Chapter - 4

Agricultural Productivity Regions in North Bihar Plain
A. THE CONCEPT OF PRODUCTIVITY IN AGRICULTURE

The term productivity has been used with different meanings and with many conflicting interpretations. Sometimes it is considered to assess an overall efficiency of a production system and expressed in the form of a ratio of output to input. In reality, production refers to the volume of output in relation to the resources used. Production in any enterprise can be increased by applying more resources with an intention of increasing productivity per unit. On the other hand, productivity can be increased without increasing production by employing less inputs for the same production. But it is commonly agreed, that productivity is the ability of a production system to produce more in the economic sense and efficiently. Therefore, agricultural productivity can be defined as a measure of efficiency in a farming system which employs land, labour, capital and other related resources.

In recent years, many attempts have been made to define the connotation of agricultural productivity. According to Dewett (1966)\textsuperscript{1}, "Productivity expresses the varying relationship between agricultural output and one of the major inputs like-land, labour or capital, other complementary factors remaining the same...". It may be born in mind that productivity is physical rather than a value concept. The connotation of agricultural productivity engaged the attention of many economists at the 23rd Annual Conference of the Indian Society of Agricultural Economics\textsuperscript{2}. Some economists suggested, that the yield

\textsuperscript{1} Dewett, K.K. and Singh, G., Indian Economics. Delhi, 1966, p. 66.
per hectare should be considered for expressing agricultural productivity. A number of objections were raised against this view because it considers only one aspect—the land, which is just one factor of production, while other factors are also responsible for the production and, therefore, it was arbitrary to attribute productivity entirely to land and expresses it in terms of output per hectare. It was suggested, for instance, that productivity should also be measured in terms of labour involvement in agriculture and different regions are compared on that basis. After a thorough discussion, it was generally agreed, that the yield per hectare may be considered to present the crop productivity in a particular region, and that other related factors of production be considered as the possible causes for the assessment of variations while comparing it with the other regions. Pandit (1965), has stated the connotation of productivity in economic terms, "Productivity is defined in economics as the output per unit of input... the art of securing an increase in output from the same input or of getting the same output from a smaller input". He further suggested, that any increase in productivity, whether in industry or agriculture, is generally the result of a more efficient use of some or all the factors of production, viz., land, labour and capital. According to Saxon (1965) basically, productivity is a physical relationship between output and the input which gives rise to that output. Horring

(1964), considered productivity in broad terms, to denote the ratio of output with one or all the associated inputs, in real terms.

There are many other concepts of productivity, and still more ways of computing it. The Chairman of the International Commission on Agricultural Typology, Prof. Kostrowicki, invited different views on this problem by sending a questionnaire to over 100 scholars throughout the World, which embodied the following two questions:

1. What methods, of measuring intensity of agriculture, should be applied in typological studies of various orders?

2. What methods, measures, indices should be used to define land, labour and capital productivity of agriculture in typological studies of various orders?

About fifty geographers from all over the world responded and suggested a number of approaches for the measurement of agricultural intensity and productivity. The Chairman of the Commission while evaluating different views pointed out, that a special study testing various methods and techniques to be used in the studies of various scale were needed.

Agricultural productivity has been looked from different points of view, such as productivity of land, labour and capital. These are considered to be the best known partial productivity ratios.


A special attention may be focussed on the productivity of land, because it is the most permanent and fixed among the three conventional categories of inputs in crop production (land, labour and capital), and in recent times it has assumed more importance due to increasing population pressure on limited land resources. It is simplest but in some respects it is most useful to examine agricultural productivity considering the land as an input. Land on unit or regional basis expresses the yield of crops in terms of output, and from a regional or national point of view, it is desirable to secure the employment to a largest number of persons.

Land productivity is obviously of prime importance as a determinant of the total food and crop production, whereas the productivity of labour is mainly important as a determinant of the income of the population engaged in agriculture. Labour productivity in agriculture has two important aspects. Firstly, it profoundly affects the national prosperity i.e., the national income; secondly, it determines the standard of living of the people engaged in agriculture. National prosperity in economic perspective is largely synonymous with the high output per man-hour. Therefore, if a country intends to increase its prosperity it needs: (a) to encourage technical assistance and improvements to the labour population, which help to increase productivity in the agricultural economy, and (b) to stimulate a continual transfer of labour from low productivity to high productivity regions. So far as raising the farmer's standard of living is concerned there are two ways: either he may be paid more than the prevailing world prices for a given

amount of work which he renders in cultivation, or the steps can be encountered to raise output e.g., productivity from the same resources. Output per man can be increased in an agricultural economy by two ways: (i) by giving each farm worker more land and livestock to look after, and (ii) by making each unit of land and livestock capable of yielding a bigger output⁹.

Land capability is of prime importance in countries with a high density of population when land resources are limited the principal means of raising production to keep pace with the growth of population is by raising yields per hectare. However, raising the productivity of land does not mean only raising the yield of individual crops. It encompasses the whole output of a farm or country in relation to the total area of the farm land, and may be raised also by changing the pattern of crop production towards more intensive systems of cultivation or adopting higher value crops.

A distinction must be made between the measurement of agricultural output in terms of calories (or some other measurement of food values), and in terms of money values of output. For example, if in temperate countries the cultivation on land is shifted from cereals to potatoes, the output per hectare in terms of calories of human food is likely to be increased. But its productivity in terms of money values may be changed-up or down according to the relative prices of cereals and potatoes in marketing systems. Again, shifting land from the main crop potatoes to early season potatoes or to luxury vegetables may increase its productivity in money terms but it will certainly reduce the output in terms of calories. Pasture

lands used for grazing of animals will usually produce less calories for human food than if it is cropped with cereals for direct consumption will show a higher productivity in money values.

