more quickly. Availability of adequate and timely credit facilities promote fast development
There are institutions like cooperative societies, Land Development Banks, Commercial Banks, Regional Rural Banks and National Bank for Agriculture and Rural Development which play an important role in agricultural development. Banks like commercial banks make credit available in the form of advances for the distribution of fertilizers and other inputs. In this way, Indian farmers are raising agricultural production by timely credit supply. So with the help of such credit, use of fertilizers, improved seeds, adoption of plant protection measures etc., may certainly be promoted.

4.2.5 Cooperative Society

Cooperative credit societies are the most important source of credit to the farmers. Primary agricultural credit societies provide short term, medium term and long term loans to the farmers for productive purposes.

Efforts to build-up institutional financing for agriculture started with the adoption of the Cooperative Credit Societies Act in 1904. Later on the All India Rural Credit Survey (1951-54) pointed out that in spite of various administrative reforms and availability of credit from Reserve Bank of India the cooperative system accounted for 3 per cent of the total borrowing of the cultivators and farmers continued to

88. Mohammad, N., op. cit. pp.223-24
depend on money lenders. It suggested establishment of large
size societies with increased State assistance. The National
Development Council (1958) recommended that the cooperatives
should be organized on the basis of village community. It should
also be remembered that the central need of the small and
marginal farmers is not merely money but the timely availability
of a package of inputs.

Now a days cooperative societies are the main
source of loans for agricultural activities. Farmers got urgent
and immediate financial help through cooperatives.

The main characteristic of cooperative is that it
provides for effective use of loans through efficient
supervision. Now the cooperatives are the best remedies in
respect of agricultural marketing.

In the field of agriculture, cooperative societies
provide various inputs which play a crucial role in the
agricultural development. Cooperatives provide chemical
fertilizers, high yielding varieties of seeds, new implements
and machinery, irrigation facilities, pesticides and spraying
equipments.

The Agricultural Cooperative Credit Societies have
become a very important source of short term and medium term
credit. They are slowly replacing the money lenders in the
villages.
The purpose of the short loan is to purchase seeds, fertilizers, cattle, etc. In times of famines, such loans are also used to support families. These loans are for a period of less than 15 months and are generally repaid after the harvest.

Medium term loans are for a period ranging between 15 months to 5 years. They are mostly used to purchase agricultural implements, to make improvements on land, etc. The purpose of these loans is to enable the cultivator to purchase relatively more costly equipment and spread the repayment over a period of 5 years.

Long term loans are for a period of more than 5 years. These loans are used to buy land, to pay off old ancestral debt, to purchase costly agricultural machinery like a tractor or a harvestor.

4.2.6 Land Tenure and Land Revenue

One of the various factors that contribute to the well being or otherwise of the agricultural industry, the system of land tenure is by far the most important. The term "land tenure" stands for the system of rights and obligations of the members of the rural community in relation to the landlord and state. It refers to the terms or conditions upon which land is held or possessed; it defines the legal relation in which the

89. Agrawal, A.N., op. cit., p.150
holder of any land stands to the government or any other superior landlord. In brief, the system of land tenure relates to the question of intermediary interests, land utilization and distribution of farm income.

Obviously that system of land tenure is ideal which provides for maximum utilization of land in the general interest of the community, most efficient cultivation and progressive farming, fair distribution of farm income, opening up of opportunities for a further development of peasants personality and peace and social progress in the countryside. The cultivator will have the incentive to produce more and better only when he enjoys security of tenure and is assured of fair return for his labour. At the same time, the system should be so designed as to promote the well-being of the whole man and to subserve desirable social ends. For the past few years various State Governments in our country have been carrying out land reforms in their respective territories with a few to make agriculture efficient and progressive and also to create new social values.

From very ancient times the state in India claimed a share of the produce of the soil from the cultivation. The institutes of Timur represented the first systematic attempt in the direction of commuting the state's share of the produce into money. The next attempt was made by Sher Shah (1940-45). During his times the whole territory was measured and neatly divided
into Suba's, which were sub-divided into Sarkar's and then into Dastoor and Pargana's from where revenue was collected. The third and most famous settlement was made under Akbar. A more scientific and detailed system of investigation into taxable capacity of different soils was undertaken as a necessary preliminary to the fixation of the revenue demand. Land was carefully measured and divided into four classes representing different grades of fertility. The share of government fixed at one third of the gross produce. Option to pay in cash based on the average prices of foodgrains during 19 years preceding the settlement was given, and the term of settlement was fixed at nine years. Mugals are credited with the introduction of regular records and revenue accounts for the purpose of gaining definite knowledge about the financial resources of the state.

The next important feature of the history of land revenue and tenure is the appearance of revenue farming, a factor of great significance in the development of local system of the land tenure in more than one province. The institution was designed to ensure a steady flow of income into the treasure of the Central Government which in the declining days of Mugal Empire became more incapable of controlling the revenue officials in the outlying parts of the empire. The system became fairly general in Bengal from the reign of Emperor Farukhsiyer (1813-17). Under it the farmer paid to the government nine-tenth of the whole collection and kept the rest as his remuneration.
With the introduction of British rule in the country, the state was regarded as the supreme landlord. The British fixed the maximum demand at one half of the net assets. The agrarian society of the British period was so structured as to impede the development of forces of production. During British rule, three kinds of land tenure was established. These were a) Zamindari, b) Ryotwari, and c) Mahalwari.

According to the Zamindari system, ownership rights were conferred on one or several Zamindars for a certain piece of land. Land revenue was either fixed in perpetuity or for a shorter period ranging between 20 and 40 years. Under the Ryotwari system, the peasant himself was the owner. The land revenue has to be paid by the owner of the land. Land revenue was fixed for 20 to 30 years. Under the Mahalwari system, lands were jointly held by the village communities. For the payment of land revenue, the village community was jointly responsible. Lumbardars collected the land revenue and received 5 per cent commission for depositing it in the state treasury.

Uttar Pradesh under the British rule was temporary settled Zamindari province. Land under the personal cultivation of the Zamindars was called Sir and Khudkasht. Next to Zamindars, there were sub-properietors and under-properietors.

The Uttar Pradesh Zamindari Abolition Committee (1944-45) estimated that one in every five cultivators was a
tenant under a tenant, a tenant of Sir and Khudkasht of occupier of land without consent. All of them have little security of tenure and could be evicted from the land by the landlord. These inferior tenure holders cultivated no less than 8.87 per cent of the total area.

Zamindari was abolished in the State with effect from July 1952 and the multiplicity of tenures was reduced to only three categories, viz., Bhumidari, Sirdari and Asami and the cultivator was brought into direct contact with the state.

The most important feature of the post-Zamindari abolition period was a marked increase in the area under cultivation and current fallow. The area under old fallow and cultivable waste decreased considerably. "Graveyards and otherwise barren land" also showed a decline of about 20 per cent.

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