Agricultural development depends upon conceptually consistent measures of aggregate agricultural output and inputs. In the recent past, rapid and far-reaching transformation have taken place in the Indian agriculture. The concept of inputs in productivity studies includes the resources committed to agriculture by the farmers. These inputs are controlled by the decisions of farmers under the framework of Government policies. These inputs may be classified as, labour and tangible capital (including intermediate products which are purchased annually from the non-farm sources, such as High yielding varieties of seed, chemical fertilizers, pesticides insecticides, modern agricultural implements irrigated water. Choice of inputs mainly determines the increase in agricultural development depending upon the qualities of inputs in relative sense and on the techniques and skills which are utilized in the production process.

Efficiency in the modern inputs application and timely operations are equally important for maximising production. It has been observed that efficiency in the use of modern inputs has helped in increasing the agricultural production
at relatively low cost. Agricultural productivity may be defined as the ratio of index of total input used in farm production.

The importance of agriculture has further been strengthened by the fact that the population of the country is increasing with leaps and bounds, exerting a great pressure on land and adversely effecting the man-land ratio. As a result cultivation of land over centuries and also of increasing pressure of population on it, the chances of adversely affecting the land in particular and environment in general are very much there. Thus there is a situation where the land has to be used with great care, and where agriculture has to be evolved lacking into cognizance all the environmental and socio-economic factors. It may, therefore, be remarked that only scientifically and intelligently thought out agricultural practices can meet this situation. This is possible if the existing conditions, practices and the changes that are taking place are studied on scientific line and in great depth. This will help solve some of the problems.

One thing that stands out in the growth performance of Indian agriculture since independence is that the sources of growth have changed over times, while over-all growth
rate of agricultural production has failed to get accelerated. In fact, despite technological change, the growth rate in the 1960s decelerated from the level attained in the 1950s. The principal factor putting down the growth rate of agricultural output was of course, the slowing down in the rate of expansion of cropped area. But the fact that even in the absence of technological change the growth rate of per hectare productivity in the 1950's got sufficiently stepped up to maintain the growth rate of output, where as in the subsequent decade, despite technological change the improvement in the growth rate of productivity turned out to be too small even to neutralise, the effect of the slowdown in area expansion, calls for a closer look into the sources of productivity growth. More specifically it raises two questions.

(1) What explains the comparatively sizeable growth of productivity in the 1950's when the benefits of technological change were yet not available and.

(2) What accounts for only a modest step-up in the growth rate of productivity in the subsequent period which saw a far more substantial increase in fertilizer use then before, and specially since the mid 1960's when the area sown under the high yielding varieties of seeds started expanding to reach close to one fifth of the total area
under all foodgrains by 1972-73. In the process of seeking answers to these questions, an attempt could be made to throw light on the role of selected modern inputs.

Prior to the recent technological breakthrough in Indian agricultural farming was, by and large, of subsistence type. This means that the farmers used mostly inputs which were raised on the farm and production was largely consumption oriented. As a result, the concept of gross returns used by some research workers in programming an analysis was not altogether unrealistic.

The situation has, however, been changed with the adoption of new technology in agriculture in the mid-sixties. Farm productivity and profitability increased with the introduction of H.Y.V. of seeds and guaranteed prices for major farm products.

This encouraged the farmers to make sizable farm investments. Today, agriculture requires a lot of capital investment and needs to be considered as a business proposition for better returns.

Once the proportion of farm inputs purchased by the farmers starts increasing, the concept of gross returns becomes less relevant for developing farm plans. In other
words, the concept of returns to fixed farm resources assumes greater relevance for making relative comparisons among different enterprises. This means that while considering the combination of farm enterprises, the farmers are not only concerned with gross return but also with the rising variable costs associated with different enterprises. More importantly, if the concept of gross returns were used in deciding the combination of various enterprises, it would ignore the concept of relative profitability from different activities, which is one of the important factors governing the choice of different products.

The foodgrains production figures of Uttar Pradesh during the period 1950-51 to 1970-71 clearly establish the fact that the progress has not been uniform in all the districts as well as in various crops. Wheat has accounted for a major rise in agricultural production where as rice has not shown any significant increase. The districtwise analysis of foodgrain production in the Upper-Ganges-Yamuna Doab reveals clearly that food grain production has considerably increased in the districts of Meerut.

This has created an imbalance in the agricultural economy of the study area for which concrete steps need to be taken to push up the growth of agricultural production in the valuable areas of the state where the total decline of
34 lakh tonnes in agricultural production from 1964-65 to 1966-67 has been reported on account of successive droughts of 1965-67 more than 50 per cent decline in the food production was reported from 13 districts. However the droughts did not affect grains production in the study area.

It is evident that the new high yielding varieties programme has not been successful in those parts of state where irrigation facilities are meagre. The drought affected districts of Uttar Pradesh did show improvement in agricultural production upto 1964-65 but there after on account of absence of any new technology suitable for these areas, production become static and thus the overall growth rate for the entire period came out to be less than that for the period of 1950-51 to 1964-65. There was hardly any difference in the per hectare production of food grains in these districts and the other parts of the state before Green Revolution era, but the Green Revolution brought with it disparity of appreciable dimensions.

While discussing the problem of agricultural productivity in the area under study, the author has tried to concentrate on the following aspects of the modern inputs.
1. Use of advance agricultural implements and machinery.
2. High yielding varieties of seeds.
3. Use of proper chemical fertilizers.
4. Pesticides and insecticides
5. Irrigation water.

USE OF ADVANCED AGRICULTURAL IMPLEMENTS AND MACHINERY:

Farm mechanisation in India is of recent origin. It is only after Independence that serious efforts were made to introduce modern agriculture machinery and implements in the cultivation of land. In the initial stages, use of such machinery was confined mostly to rich landowners and peasants who could afford the expenditure. The medium and small farmers were still adopting the traditional methods of cultivation.