The productivity of labour is somewhat more complex aspect than land productivity. Land productivity measures the income of the population engaged in agriculture, and can be examined in terms of output per worker. It takes into account all the labour which contribute efforts for agricultural production directly on the farm and that is used indirectly off the farm in producing the materials and rendering services. The labour input may be expressed as the total numbers in labour force or in order to take into account the intensity of labour as the number of man-hours worked in agriculture. Similarly, the total agricultural output may be taken as the gross farm output or it may be taken as the value added by labour and other factors in the agricultural sector i.e., the value of fertilizers, pesticides, fuels and other inputs from outside the agricultural sector, is subtracted from the value of the output in order to determine the net contribution of the agricultural sector.

Labour productivity is in fact the most common form of agricultural productivity measurement, and is usually implied in economic discussions when no specific definition is given. As the output per man is one of the major determinants of the general level of economic welfare, labour productivity is a significant yardstick of economic progress. Various measurements of labour productivity may have specific uses in policy


formations e.g., with regard to income distribution and occupational distribution of labour force, etc.\textsuperscript{12}.

Increases in the productivity of land and of labour often go hand in hand. When crop yields are increased or the pattern of cropping intensified there is usually, although not always, an increase in output per man. Similarly, when improved methods are adopted to increase efficiency and raise labour productivity and farm incomes, there is often, as a secondary result, an increase in land productivity and total output.

Capital productivity of agriculture is particularly complicated to compute and difficult to interpret. This is largely because of diversity of capital being utilised in agricultural production, for land purchase for land improvement, land reclamation, drainage, irrigation, farm buildings, mechanical power, machinery and implements, livestock, feeds, seeds, fertilizers, crop protection chemicals etc. The presence or absence, amount, quality and price of each factor of production varies spatially, affecting the relationships between them and their deployment on individual farms. These spatial patterns are not static, labour and capital being geographically mobile. The use of each production factor will not depend solely upon its availability. It will be influenced by technological, economic and social circumstances which permit the substitution of one for another and in turn will be affected by their degree of divisibility.

Estimates of capital productivity give relatively little guidance in ensuring the most efficient use of the limited capital resources. In part this is because the statistics of capital use in agriculture are less informative.

\textsuperscript{12} Ibid. p. 98.
than those on land and labour, not because much of this investment, especially in less developed countries consists of non-monotized investment stemming from the unpaid labour of the farmers themselves. The terracing of slopes, the bunding of paddy fields, the construction of irrigation ditches are examples of this type of non-monotized investment which is of crucial importance for raising both output and productivity. This does not mean that capital is not of vital importance to agriculture. The requirement of fixed capital stock in agriculture - even excluding land - often appear to be greater in relation to the output than those of manufacturing industries and mining, though there are considerable differences between countries in methods of estimation.

The productivity of livestock is again more difficult to measure than the productivity of land. The difficulty arises both in the measurement of the input and output. Much of the livestock production results in more than one end product; cattle may produce milk, beef and hides, sheep may produce wool and meat etc. A comparison of the milk output of specialised dairy cows with that of dual purpose animals kept for both milk and beef may be misleading. To aggregate the output of all livestock products, with suitable price weights, solves part of problems but not all of it, because of the widespread use of livestock, particularly in the less developed regions, for draught power. A complete accounting of the output would, therefore, also requires the inclusion of the draught power produced by livestock. The principal input is the capital represented by the livestock itself. Other inputs include the feeding stuffs which they consume, whether from grazing or in the farm of preserved or concentrated feeds, and the land which is as a pasture or crop land is devoted to livestock production.
The above measures of livestock productivity when combined shall not give a very satisfactory indication of productivity. The simplest and the most frequently used comparison of the livestock is the output of milk or meat per animal, which would be significant when cattle are of about the same size or weight. But if in any country the common breeds of livestocks are of large and in another small, differences between the average output per animal in two countries will in part reflect these differences in size rather than their relative efficiency. And since small cattle eat less, and since more small cattle can be kept on a given area, the total output of meat or milk per unit of feed or per hectare of land may be as high in one country as in the other. It could not then be said, that the average productivity of the large breeds was greater than that of the smaller breeds.\(^\text{13}\)

The whole output from each hectare of land used for agriculture is known as the overall productivity of land. It is more significant than yields per hectare or livestock yields. The individual yields reflect only the efficiency of crop husbandry or livestock husbandry, the overall productivity also takes into account the marginal skill with which the various farm enterprises are integrated to increase the total farm output. The overall productivity reflects the opportunities to produce high value crop e.g., tobacco or in suitable climates or under irrigation to raise more than one crop per year from the same land. Thus, the countries with the highest total output per hectare appear to have an overall productivity some forty times greater than those with the least intensive agriculture.\(^\text{14}\)

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13 Ibid. p 108
14 Ibid. p 110
B. THE MEASUREMENT OF AGRICULTURAL PRODUCTIVITY

The measurement of productivity is not a simple task as it involves a relationship between inputs and output in agricultural production. Input to agriculture itself is a complex thing which governs farming efficiency. Stamp (1960)\(^{15}\), while attempting to measure crop productivity per unit area emphasized that areal differences in crop productivity are the result partly of natural advantages of soil and climate and partly of farming efficiency. Farming efficiency refers to the properties and qualities of the various inputs, the manner in which they are combined and utilised for production and effective market demands for the output.