Nevertheless, it was in the last ten years that the farmers quickly realised the advantages and adopted the modern agricultural machinery. The pace of mechanisation quickened only in the last seven years and that too in states with large area under irrigation, large areas under double cropping and with high levels of production.

The agricultural machinery now in use in India includes tractors, combine harvesters, 'threshers, power tillers, sprayers, etc. They are all manufactured in the country, but as the cost still remains high consequently the poor farmers are deprived off.
The indigenous wooden plough remains the primary tillage implement on Indian farms. Increase in the scope of the use of implements can contribute substantially towards modernisation of equipment in the farm.

The power utilization efficiency is increased almost to the same extent as in modern implements. However if introduced on a large scale, it will mean a substantial increase in the total power utilized on the farm.

It has been proved beyond doubt that when used judiciously farm implement and machinery can play a very important role in increasing agricultural production. The operations in agriculture depend upon various resources available to the farmers for whom power and equipments are of more consideration. It has been estimated that the animal energy costs Rs. 100 per horse power/hour and mechanical Rs 0.40 per horse power/hour. By using tractor power we can reduce cost over 50 per cent and speed up the work five times\(^1\). In agricultural production process, a number of operations right from preparation of seed-bed to the final processing of products to be included. A number of mechanical operations are required to be utilized at all stages to achieve the higher efficiency. Thus, in order to make the agriculture more

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productive and profitable, efficient and time saving devices, implements and machinery should be brought in use to minimise the production cost as well as time required per agricultural operation.

The first basic need for good growth of crops is a good seed-bed having adequate depth from weeds for good germination and root development. This operation is being done with the wooden plough.

For the multiple cropping, seed-bed preparation may be done with the conventional implements like plough, harrow and cultivators. In irrigated areas it is desirable to be the initial tillage operations with a mould plough.

The indigenous wooden plough remains the primary tillage implement on the Indian's farms. These wooden implements were used for agricultural purposes. The result was that the farmers were not able to plough the lands which were left uncultivated for a long time, with the result agricultural productivity has increased manifold with the use of modern scientific agricultural implements in the field of agriculture. Lack of penetration and narrow width are some of the deficiencies of this tool, resulting in poor quality of work and low turnover. The power utilization efficiency is increased almost to the same extent as in modern implements in many operations.
A significant negative effect of the mechanization is on the use of draft animals. Mechanization of irrigation operation significantly reduces employment of draft animals being complementary to human labour use. Introduction of tractors also resulted in a sharp reduction in the use of bullocks on tractorised holding to the extent of about 80 per cent.

Sharma R.K.² investigated the difference in conservation and modern mechanical patterns of agriculture. He calculated productivity, using tractors and bullocks in farms in the district of Karnal (Haryana). In order to assess the impact of tractorisation. The study was based upon data collected from a sample of 50 bullocks. The result of this investigation is quite revealing.

In India use of modern agricultural implements has increased manifold. These agricultural implements are the backbone of the field with out which production can not be increased. Modern agricultural implements have reduced the use of agricultural labour and cost of production has also reduced in many cases. A tractor can cultivate 100 times more

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land than a wooden plough. In the upper Ganga Yamuna Doab, there are sufficient number of such implements which are used for increasing production.

Apart from mechanisation the other essential production factors to maximise production, are well prepared seed-bed, timely sowing, proper manuring, adequate irrigation, control against pests and diseases, timely harvesting, careful processing and storing. At every stage of operation, the first thing a farmer looks for is a device for doing the work. Better device means greater power and efficiency, resulting in a corresponding reduction in labour, time and cost of production. One of the basic reasons for the efficiency of the western farmers is that they have an abundance of power with the right tools for twentyfour hours a day. But the average Indian farmer with his pair of poorly built animals hardly gets more than a horse-power to work the crude devices at his disposal, and that again, for not over five hours a day with the acute scarcity of labour during peak cultivation periods. The farmers generally find themselves lagging behind in many of the operations and production is therefore badly effected. Better implements with greater covering and more power to speed up the operations are beyond doubt necessary to aid production and cheapen the cost of productive operations.
This is a gradual process for example, the implements for tilling the land have changed from the crude form of hand-operated ploughs to bullock-drawn ploughs to tractors run by steam power and finally to modern tractors. At stage a new device with better performance has replaced the older one resulting in an increase in the level of output, other things remaining equal. This process of mechanisation is termed as technological change as it involves replacement of a device used so far, resulting in eventual fall in marginal cost through reduction in operating costs and/or increase in the level of output.

The harvesting operation takes a lot of man power, and yet little has been done in this line. Imported bullock operated reapers have been tried but have not been very useful due to heaviness in draft. Attention to modify them to suit Indian conditions have not been pursued this needs an immediate attention push type manually operated Japanese harvesters have been tested in row-paddy, with a little success and have given rise to a new technique in harvesting. The work requires to be pursued vigorously. Satisfactory progress has been achieved in the case of processing equipment. Quality of cane crushers, and electrically driven rice hullers is improving. These have considerably reduced the
extraction losses in cane and also breakage losses in paddy cutting chaff into bits results in a great saving of fodder and this cut material is generally better relished by the cattles.

The main crops for which harvestin, equipments are needed in the country include wheat, paddy, groundnut, potatoes etc. For other crops, the demand of these equipment has not become so critical as yet and it will need to be developed and introduced in due course of time. These crops include cotton, sugarcane, maize and fodder (barseem and sorghum etc. Efficient harvesting and threshing greatly facilitate an effective programme of multiple cropping. The pusa reaper is suitable for harvesting grain crops. The cut crop is delivered in united bundles at one side of the machine. The machine reduces the cost of harvesting of crop.

"The state of progress of industry or agriculture is fairly and accurately represented by the power use index".

The term "power" use in agriculture refers generally to the power contributed by man, animal and machinery engaged in agriculture. The index of energy used in agriculture can either be obtained by dividing the number of energy sources by the total cropped area to get the value per hectare or converting them to a certain uniform scale
e.g., horse power equivalent in relation to cropped land/ 
agricultural population in a study area.

Thrashing machines for rice, wheat and barley (a simple 
power thrasher for 5 horse power (H.P.) engine) were designed 
at Kanpur and were tested at Government research farm. This 
has an output of 670 Kg/8 hours\(^4\). At Jaipur a 5 horse power 
(H.P.). For har having different grain sieves was fabricated 
and the out-turn of this implement was 400 Kg per day.

A double dram thrasher was made and given power drive. 
This has been improved by fitting an expanded metal around 
the drum to increase efficiency of threshing. This gave an 
out put of 400 Kg per day using for labours. Thrashers 
which are commonly in use are mostly suitable for large hold-
ings. Almost all of them work the straw down to a fine condi-
tion making chaff (bhusa). They are in fact a combination of 
what is conventionally known as thrasher, and a hammer mill 
and require high horse power for operation. Such a design 
approach has kept their cost quite high. There is an existing 
demand for smaller thrasher and thrashers which do not make 
chaffs (bhusa). Keeping in view these considerations the 
Pusa 20, 30 and 40 thrashers have been developed. They work 
on simple principles and are suitable for smaller holdings. 
They are comparatively cheaper and efficient. Besides, their 

3. F.A.O. Smaller Farm land can yield More, Rome, 1969, 
pp. 35-6.

4. Nirmal, T.H., and Luthra, T.H., Pusa 20, 30, and 40 Model 
Thrashers, Indian Farming, Vol XIX, No. 11, February, 1970, 
pp. 43-44.
out put versus weight ratio is low. It is also flexible in its operation and can be run directly from the power take off pulley standard tractors, by power tillers, smalls gasoline engines or electric motors. The small model can be run on common house current as power requirement is very low.

Greater use of threshers too is oriented to some agriculturally advanced regions of state and where farmers are engaged to involve recent know how in the agricultural production process to minimise the losses and to maximise the returns. Mechanical threshing is frequently done in all districts of upper Doab namely, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad with the introduction of high yielding varieties of cereal and other crops in conjunction with application of other farm of inputs such as water, fertilizers, insecticides and energy, there has been an appreciable increase in farm production in India. Threshing of farm crops constitute one of the most significant operations in the crop production system. The age-long practices of threshing by animal treading come to be improved in the last two decades by the development of simple implement called the alpad wheat thresher having an out-put of about 75 Kg per hour.

5. Ibid, p. 44.
Power operated threshers have become popular in the recent years. The Pusa thresher is suitable for threshing wheat and other grain crops. With the help of a separate attachment, the machine can be used for chaff making.

Specialised machines are an essential part of a successful programme of multiple cropping. They reduce the labour required in different operations and facilitate the adoption of improved agronomic practices. This can be used in both by electric and diesel engine.

Seed drills and planter are used to sow crops. Sowing equipment has been developed to suit the improved agronomic practice which aims at better environment for the germination of the seed and the growth of the plant.

The conventional seed-cum-fertilizer drills are used to place the right amount of seed and fertilizer at the right depth in the field. They are suitable for sowing on flat beds. Another conventional seed drill is a seed control device developed recently may be used with advantage to sow row crops like maize and cotton. In upper Ganga Yamuna Doab the increase in the use of pumps has been unexpected. In Saharanpur, Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad, increased from 61,381, 52591, 50576, 51275, 29,229 respectively in 1983.
The probable reason for this high rate of increase in the use of electric pump may be ascribed to the unreliable nature of the monsoon. In 1963 the number of electric pumps used in the districts of upper Ganga-Yamuna Doab namely Saharanpur, Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad are 14646, 24652, 35432, 35432, 33221 and 6331 respectively. In order to ensure cultivation of Kharif and rabi crops, it is very essential that the farmers should have adequate management for irrigation so that they can irrigate their fields in both seasons.

During the period of 1960 and 1983, it has been noticed that the use of developed seed sowing machines and pesticide spraying machines have become gradually popular. If this trend continues, it is possible that in near future this part of Uttar Pradesh may become a surplus region of India.

Use of modern agricultural implements and their availability is considered to be an indispensable tool for enhancing the agricultural productivity per hectare. The use of modern implements such as tractor, thrashers, seed Drillers has reduce, the operation cost over 60 per cent and speed up the work many times. The farmers of the upper Ganga-Yamuna Doab are more capable for using such types of implements. In the table no X it is shown that in 1966-67 total number
<table>
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<th>DISTRICTS</th>
<th>CROPPED AREA</th>
<th>PLOUGHS</th>
<th>TRACTORS</th>
<th>THRASHERS</th>
<th>PERSON WHEELS</th>
<th>SEED DRILLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOTAL CROPPED AREA</td>
<td>PERCENTAGE OF INCREASE AND DECREASE</td>
<td>NO. OF PLOUGHS</td>
<td>PERCENTAGE OF INCREASE AND DECREASE</td>
<td>NO. OF TRACTORS</td>
<td>PERCENTAGE OF INCREASE AND DECREASE</td>
</tr>
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<td>Saharanpur</td>
<td>5.18</td>
<td>5.98</td>
<td>+ 15.44</td>
<td>143177</td>
<td>131931</td>
<td>- 7.98</td>
</tr>
<tr>
<td>Kasauli</td>
<td>4.66</td>
<td>5.11</td>
<td>+ 15.02</td>
<td>111162</td>
<td>167686</td>
<td>- 32.51</td>
</tr>
<tr>
<td>Nainital</td>
<td>6.72</td>
<td>5.03</td>
<td>- 25.44</td>
<td>155528</td>
<td>172465</td>
<td>+ 9.76</td>
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<tr>
<td>Balrampur</td>
<td>5.44</td>
<td>5.85</td>
<td>+ 7.53</td>
<td>118006</td>
<td>103623</td>
<td>- 12.77</td>
</tr>
<tr>
<td>Ghazipur</td>
<td>-</td>
<td>3.10</td>
<td>-</td>
<td>86841</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Upper Ganga Valley and Yamuna Valley</td>
<td>21.8</td>
<td>25.07</td>
<td>13.4</td>
<td>530973</td>
<td>662546</td>
<td>19.85</td>
</tr>
</tbody>
</table>