There is a substantial literature relating to the methological procedures for measuring productivity in agriculture. The measures of agricultural productivity which are most frequently understood are those of partial productivity and refer to the relation of a single input or a group of inputs to the total output or to a part thereof (yield per hectare, output per man-hour, and output per unit of capital). The data required to measure the productivity of a simple input are more likely to be available than those required for measures of overall productivity. Besides, the aggregate of total inputs may tend to obscure the effect of change in their composition. Many attempts have been made to measure the agricultural productivity in different countries of the world.

Thompson (1926)\(^{16}\), while measuring the relative productivity of British and Danish farming emphasized it in terms of gross output of crops


and livestock. He considered seven parameters. They are: (i) the yield per acre of land; (ii) the livestock per 100 acres; (iii) the gross production or output per 100 acres; (iv) the production of arable land; (v) the number of persons employed; (vi) the cost of production expressed in terms of wages and labour costs, rent or interest; and (vii) price relative profitability and general economic conditions.

Ganguli (1938)\textsuperscript{17}, in his study of the Ganges valley presented a theoretical discussion for computing productivity in agriculture. Firstly, he took into account the area under any crop 'A' in a particular unit area belonging to a certain region. This area is expressed as a proportion of the total cropped area under all the selected crops. Secondly, he tried to obtain the index number of yield. This is found by dividing the yield per hectare for the entire region as the standard. This yield may be expressed as a percentage and this percentage may be regarded as the index number of yield. Thirdly, the proportion of the area under 'A' and corresponding index number of yield were multiplied. There are two advantages which are apparent by using this method: (i) the relative importance of the crop 'A' in that unit of study is assessed as indicated by the proportion of the cropped area which is under 'A', and (ii) the yield of the crop 'A' in comparison to the regional standard. The product thus, obtained indicates actually an index of the contribution of the crop 'A' to the productivity of the unit considered.

Kendall (1939)\textsuperscript{18}, taking the acre yield of ten leading crops in each of the forty-eight administrative counties in England for four selected years,


initiated four coefficients: (i) productivity-coefficient, (ii) ranking coefficient, (iii) money value coefficient, and (iv) starch equivalent or energy coefficient. Of the four coefficients, the ranking coefficient is probably the easiest to calculate and which gives a reasonable ranking of counties in order of productivity. To obtain the ranking coefficient, Kendall ranked each of the ten crops in the forty-eight counties in order of their yields, then the sum of the ranks occupied by the county was divided by the number of the crops considered to obtain the average rank of the county. Kendall's money value coefficient was based on the value of crop production of each county, which was obtained by multiplying the volume of production of a particular crop by the relative price, and thus results of the ten crops for each county were added together and the total was divided by the total acreage in the county under the ten crops. Kendall's energy coefficient is based on the total energy value of various arable crops expressed as starch after adding the proportions assignable to by-products and the energy index was constructed by ascertaining the production of energy for crops per acre on the basis of a prepared table showing the energy value of various crops.

Kendall's money value coefficient possesses one major difficulty, that data for major crops were not available, for example, there are many vegetables and beans which are grown mostly for the consumption on the farms and their price data are not recorded in contrast to cereal crops whose data are adequate. While determining the money value coefficient, another difficulty arises with regard to the prices, for example, which prices prevailing in the area should be adopted, or those prevailing in the region or in the country as a whole, in addition to the local variations in the prices which depend on circumstances like proximity to the market or the relative
nutritive character of the product. Significant differences in prices per tonne between the crops affect the final result heavily in favour of the higher priced commodity. In this method, the production of each unit area is valued by multiplying the volume of production of a particular crop by the price, and then add the results for the selected number of crops together. The total is divided by the total acreage in the unit area under the total selected crops. The result gives for each unit area a figure of money value per acre under the crops considered. So far as energy coefficient is considered as index based on nutritional factor ignores local variations because of the absence of the data. Kendall, therefore, suggests a starch equivalent coefficient as the most suitable method. While calculating a coefficient based on starch equivalent it should be decided:

(a) Whether a gross or net digestible energy figure is to be taken;

(b) Whether any allowance is to be made for by-products, such as wheat and barley straws or the green stalks of maize, jowar and bajra; and

(c) whether any account should be taken of the fact that the energy in certain foods has first to be fed to livestock and then wheat and maize are to be used for human consumption. The basic question that arises in this technique is whether the gross starch equivalent of various crops should be considered or the net equivalent. Net energy refers to the amount of energy for work and body building, whereas gross figure includes the energy employed in the digestive process of the consuming animal and similar non-realisable forms. Kendall suggested, that the production of energy be preferred as the gross figure.
Hirsch (1943)\textsuperscript{19}, suggested 'Crop Yield Index' as the basis of productivity measurement. It expresses the average of the yields of various crops on a farm or in a locality relative to the yields of the same crops on another farm in a second locality. Zobel (1950)\textsuperscript{20}, has attempted to determine the labour productivity. He considered the productivity of labour as the ratio of the total output to the total man-hours consumed in the production of that output resulting in output per man-hour. This has been expressed by the following equation:

\[ \pi = f(P, L) \]

where,

\[ \pi \] = Productivity of labour;

\[ P \] = Production; and

\[ L \] = Labour utilized

Huntington and Valkenburg (1952)\textsuperscript{21}, considered land productivity on the basis of acre yield of eight crops raised very widely in Europe. For each crop, the average yield per acre for Europe as a whole was taken as an index of 100, and the specific yield in each country was calculated accordingly. Stamp (1952)\textsuperscript{22}, adopted Kendall's 'ranking coefficient' method by selecting twenty countries and nine crops for measuring agricultural efficiency in Europe. The countries were placed in order of output per acre


\textsuperscript{22} Stamp, I. D., The Measurement of Agricultural Efficiency with Special Reference to India. \textit{Silver Jubilee Souvenir Volume}. Indian Geographical Society, 1952, PP. 177-78.
for each crop. The places occupied by each country in respect to the selected crops were then averaged, and from these averages, the ranking coefficient of agricultural efficiency of each country was obtained. If a country was at the top of every list, it would have a ranking coefficient of one, and if it were at the bottom of every list, it would have a ranking coefficient equal to the number of countries considered.

Another approach to measure productivity is to convert the total food production into calories. Quantitatively food requirements are generally estimated in terms of heat unit calories. A physiological calorie (also called kilocalorie and in abbreviated form as kcal) is the amount of heat necessary to raise the temperature of one kilogram of water by one degree centigrade. The caloric intake is a measure of the general health of a person which determines the amount of heat and energy needed by the human body.

Stamp (1958)\(^2\)\(^3\), has taken calorific value of farm production for measuring agricultural productivity. He tried to compute the Standard Nutrition Unit (SNU) by converting all the food production per acre in calorie. The British Medical Association has carried out an exhaustive enquiry based on all available sources and published a table to show the calorie intake among adults from 2,100 calories a day for a women in sedentary occupation to 4,250 calories for a man engaged in active manual work. For children the available intake is calculated at 800 calories a day for infants under one year to 3,400 calories for teenage boy. The average of the different calories worked out at 2,540 calories a day. Taking into

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consideration the average age-structure of the population, the range of occupations, the weight and height of the people living under the climatic conditions of north-western Europe, the average is 2,460 calories a day or about 9,00,000 calories per year. Making allowance for a lose of 10 per cent in harvesting, cooking and food preparation the figure of 10,00,000 calories a year in terms of farm production may be accepted.  

A Nutrition Expert Group of Indian Council of Medical Research has recommended the daily allowances of nutrients for the people living in India. They have published a table to show the caloric intake among adults from 1,900 calories a day for woman in sedentary work to 3,900 calories for man engaged in heavy work. For children it was recommended 110 calories per kg weight of the body per day for infants under one year to 3,000 calories for teenage boy.  

Shafi (1960), has calculated this under Indian conditions in the twelve villages of Eastern Uttar Pradesh. The net calorie intake ranges from 1,800 calories a day (667,677 a year) to 2,175 calories a day (795,514 a year). According to him in no case it reaches the 9,00,000 calories postulated as the Standard Nutrition Unit. He concluded that in the well drained and irrigated villages of Eastern Uttar Pradesh the calorie intake per person amounts to about 2,000 calories a day. Where the calorie intake drops below 2,000 calories a day, both standard of living and standard of health are perceptibly below.

26 Shafi, M. Land Utilization in Eastern Uttar Pradesh. Aligarh. 1960, P 222
Loomis and Barton (1961), have measured United States agricultural inputs and productivity in aggregate. To them, aggregate productivity depends upon conceptually consistent measures of agricultural outputs and inputs. The measures of inputs include all the production factors that depend directly on the decisions of farmers. Meiburg and Brandt (1962), have surveyed the earlier indices relating to the United States agricultural output, e.g., output estimates of total productivity. They considered eight indices of agricultural production which cover various phases of the period extending between the years 1866 and 1960. Mackenzie (1962), has measured the efficiency of production in Canadian agriculture by using the co-efficient of output relative to input. He mentions that the concept of productivity measurement is difficult to define and even more difficult to quantify. Oommen (1962), while working out the trends of productivity in agriculture of the state of Kerala (India) has measured productivity on the basis of yield per acre.

Enyedi (1964), while describing geographical types of agriculture in Hungary used the following formula for determining agricultural productivity:

\[ \text{Productivity} = \frac{\text{Output}}{\text{Input}} \]

where,

\[
\frac{Y}{Y_n} : \frac{T}{T_n}
\]

\[
Y = \text{total yield of the crop in the unit area};
\]

\[
Y_n = \text{total yield of the crop at the national level};
\]

\[
T = \text{total cropped area of the unit};
\]

\[
T_n = \text{total cropped area at the national level}.
\]

Horring (1964)^{32}, suggests that the concept of productivity is based not only on the simple relationship between output and input but rather on the differences between two or more relationships i.e., differences in the same agricultural region or sub-region as between successive periods (in time), and between similar agricultural regions in different countries or regions during the same period (in space). It may also be possible to make comparisons between the trends of productivity for different products, between different regions of the national economy or between the agricultural regions and national economy as a whole.

The Indian Society of Agricultural Economic considered the problem and published a series of articles under the heading of 'Regional Variations in Agricultural Development and Productivity'^{33}. Among the contribution Chatterji and Maitreya (1964)^{34}, have determined the levels of agricultural development and productivity during 1950-51 to 1957-58 in the

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state of West Bengal considering two important crops of rice and jute. They took into account the acre yield figures for this purpose. Dhondyal (1964)\textsuperscript{35}, has measured variations in agricultural development and productivity by selecting three representative districts from the three regions of Uttar Pradesh, while assessing the role of credit, intensive crop enterprises, and the influence of irrigation during 1962-63.