Source: Livestock Censuses 1966-67 and 1982-83
of tractors were 2650. This figure rose to 3631 in 1966. Therefore the percentage increase comes to 93%. The table no. X further reveals that in the Upper Ganga-Yamuna Doab the increase in the number of tractors was comparatively higher in Kuzafarangar and Meerut districts. In Kuzafarangar the number of tractors rose from 16 to 165 in 1966-67 to 1962-63. While in Meerut it was 14 in 1966-67 which had gone number to 6433 in 1962-63 have also increased with the increase of tractors such as threshers and seed drills. The number of threshers in Upper Ganga-Yamuna Doab was 2572 in 1966-67, which had increased to 75220 in 1962-63. Among all the districts of the study area, the district of Bulandshahr was having much use of thresher—about 20529 in 1962-63 and lowest in Ghaziabad about 9409. The table XIII further shows that the total number of thresher were 2572 in 1966-67, the figure increased to 75220 in 1962-63.

The seed drillers also increased to the maximum extent. The number of seed drillers in the upper Ganga-Yamuna Doab had increased from 979 to 25214 in 1966-67 and 1962-63 respectively. Among the districts of upper Ganga-Yamuna Doab the number of seed drill was highest in Meerut district (about 7752) and lowest in Saharanpur (1403) in 1962-63. However in 1966-67 the number of seed drills was highest in Meerut district about 386 drills) and lowest in Bulandshahr 95 drills.
IMPROVED VARIETIES OF SEEDS:

Lack of adequate supply of good quality seeds result in lowering the yield per hectares. It often happened that poor farmer had to borrow seeds from the village money lenders which were generally of poor quality, because it contains a mixture of different varieties of seeds collected from many cultivators to whom he had advanced seeds in the preceding year. This poor quality of seed lead to depletion in the productivity as well as in quality of seeds.

The use of improved variety of seed will result in increasing the yield per hectare and for profitable farming. Seeds must be good and reliable. Good seeds possess vigour and high germination percentage, and are free from the extraneous matters. They are also capable of producing bumper crop as well as increasing yield per hectare.

The improved varieties are superior in yield but the main difficulty that defective system of seed distribution and absence of proper organization for multiplication and trade in the improved varieties of crops. The present Government, however is trying to solve this problem relating improved seed suited to local conditions. Initiative has been taken to distribute the improved varieties over entire agricultural
area as a result of which one can form a very conservative estimate. The use of new varieties of seeds under the integrated Rural/Agricultural Development programme, in the sixteen selected districts has been rising by no less than 44 per cent per year.

High yielding varieties programme is the main plan of the new agricultural strategy. This programme covers major food crops mainly wheat, rice, maize, bajra, jowar, sugarcane and pulses. The success of this programme depends largely on rapid increased food grain production in the country. The food production has increased three fold out of which rice production is more than 76 per cent.

The coverage of area under this programme has registered a sharp increase from 16.9 lakhs hectares in 1966-67 to 4,20 crore hectares in 1978-79. The target for 1980-81 has been fulfilled to the extent of 4.80 crore hectares.6

Among the five crop included in this programme the high yielding varieties of wheat has proved a success because decentralized water management system in a large

part of wheat growing areas, better crop growth conditions, assured market and the policy adopted by the Government.

An important development in rice cultivation is the replacement of coarse high yielding variety by a fine grains varieties like Ratan, Vijaya, IR.20 Mahesuri etc. Some new high yielding hybrid varieties of jowar like CSH-5 and CSH-6 have been evolved to suit the prevailing cropping pattern in the major jowar producing areas, and have been taken up for extensive cultivation.

The central ware housing corporation has acquired Godowns and ware houses for storage of agricultural produce. It is hoped that in a couple of years the existing capacity for the storage of food grains will reach the target of 35.60 lakhs tones.

With the inception of intensive cultivation programme in early sixties the farmer had an unprecedented opportunity to bring a real break-through in agricultural production of high yielding varieties. This programme has lead the farmers to show awareness towards better use of high yielding varieties of seeds. As a result an abrupt transformation of areas of traditional varieties to has taken place.

The performance of crop plantation under this programme looks very appreciable in three districts of upper
Ganga-Yamuna Doab namely Muzaffarnagar, Meerut and Bulandshahr. In Saharanpur however it covered the lowest figure about 0.12 million hectares (0.19 per cent). Muzaffarnagar, Meerut and Bulandshahr shared about 0.13, 0.24 and 0.22 million hectare (55.55, 59.84 and 44.43 per cent) respectively.

Though relatively of new origin, the development of high-yielding varieties of seeds some food crops has revolutionised agricultural production, especially in developing economics. These seeds have a higher yield rate compared to traditional ones for a given level of complementary inputs. Higher resistance to certain crop diseases and marginal reduction in the duration of crop (the time for which the crop is on the land) in some cases are the other major advantages of high yielding varieties of seeds.

**USE OF CHEMICAL FERTILIZERS:**

Fertilizer is universally recognised as one of most crucial inputs for increasing the agricultural productivity. Fertilizer is a costly input accounting for a sizeable percentage in the cultivation expenses. The nutrients available in the soil are getting depleted over the years by repeated cultivation, and as such, the demand for fertilizers have been steadily rising. The most profitable rate of fertilizer
use is actually not the level at which the maximum yield is produced but the level at which the cost of added fertilizer equals the value of added return. The fertilizer are the material applied to supplement the nutrient furnished by the soil. Fertilizers are the key to the modern agriculture. In the early days only ten elements were known to be essential for plant growth. They were carbon, hydrogen, oxygen, phosphorous, potasium, nitrogen, sulphur, calcium, iron, Magnesiam etc. In the modern time five others (borone, magnise, copper, zinc and molybdenum) were added to the list. India's deficiency makes fertilizers much costlier, and a good deal of our foreign exchange reserves are drained out of the country. Thus the country can hardly afford in the coming years with the balance of payments under pressure.

An important step to enhance efficiency in agriculture is to ensure the correct use of fertilizers not just by going along with general recommendations but by ascertaining the actual nutrient deficiencies of the soil. In this regard the care have to be taken by applying an appropriate quantity of nitrogen, phosphorus and potash.

Chemical fertilizers have been recognized as the most important element of the package improved practices. Special efforts comprising a composite crop demonstrations, short training courses for formers etc, are to be made to popularize the use of fertilizers.
The application of fertilizers and development of new technology are not the major problem in the region under study. Main problem is the dissemination of these techniques among the farmers. The adoption of improved practices by a farmer is essentially based on his capability to acquire information about the new techniques, and to convert them into practice.

To ensure the efficiency of fertilizer it is inevitable to have a thorough soil testing rather than to depend on general recommendations based on farm practices.

There is a correlation between production of food and non food crops and consumption of fertilizers. In fact, an increasing trend in fertilizer consumption has been noticed as a result of increase in the agricultural production.

In any scheme for boosting agricultural output, the use of chemical fertilisers has an important role. Indian soil, though varied and rich is deficient in nitrogen and phosphorous the two plant nutrients which together with organic manure influence the crop return. To cope with rapidly rising population faster the use of large doses of chemical fertilisers to augment our agricultural production is the only way.
Taking India as a whole, the study on the district-wise growth of fertilizers use reveals that bulk of past growth in fertilizer use has been concentrated in a small percentage of districts. The impact of high yielding varieties on growth in fertilizer use has been mainly confined to districts with moderate to high levels of irrigation.

The physical, chemical and biological reactions between the soils and fertilizers determine the requirement of nutrients for the plant growth.

The latest bio technological developments have given new dimensions for getting nitrogen for plants, during the growing season or over a long period.

Fertilizers constitute an important inputs for increasing agricultural production. The importance of fertilizers in Green Revolution has been well appreciated by cultivators as well as other associated with agricultural production. Now-a-days the farmers have realized the importance of fertilizer and using the chemical fertilizer liberally so as to augment the production.

A comparative study made for second Five Year Plan period (1956-1961) revealed that in India, the contribution of fertilizer in increasing agricultural production has reached to the extent of 45 per cent, while other factors
like irrigation, improved high yielding variety of seeds, double-cropping and land reclamation measures contributed only 27, 13, 10 and 15 per cent respectively. The role that fertilizer have played in increasing wheat production in the area under study is highly recognizable. During the period of excessive use of fertilizers to increase the agricultural production in the area, the demand for fertilizers has always been more than the supply. The use of different fertilizers like urea, ammonium sulphate, nitrate, triple super phosphate, nitrophosphates etc. It is evident that in the use of fertilizer, emphasis has already been shifted from single nutrient use to all the three nutrients use. It is to be noted that the trends in the use for N.P.K. ratio is progressive by increasing.

In our country, the use of fertilizer, particularly the nitrogenous fertilizer, has witnessed phenomenal growth, that is from 60 thousand tonnes in mid sixtees to about 5 million tonnes in late seventees.

One hundred pound of concentrated chemical fertilizer may contain as much plant food as one tone of cattle manure. The question, however is not of using either organic manure

or chemical fertilizer, but of using both manures and fertilizers on the basis of economical crop production.

For further increase in yield, the native soil fertility can not be relied upon and recourse has to be taken to the application of manures and fertilizers. So the fertilizer has necessary for increasing productivity per unit area.

To maximise agricultural productivity of the land every unit of cultivated land should be provided fertilizer. The miracles brought about by the high yielding varieties could not be possible without the use of optimum doses of fertilizers.

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 future lies in increasing the production per unit area. Fortunately the last Five Year have given us confidence that the scope for increasing production by utilizier fertilizer-responsive varieties is very large. Scientific evidences indicate that India can feed its growing population without facing much difficulties and has a capacity to run a number of agro-based industries. The proper combination of fertilizers with high yielding varieties is the key which can unlock the door to increase the yield to its maximum limit.
The contribution of fertilizers in increasing agricultural production has been very well demonstrated in our country. The importance of fertilizer in the phase of Green Revolution has been appreciated by the cultivators, as well as all others concerned with agricultural production. The table X. shows districtwise distribution of fertilizers in the study area. It is evident from the table X. that there is a constant increase of the use of fertilizer since 1966-67 per hectare consumption of fertilizer in upper Ganga-Yamuna Doab was 7.18 kg per hectares in 1966 while has gone upto about

<table>
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<th>DISTRICTS</th>
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<td>-</td>
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<td>Ghaziabad</td>
<td>7.18</td>
<td>97.08</td>
<td></td>
</tr>
<tr>
<td>Total of Upper Ganga-Yamuna Doab</td>
<td>7.18</td>
<td>97.08</td>
<td></td>
</tr>
</tbody>
</table>
95.5 kg per hectare in 1982. It is clear from the table that the highest ranking districts were Meerut and Ghazia-bad, where in the respective districts the use of fertilizers is about 110.84, 106.95 kg per hectare. In the upper Ganga-Yamuna Doab lowest quantity of fertilizers is used in Saharanpur and Bulandshahr (83.33 and 60.11 kg per hectare respectively, in 1983-84). The average consumption of fertilizers in the Ganga-Yamuna Doab has been estimated at 95.51 kg per hectare in 1982. The average use of chemical fertilizers in the study area is comparatively more than the state average.

THE USE OF PESTICIDES AND INSECTICIDES:

To grow more, to raise more food productivity, to feed the teeming millions involve many problems. The main problem the Indian farmers facing is to control the weeds, insects and pests.