Sapre and Deshpande (1964)\textsuperscript{36}, modified the Kendall's ranking coefficient by giving a weightage to the area devoted to a number of crops. The weighted ranks of various crops are proportional to the percentage of crop land under each crop. For example, an enumeration unit 'A' has rank 2 on the basis of wheat-acre-yield and occupies 30-per cent of the total cropped area, rank 3 on the basis of rice-acre-yield and occupies 25 per cent of the total cropped area, rank 8 on the basis of gram-acre-yield and occupies 10 per cent of the total cropped area. Thus, the weighted average of the ranks would be: \((2 \times 30) + (3 \times 25) + (8 \times 10) = 215\) divided by the sum of the weights as \(215/65 = 3.3\). According to Kendall's method it would have been \(2+3+8\) divided by the number of crops as \(13/3 = 4.3\).

The Indian Society of Agriculture Statistics, organised a symposium on the topic 'Measurement of Agricultural Productivity' at the 17th annual conference of the society held at Jaipur (Rajasthan) in 1964. The research papers contributed by different scholars appeared in the society's journal, Indian Journal of Agricultural Economics, Vol. 19, No. 1, 1964, pp. 193-97. \textsuperscript{35}

Sapre, S.G. and Deshpande, V.D., Inter-District Variations in Agricultural Efficiency in Maharashtra State, Indian Journal of Agricultural Economics, Vol. 19, No. 1, 1964, P. 243. \textsuperscript{36}
'Journal of the Indian Society of Agriculture Statistics' in the issue of 1965. Sharma (1965)\textsuperscript{37}, while defining the concept agricultural productivity has suggested various parameters on which it can be measured. According to him, productivity can be considered in relation to land, labour and capital. It can also be considered in terms of overall resources employed in agriculture. In case of commodities like foodgrains, fruits, vegetables, sugarcane and edible seeds, he suggested, that the output of these commodities be converted into calories. While considering the other non-food crops such as cotton and other fibres the only common measures being the value which involves the pricing of different products. For evaluating the value of production, farm harvest or wholesale prices have the definite significance. He also emphasized agricultural workforce as the basis of productivity measurement, e.g., the total number of labourers employed (in order to account the intensity of labour) or the number of man-hours worked in agriculture per unit area.

Khusro (1965)\textsuperscript{38}, has linked assessment of productivity with the output per unit of a single input and output per unit of cost of all inputs in the agricultural production. Saran (1965)\textsuperscript{39}, has applied Cobb Douglas, 'Production function' approach for the measurement of productivity. The common purpose of this function is to express output/input relationship

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between several inputs and one output in the agricultural systems. The function takes the following form:

\[ Y = A x_1 x_2 x_3 x_4 \ldots x_n^y \]

where, \( x_1, x_2, x_3, x_4 \ldots x_n \) denote various inputs, like land, labour, capital and other working expenses. The values of \( b, c, d \ldots y \) represent elasticities of the respective inputs. Tambad (1965 & 1970)\(^4\), has adopted 'Crop Yield Index' as the basis for measuring agricultural productivity. He advocates, that the purpose of this technique is to express the average yield of various crops on a farm or in a region relative to the yield of same crop on another farm or in a second region. It can be expressed by the following equation:

\[
\text{Crop Yield Index} = \frac{\sum_{i=1}^{n} \frac{Y_i}{A_i}}{\frac{\sum_{i=1}^{n} A_i}{Yio}}
\]

where,

\[ i = 1,2,3,4 \ldots n \] are the number of crops considered in an unit area or year;

\[ \text{Yi} = \text{yield per acre of crop i in a farm area or year;} \]

\[ \text{Ai} = \text{the weightage of crop i denoted by the area under the crop as a percentage of total cropped land;} \]

\[ \text{Yio} = \text{the average yield per acre of crop i at the group of farms or entire region or the base year.} \]

Shafi (1965)\(^4\), has assessed the productivity on the basis of labour

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population engaged in agriculture. According to him, it can be computed by dividing the gross production in an unit area by the number of man-hours or less precisely by the number of persons employed in agriculture. In order to assess the productivity on the basis of population engaged in agriculture, it can either be obtained by dividing the total production with the number of workers, or a reverse index be adopted where the total number of workers per unit of production is assessed.

Aggarwal (1965)\(^{42}\), has adopted 'Factorial Approach' while measuring agricultural efficiency in Bastar district of Madhya Pradesh (now forming the part of Chhatisgarh state). In this approach a number of human controlled factors influencing crop production, with the exception of environmental factors were selected. They are as : crop superiority, crop commercialisation, crop security, land use intensity and power inputs.

Buck (1937)\(^{43}\), assessed the agricultural progress in China by adopting the approach of 'Grain Equivalent'. For this purpose he converted all the agricultural products into kilograms of grain equivalent as a unit of measure a kilogram, with whatever kind of grain was predominant in the region. A modification in his method was made by Clark and Haswell (1967)\(^{44}\), to express the output in terms of kilograms of 'Wheat Equivalent' per head of population.

\(^{42}\) Aggarwal, P.C., Measurement of Agricultural Efficiency in Bastar District: A Factorial Approach, Unpublished Proceedings of the Summer School in Geography held at Nainital, Department of Geography, Aligarh Muslim University, Aligarh.1965.