After independence the production of pesticides in India has increased to a greater extent. The first plant was established in 1952 and the first D.D.T. Plant came into existence in 1955.

More than 1000 pesticides are being produced in these plants. To protect the plants and hence to maximise the food
grain production, pesticides are the most essential part of the production factors. Appropriate use of pesticides can increase the agricultural production. The consumption of pesticides has increased from 3,750 tones in 1952 to 80,550 tones in 1982 with the result the agricultural production has stepped up manifold.

It has been estimated that the average yearly losses due to weeds in crops is greater in amount than due to plant diseases. A large amount of income of a farmer is spent to control the weeds. If weeds are not controlled properly the production is liable to be diminished to a considerable extent. According to an estimate one year's weeding means seven years seeding. For maximum production weeding is a necessary practice. By doing proper weeding at least 10 to 25 per cent production can be increased. Pests and insects can be controlled by the use of insecticides, herbicides, fungicides and chemicals such as D.D.T., Parathion, Dithion etc. It has been observed that in the recent years the use of insecticides and pesticides has increased to a considerable extent with the result the yield per hectare has increased.

Insects, Rats, Mites, Hemotobies and other animal pests, plant diseases, weeds and nutritional imbalances affect the growth and yield of agricultural and horticultural crops. The forest trees are also suffered equally. Cereals, pulses and other commodities, such as, potatoes, sweet potatoes, groundnut, sesame, tobacco, cashewnut, onion, garlic, pepper, tamarinde, coriandres, camin, turmeric, ginger, copra and many kinds of seeds and dried fruits, dried and processed materials suffer damage in storage, both in quantitatively and qualitatively. On an average the loss in India due to pests and disease in estimated to be 10 per cent to 20 per cent annually. Food grain lost more than 10 per cent of the total loss. In absolute figures it comes to nearly 8 million tones while accounts an enormous quantity. Besides pest infected commodities fetch a very low price in the markets.

The new technological developments in agriculture, involve new crop varieties and cropping patterns, use of fertilizers, new irrigation facilities, reclamation of new lands and intensive farming practices. However this development on the other hand provides favourable condition for the multiplication and spread of pests and diseases. Therefore, plant protection assumes greater importance in alround agricultural development programmes.
InPACr Q-b' IRRIG.AriOiv Or. /^G.q^ LTbRAL pKOJlCI'I'/irY :

Irrigation is most important input in the process of agricultural production. The growth of irrigation facilities in the region under study are not uniform which have resulted in economic disparities. Due to erratic rainfall farmers can not grow more than one crop in the year. To get multiple cropping one has to manage irrigation facilities either through canals, wells or tanks.

Agricultural operations depend greatly upon water availability at required times. The rivers in India have played an important role in the development of irrigation system of all the regions. The distribution of irrigation water in all the regions however is not uniform resulting in an economic disparity through out the region. As irrigation supports other inputs like fertilizers and better seeds the maximum efficiency of fertilizers therefore rests upon better facilities of irrigation. In addition to this better seeds can only show their impact, if irrigation is managed properly. To get the maximum benefit from irrigation, a region requires a proper distribution minor irrigation. Besides under ground water should also be taped as a substitute of surface irrigation. In some places tank irrigation also plays an important role.
The better management of irrigation also depends on the check of the losses that occur due to evaporation and seepage. The lifting of underground water depends entirely on energy. Therefore electric supply as well as the oil for pumping sets should be maintained.

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. In addition to this, adoption of certain agricultural innovations, chemical fertilizers and manures and new varieties of seeds are also essential. The farmers having adequate and assured irrigation facilities can adopt improved agricultural practices without much difficulty.

India present level of utilization of irrigational resources the development of agriculture can not be over emphasised.

The important crops grown under irrigation are ragi, paddy, jowar wheat, vegetables, sugar cane and to some extent pulses and groundnut also require irrigation.

The upper Ganga plain is one of the highly irrigated agricultural regions of India and irrigation has played a dominant role in boosting its agricultural prosperity.
particularly during the last one hundred years. In this region about 30% of the net sown area is irrigated. There is a wide regional variation in the irrigated area. In most of the upper Ganga Yamuna Doab districts like Muzaffarnagar (59%), Meerut (68.6%), Bulandshahr (64.2%) in the upper Ganga-Yamuna Doab record the highest percentages, that is more than a double of the state average, while other districts of this region irrigate only to the extent of 30 to 50 per cent of the net sown area.

In the upper Ganga Yamuna Doab there are a number of irrigation means such as canals, wells, tube-well tanks etc. The major source of irrigation in the upper Ganga-Yamuna Doab however is canal. The canals work in two way—firstly they help in irrigation and also check the floods.

In the upper Ganga-Yamuna Doab there are three main canal systems.

1. Upper Ganga Canal
2. Lower Ganga Canal
3. East Yamuna Canal

The major sources of irrigation in the Upper Ganga-Yamuna Doab are

1. Canal irrigation
2. Underground irrigation.
Canals constitute the main source of irrigation in the area. Nearly 50% of the total cultivated land is under the canal irrigation.

Under ground irrigation can be divided into two categories.
1. Wells
2. Tube-wells

Well irrigation is one of the oldest methods in this region. In fact, the well irrigation suits the poor farmers very much because it does not require much capital to operate it. To this no machinery is required. The well irrigation entails more labour on the part of the cultivator for raising water from varying depth.

The tube-well which are comparatively of recent development in the upper Ganga-Yamuna Doab are the major source of irrigation in various tracts of this region.

The regional economy of the Ganga Yamuna doab is dominated by the agriculture and associated industries. In the upper Doab with the exception of district Bulandshahr (43.1%) canal irrigation shares more than four of the net sown area. Among all the districts of upper Ganga Yamuna Doab Muzaffarnagar show highest percentage (65.7) of irrigated area. In the upper Ganga-Yamuna Doab irrigation facilities
### TABLE XII

**IRRIGATION IN DISTRICTS OF UPPER GANGL-AMINA DOAB**

**BETWEEN 1966-67 AND 1983-84**

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>TOTAL CROPPED AREA IN (hectare)</th>
<th>NOT IRRIGATED AREA IN HECTARE</th>
<th>CANAL PERCENTAGE</th>
<th>TUBE-WELL PERCENTAGE</th>
<th>OTHER WELL PERCENTAGE</th>
<th>OTHER SOURCES PERCENTAGE</th>
<th>NOT IRRIGATED AREA PERCENTAGE TO TOTAL CROPPED AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saharaerpur</td>
<td>518678</td>
<td>611923</td>
<td>146852</td>
<td>27627</td>
<td>54.92</td>
<td>69.25</td>
<td>25.67</td>
</tr>
<tr>
<td>Muzaffarnagar</td>
<td>446676</td>
<td>511237</td>
<td>225034</td>
<td>290348</td>
<td>50.61</td>
<td>57.67</td>
<td>26.97</td>
</tr>
<tr>
<td>Meerut</td>
<td>672509</td>
<td>508748</td>
<td>254674</td>
<td>295610</td>
<td>48.27</td>
<td>67.31</td>
<td>28.92</td>
</tr>
<tr>
<td>Bulandshahr</td>
<td>544330</td>
<td>580440</td>
<td>266834</td>
<td>336125</td>
<td>34.34</td>
<td>70.15</td>
<td>32.16</td>
</tr>
<tr>
<td>Ghaziabad</td>
<td>*</td>
<td>313018</td>
<td>*</td>
<td>173033</td>
<td>*</td>
<td>64.41</td>
<td>*</td>
</tr>
</tbody>
</table>

**Total upper Ganga-Yamuna Doab**

| 2102293 | 4527366 | 987444 | 1371243 | 49.28 | 65.75 | 28.36 | 65.75 | 21.67 | 1.38 | 0.59 | 6.04 | 44.82 | 53.79 |


*1966-67 Ghaziabad was not formed as District.*
are on the increase with the result the percentage of net irrigated area has increased from 44.82 in 1966-67 to 54.26 in 1983-84.

The development of canals and wells in the study area has a considerable influence over crop land use patterns and also nature of occupation of the people. Increase in irrigated land has been a baon to the cultivators. It has not only increased the area under cultivation but also has increased the output per hectare.

Government of India is providing more facilities through "Integrated Rural Development Programme". Irrigation development in the seventh Plan is also based on a quick completion of ongoing schemes such as utilisation of potential and better management schemes.

Table No. XV shows that crop growth and subsequently the production depends to a greater extent on the availability of water and its proper use. When we are concerned with the expansion of irrigated areas in order to increase agricultural productivity, the same can be achieved by increasing the yields of crops on the samelands that has already avail irrigation. Therefore, the following irrigation sources have been developed in upper Ganga Yamuna Doab, i.e., Canals, tube-wells, tanks (including lakcs and pound) and other. The
respective share of each source in the state is shown in Table XII. The figures in the table include two points of time with a gap of 17 years (1966 and 1983). It is evident from the table that among all the sources, two major sources, viz., canals and tube wells irrigate the largest area of upper Ganga-Yamuna Doab. It is also noticeable from the same table that the extent of irrigation by the above sources follow a quite significant increase from 1966-67 to 1983-84. In the upper-Ganga-Yamuna Doab the irrigated area to the total cropped area in 1966 was 44.82 per cent which has increased to 54.26 per cent in 1983.

The percentage of irrigated area to the total cropped area in each district of the region under study has increased from 27.15 to 45.26 (in Saharanpur) 50.36 to 56.57 (in Muzaffarnagar) 52.73 to 57.91 (in Meerut) and 49.02 to 57.94 (in Bulandshahr). Figures of Ghaziabad in 1966 was not available because at that time it was a part of Meerut district.

IRRIGATION BY CANALS:

The canal irrigation holds a special significance over the other sources of irrigation in the region under study.
In 1966-67 area under canal irrigation was maximum in Muzaffarnagar District of the region, it was about 59.61%. But in 1983-84 area of Bulandshahr district was having maximum irrigation by canal (70.15%). In 1966, 42.29% area of total upper Ganga Yamuna Doab was irrigated by canals. But this percentage had increased to 31.30% in 1983-4.

**TUBE-WELL**

Tube well irrigation though of recent origin in India is of much importance in upper Ganga-Yamuna Doab. The importance of tube-well irrigation over canals can well be appreciated by the fact that it can be constructed close to the places where water is needed for irrigation. The total irrigated area by tube-well in 1966 was only 28.36 per cent in the upper Ganga Yamuna Doab which has increased to approximately 65.75 per cent in 1983. This shows that the percentage of tube-well irrigation has moved much faster than other means of irrigation. In this regard the district of Bulandshahr, shows a high percentage of tube-well irrigation in 1966, and in 1983-84 the highest percentage is also in Bulandshahr district while in 1966 Saharanpur district is having the lowest figures (25.67). In 1983-84 the Muzaffarnagar district is having the lowest figure (57.67).
OTHER SOURCES:

As it has been stated earlier that the irrigation by other sources constitute mainly wells other than tube-wells, tanks and ponds. In the area where canals and tube-wells irrigation is inadequate, other sources are required to supplement the water. As a whole in the study region the total irrigated area by other sources has increased from 0.59% to 1.38% from 1966-67 to 1983-84 respectively. In 1983 District of Bulandshahr was having the maximum area (4.76%) under this category.

MEASUREMENT OF AGRICULTURAL PRODUCTIVITY IN UPPER GAHG-
YAMUNA DOAB:

In order to increase the crop production, use of modern technology is highly indispensable in every part of the world. For measuring the level of productivity of agriculture, different geographers have applied various methods. With a view to measure the agricultural productivity in the area under study the author has adopted the methods of crop yield index.