Dovring (1967)\textsuperscript{45}, attempted to measure the productivity of labour in the United States agriculture in terms of aggregate for period extending from 1919 to 1954 as well as commoditywise. Bhatia (1967)\textsuperscript{46}, while examining the change and trends in agricultural efficiency in the state of Uttar Pradesh during the period 1953-63 adopted Ganguli's method of productivity measurement by devising a mathematical equation that would be read thus:

(i) \[ I_{ya} = \frac{Y_c}{Y_r} \times 100 \]

where,

\( I_{ya} \) = the yield index of crop a;

\( Y_c \) = the average acre yield of crop a in the component unit; and

\( Y_r \) = the average acre yield of crop a in the entire region, and

\( E_i = \frac{I_{ya}C_a + I_{yb}C_b + \ldots I_{yn}C_n}{C_a + C_b + \ldots C_n} \)

where,

\( E_i \) = the agricultural efficiency Index

\( I_{ya}, I_{yb} \) etc. = the indices of various crops

\( C_a, C_b, \) etc. = the proportion of cropland devoted to different crops.

Shafi (1967 and 1969)\textsuperscript{47}, applied Stamp's 'Standard Nutrition Unit' technique for measuring the efficiency of agriculture in India. He considered

\textsuperscript{45} Dovring, F., Productivity of Labour in Agricultural Production, \textit{Agricultural Experiment Station Bulletin No. 726}, College of Agriculture, University of Illinois, Urbana, 1967.


district as the areal unit and selected all the food crops grown in India. Noort (1937)⁴⁸, considered 'Net Total Productivity' as a method for the measurement of field productivity and also to assess comparisons 'in time' or 'in space'. The purpose of this measure is to account changes in labour and capital inputs in agriculture.

Sinha (1968)⁴⁹, has adopted standard deviation formula to determine agricultural efficiency in India. In his study he selected all the 25 major crops grown in the country. These crops were grouped into: cereals, pulses, oilseeds and cashcrops, and the specific yields per hectare of cereals, pulses and oilseeds were taken into account. In case of cash crops, he considered the monetary values of the crops which were calculated (in Rs.) per hectare by incorporating the wholesale prices of the crops concerned. Finally, the standard scores were computed and to give them weightage, the computed values were multiplied by the average figures i.e., the area cultivated under the crops.

Shafi (1972)⁵⁰, while measuring the productivity of the Great Indian Plains attempted to modify the Enyedi's formula. In the modified form of the formula, the summation of the total yield of all the crops in the district is divided by the total area under the crops considered in the district, and the position thus obtained is examined in relation to the total yield of all the crops considered at the national level divided by the total area under those

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crops. The formula would be read thus:

\[
\frac{\sum y}{t} : \frac{\sum Y}{T}
\]

where,

\[yw, yr, ym...n\] = total yield of various crops in the district;

\[Yw, Yr, Ym...n\] = total yield of various crops at the national level;

\[t\] = total area under different crops in the district;

\[T\] = total area under different crops at the national level.

Singh (1972) attempted to measure the agricultural efficiency of the state of Haryana in terms of nutrition unit per unit area. He has tried to measure the carrying capacity per square mile in the unit area, which can be expressed as:

\[Cp = \frac{Co}{Sn}\]

where,

\[Cp\] = carrying capacity;

\[Co\] = calorie output per square mile;

\[Sn\] = Standard nutrition for ingestion in calories per person/annum.

Singh expressed it as a percentage of the carrying capacity in the entire region to obtain index numbers, which is meant to give a measure of

---

the agricultural efficiency of the areal unit relative to the entire region. The above may be expressed in the following form:

\[
\text{lae} = \frac{Cpe}{Cpr} \times 100
\]

where,

\begin{align*}
\text{lae} & = \text{the index number of agricultural efficiency of an enumeration unit; } \\
Cpe & = \text{the carrying capacity in terms of population in the component enumeration unit; } \\
Cpr & = \text{the carrying capacity in the entire region. }
\end{align*}

The participants to the Indian Society of Agricultural Statistics in its 30th Annual Conference held at Bhubneshwar (Orissa) in India, discussed some aspects on agricultural productivity in the Indian context. Raheja et al. (1977), have measured the impact of high-yielding varieties of seeds based on the data collected under the scheme 'Sample Surveys for Assessment of High-Yielding Varieties Programme', during 1973-74 and regional variations in productivity on the basis of yield per hectare in India. Singh et al. (1977), have accounted for the levels of increase in the yield of different crops during three decennial years i.e., 1950-51, 1960-61 and 1970-71 in each state of India, considering the relationship between the output of foodgrains and related inputs like the application of fertilizers, proportion of area sown more than once and gross irrigated area.


Nangia et al. (1977)\textsuperscript{55}, conducted a field survey in the village Khandewala of Haryana state. The study takes into account the productivity levels at different fields of the village in terms of money value during 1974-75 and a number of factors enumerated in three broad categories, viz. environmental, institutional and technological which hold responsibilities for the productivity variations.

Bhalla (1978)\textsuperscript{56}, has considered output per person considering the constant average prices for measuring productivity of labour in Indian agriculture by selecting nineteen crops during the period of two trienniums 1962-65 and 1970-73 for each district of India.

Singh (1979)\textsuperscript{57}, devised a method of presenting a two dimensional picture of agricultural productivity comprising two components, viz., intensity and spread considering three variables (i) yield; (ii) grain equivalent; and (iii) cropping system for each of the district of the state of Andhra Pradesh. Accordingly, a relative share of intensity and spread for each micro unit (district) has been computed to the macro unit (state) separately for the above three variables with the help of equations that he has derived in his study.

Considering the merits and demerits of the techniques considered the author feels that Yang's Index of agricultural productivity is the most suitable and hence the present study is based on Yang's Index as the measure of agricultural productivity in the area under consideration.

\textsuperscript{55} Nangia, S. et al., Variations in Field Productivity - A Cash Study of Khandewala, Haryana. \textit{Occasional Papers No. 7 (Mimeo)}, Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi, 1977.


\textsuperscript{57} Singh, V.R., A Method for Analyzing Agricultural Productivity : In (Ed. J.T. Coppock) \textit{Agriculture and Food Supply in Developing Countries} Published for the Commission on World Food Problems and Agricultural Productivity of the IGU, Department of Geography. University of Edinburg. 1979. pp. 43-51.
The productivity indices have been calculated by adopting a statistical technique initiated by Yang (1965)\(^{58}\), because it has its relative merit over other methods. It not only gives weightages to the real extent of crops but also is applicable in the agricultural realities of the developing world. Moreover, it is explicitly a relative index of productivity which measures productivity levels of units of observation with reference to regional yield. The productivity indices have been computed for three different periods, i.e., 1985-90, 1990-95 and 1995-2000. For each period, moving averages were obtained by taking five successive years, for 1985-90, five years data (1985-86, 1986-87, 1987-88, 1988-89 and 1989-90). For calculating agricultural productivity, seventeen major crops grown in the region were considered. They were grouped into as: cereal crops - rice, wheat, maize and barley; pulse crops - gram, masoor, arhar, khesari and peas; oilseed crops - mustard and rapeseed, sesameum, linseed and sunflower; and cash crops - sugarcane, potatoes, jute and tobacco. The data were collected from *Annual and Season Crop Reports, Bihar Through Figures* and official records of the Directorate of Statistics and Evaluation, Patna, Bihar.

Yang's crop yield index method deals with the calculating of index on the average yield basis of different crops selected for enumeration on an unit area and the yield of those crops in the entire region. The procedure for calculating the crop index for West Champaran district is explained in

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Table 4.1

**Method of calculating Crop Yield Index of West Champaran District**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield in quintal per hectare</th>
<th>Area under crop in the district (in '000' hectare)</th>
<th>Crop yield in the district as a percentage of the entire region</th>
<th>Percentage multiplied by area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average yield in the entire region</td>
<td>Average yield in the district</td>
<td>col.3</td>
<td>(col.5xcol.4)</td>
</tr>
<tr>
<td>Rice</td>
<td>10.52</td>
<td>13.21</td>
<td>199.4</td>
<td>125.57</td>
</tr>
<tr>
<td>Wheat</td>
<td>16.15</td>
<td>16.14</td>
<td>81.4</td>
<td>99.93</td>
</tr>
<tr>
<td>Maize</td>
<td>15.91</td>
<td>16.52</td>
<td>9.2</td>
<td>103.83</td>
</tr>
<tr>
<td>Barley</td>
<td>8.39</td>
<td>10.0</td>
<td>2.2</td>
<td>119.18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>292.2</strong></td>
<td></td>
<td>34390.37</td>
<td></td>
</tr>
</tbody>
</table>

Crop Index for West Champaran District

\[
\frac{34390.37}{292.2} = 117.69 \text{ per cent}
\]

The average yield of each of the crop grown in the entire region should be determined initially, later on, a value in percentage is obtained by dividing the yield per hectare of 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 4.1. By considering the area devoted to each crop as a weight and multiplying this with the percentage index, the product is obtained which is given in col. 6 of the Table 4.1. By adding the products, and dividing the sum of the products by the total cropped area (the sum of col. 4), the average index obtained is the desired crop index for that particular district. The computed values of productivity indices for each district of the region are given in Appendix D.
I. Crop Productivity Regions - 1985-90

On the basis of productivity indices computed for the districts of North Bihar Plain have been grouped into three distinct categories i.e., high, medium, and low. The number of districts in each category have been shown in Table 4.2, and the productivity regions demarcated in Figs.4.1 to 4.5.

Table 4.2

Districts Forming Different Productivity Regions - 1985-90

<table>
<thead>
<tr>
<th>Productivity Category</th>
<th>Cereals</th>
<th>Pulses</th>
<th>Oilseeds</th>
<th>Cash crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indices</td>
<td>No. of District</td>
<td>Indices</td>
<td>No. of District</td>
</tr>
<tr>
<td>High</td>
<td>Above 7</td>
<td>105.53</td>
<td>Above 6</td>
<td>115.28</td>
</tr>
<tr>
<td>Medium</td>
<td>94.39 to 4</td>
<td>111.53</td>
<td>98.06 to 5</td>
<td>115.28</td>
</tr>
<tr>
<td>Low</td>
<td>Below 7</td>
<td>94.39</td>
<td>Below 7</td>
<td>98.06</td>
</tr>
</tbody>
</table>

(i) Productivity Regions-Based on Cereal Crops Yield Index

Cultivation of cereal crops constitute the most important position in agriculture of the region. They occupy about 4006 thousand ha. (75.73 per cent) of the total cropped area. The districtwise productivity shows, that the highest productivity is occupied by Samastipur district with an index value of 118.08, whereas Katihar has the lowest value index value of 86.05 during 1985-90 (Appendix D). It may be seen from Fig.4.1, that high productivity region spreads over the western districts namely, East and West Champaran, Gopalganj, Saran, Siwan and two southern districts of Samastipur and Begusarai of the region, while medium productivity region comprises the Bhagalpur and Khagaria districts lying in the southern part and the districts of Madhubani and Darbhanga to form the northern part where the productivity index values range between 105.53 and 94.43. However, the low
NORTH BIHAR PLAIN
Productivity Regions - Based on Cereal Crops Yield Index
1985-90

Fig. 4.1
productivity areas are found in central and eastern parts of the region to include the districts of Sitamarhi, Muzaffarpur, Vaishali, Saharsa, Madhepura and Katihar.