The study is based on districtwise data collected from official records of Directorate of Agricultural Statistics, Uttar Pradesh9. The productivity indices of crops for each districts were computed according to the methodology

given by Yang and has been tested in the area under study.

The productivity indices of crops considered for each district were computed according to the Yang's methodology. The methodology is explained by the author testing Saharanpur as an example.

<table>
<thead>
<tr>
<th>Name of crop</th>
<th>Yield in quintal per hectare</th>
<th>Area of crop in the distt in hectares</th>
<th>Crop yield in the distt as % of the state (Col 3/Col 4)</th>
<th>Percentage multiplied by area in hectares (Col 5xCol 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>18.39</td>
<td>21.43</td>
<td>116.5</td>
<td>21178651</td>
</tr>
<tr>
<td>Rice</td>
<td>11.14</td>
<td>16.51</td>
<td>148.20</td>
<td>12417529</td>
</tr>
<tr>
<td>Maize</td>
<td>7.72</td>
<td>10.10</td>
<td>130.82</td>
<td>3548100</td>
</tr>
<tr>
<td>Barley</td>
<td>13.31</td>
<td>14.90</td>
<td>111.94</td>
<td>92574</td>
</tr>
<tr>
<td>Cilseed</td>
<td>4.99</td>
<td>2.86</td>
<td>57.31</td>
<td>204539</td>
</tr>
<tr>
<td>Pulses</td>
<td>8.58</td>
<td>4.17</td>
<td>48.60</td>
<td>585046</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>456.55</td>
<td>499.00</td>
<td>109.29</td>
<td>15638415</td>
</tr>
<tr>
<td>Potatos</td>
<td>158.21</td>
<td>191.86</td>
<td>121.26</td>
<td>175012</td>
</tr>
<tr>
<td>Bajra</td>
<td>7.76</td>
<td>4.66</td>
<td>60.05</td>
<td>60590</td>
</tr>
<tr>
<td>Total</td>
<td>468183</td>
<td></td>
<td>53900456</td>
<td></td>
</tr>
</tbody>
</table>

Crop index for the district Saharanpur = \( \frac{53900456}{468183} \)

= 115.12%

This index represents the yield of all crops in a district compared with the average crop yield of the state (U.P.). Before calculation the crop yield index for a particular district the average yield of each of the crops grown in the state must be determined. Later on a value in percentage is obtained by dividing the yield per hectare of a crop in the particular district by the average yield of the crop in the entire region. This value gives the index number as shown in col 5 of Table No. XIII. By considering the area devoted to each crop as a weight and multiplying this percentage index, the products are obtained as listed in col. 6 of Table No. XIII. By adding the products and dividing the sum of products by the total cropped area in the district (the sum of the col. 4), the average index obtained is the desired crop index for the particular district, using crop area as weight. Applying above method the author has determined the productivity index with respect of selected crops (wheat, Rice, Maize, Sorley, Oilseed, Pulses, Sugarcane, Bajra, Potato) of each district, of upper Ganga-Yamuna Doab. The productivity indices obtained by crop yield index method for each district of upper Ganga-Yamuna Doab (for the year of 1966-67 and 1982-83 respectively) were arranged in ascending order then grouped as follows.
UPPER GANGA–YAMUNA DOAB
PRODUCTIVITY INDICES 1966-67

LEGEND

140 ABOVE
125-140
110-125
95-110
80-95

KM 0 10 20 30 40 50 60 70 80 90 KM

FIG. 6
Table No. XVII represents crop productivity indices for all the districts of upper Ganga-Yamuna Doab, as calculated on the basis of the crop yield index method. In 1966-67 Bulandshahr district showed the lowest productivity index amounting to 86.9. Saharanpur and Meerut districts showed low productivity with productivity indices of 105.4 and 109.6, respectively. Muzaffarnagar was in the rank of medium productivity area with productivity index of 113.3 (Fig 6).

In year 1982-83 the use of modern implements, fertilizers rate of literacy and area under irrigation have increased with the result the productivity indices of all the districts of upper Ganga-Yamuna Doab the limits between 115.12 and 143.95 Bulandshahr reached in the rank of very high productivity area with productivity index of 143.95. While Muzaffarnagar, Meerut and Ghaziabad were in the rank of high productivity with productivity indices of 127.3, 130.0.
UPPER GANGA–YAMUNA DOAB
PRODUCTIVITY INDICES 1982-83

LEGEND

140-ABOVE
125-140
110-125
95-110
80-95

FIG. 7
130.0 and 132.5 respectively. Sohagpur was in the rank of medium productivity with productivity index of 115.12 (Fig. 7).

In upper Ganges-Yamuna Plain productivity indices have considerably changed during the last 16 years under the new agricultural strategy. This change is mainly due to the use of modern inputs such as high yielding varieties of seeds, chemical fertilizers, irrigation facilities, farm implements, pesticides and insecticides and also other agricultural practices. The factors responsible for the increase of agricultural productivity in the study region are abolition of zamindari system, improved tenancy system, size of holdings, land tenure, land reclamation, land reforms (to eliminate the middlemen and to protect the interests of the tenants) an organised marketing system for agricultural commodities and provisions for infrastructure facilities and also the storage facilities. In addition, for health and education schemes have been launched by Government of India under the Five Year Plan.
<table>
<thead>
<tr>
<th>Districts</th>
<th>Years 1966-67</th>
<th>Districts</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saharanpur</td>
<td>105.4</td>
<td>Saharanpur</td>
<td>115.1</td>
</tr>
<tr>
<td>Muzaffarnagar</td>
<td>113.3</td>
<td>Muzaffarnagar</td>
<td>127.3</td>
</tr>
<tr>
<td>Meerut</td>
<td>104.6</td>
<td>Meerut</td>
<td>130.0</td>
</tr>
<tr>
<td>Bulandshahr</td>
<td>86.9</td>
<td>Ghaziabad</td>
<td>132.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bulandshahr</td>
<td>143.95</td>
</tr>
</tbody>
</table>