**(ii) Productivity Regions Based on Pulse Crops Yield Index**

Cultivation of pulse crops covers about 247.2 thousand ha. (4.67 per cent) of the total gross cropped area. The high productivity region is mainly confined to the western districts of the region, except the district of Gopalganj, which falls in medium productivity region. The medium productivity comprise two districts in northwestern part are namely, East Champaran and Gopalganj, and three central districts namely, Madhubani, Darbhanga and Samastipur where the index value ranged between 98.06 and 115.28.

The region characterised with low productivity forms a compact block to cover the western part to include the districts of Purnia, Katihar, Saharsa, Madhepura, Bhagalpur, Khagaria and Begusarai. The productivity indices computed for the districts of this region have the index value below 98.06. The highest productivity index with a value of 141.16 place the district of Siwan at the top, while the lowest value of 82.93 is for the Bhagalpur district.

**(iii) Productivity Regions - Based on Oilseed Crops Yield Index**

Cultivation of oilseeds constitutes an important position in the agricultural economy of North Bihar Plain. They occupy 111.51 thousand ha. of the cultivated area, accounting for about 2.11 per cent of the total cropped area of the region. Figures shown in Appendix D indicate that the highest index value of 139.84 is assigned to the Begusarai district and the lowest is
Fig. 4.2

NORTH BIHAR PLAIN
Productivity Regions - Based on pulse Crops Yield Index 1985-90

INDEX
HIGH Above 115.28
MEDIUM 98.06 - 115.28
LOW Below 98.06

Kilometres
NORTH BIHAR PLAIN
Productivity Regions - Based on Oilseeds Yield Index
1985-90

Fig. 4.3
computed for the district of Muzaffarpur (69.79). It can be seen from Fig.4.3, that the districts lying in the southern part of the North Bihar Plain form a continuous belt, extending east to west, to be designated as the high productivity region. These districts are namely, Bhagalpur, Khagaria, Begusarai, Samastipur and Vaishali. One more district of West Champaran of northwestern part may also be included which possesses a value equal to high productivity.

The districts of Sitamarhi, Madhubani, Darbhanga, Saharsa, Madhepura and Siwan of central and northern parts form a compact block of medium productivity, except the district of Siwan, which lies in western part of the region. The productivity indices values for these districts range from 89.79 to 108.29. The remaining six districts of Purnia and Katihar lying in the eastern part, and Muzaffarpur, Saran, East Champara, and Gopalganj forming the western part form two separate tracts of low productivity with an index value below 89.79.

(iv) Productivity Regions-Based on Cash Crops Yield Index

Cash crops form the second most important group in the cultivation to cover 347.6 thousand ha. (6.57 per cent) of the total cropped area. During 1985-90, the highest index value of 126.53, was computed for the district of Begusarai, to be designated as high productivity area and the lowest obtained for the Khagaria district (68.65) Appendix D. It can be seen from Fig.4.4, that there are five districts, namely, Begusarai, Samastipur, Madhubani, East Champaran and Gopalganj, which have high crop productivity with the index value more than 105.94.
NORTH BIHAR PLAIN
Productivity Regions - Based on Cash Crops Yield Index 1985-90

Fig. 4.4
The cultivation of cash crops forms a narrow belt bearing a medium productivity in the districts of lying in the southern and southwestern parts of the region. A tract bearing S-shape of medium productivity can be recognized in central and northeastern parts to include the districts of Darbhanga, Saharsa and Purnia. The district of West Champaran lying in the northwestern portion of the region also forms a part to belong to medium productivity area. The low productivity region makes two separate blocks to include the districts of Katihar, Bhagalpur, Khagaria, Madhepura, Muzaffarpur and Sitamarhi.

(v) Productivity Regions-Based on Composit Yield Index

To determine the overall pattern of agricultural productivity during 1985-90, a composite index was computed considering all the crops which formed each group. Productivity regions considering all the crops are shown in Fig.4.5, and the number of districts with their names included in each category are given in Table 4.3.

<table>
<thead>
<tr>
<th>Productivity category</th>
<th>Crop Index</th>
<th>No. of District</th>
<th>Name of District</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Above 105.75</td>
<td>4</td>
<td>Samastipur, Begusarai, West Champaran, Siwan</td>
</tr>
<tr>
<td>Medium</td>
<td>95.63 - 105.75</td>
<td>7</td>
<td>East Champaran, Gopalganj, Vaishali, Madhubani, Saran, Darbhanga, Sitamarhi</td>
</tr>
<tr>
<td>Low</td>
<td>Below 95.63</td>
<td>7</td>
<td>Muzaffarpur, Saharsa, Bhagalpur, Madhepura, Khagaria, Purnia, Katihar</td>
</tr>
</tbody>
</table>
An analysis of productivity based on composite index shows that high productivity areas spread over the four districts namely, West Champaran, Siwan, Samastipur and Begusarai with the index values over 105.75.

The medium productivity region forms almost a circular band with a low productivity area lying in its centre. The medium productivity region consists of the districts of Vaishali, Saran, Gopalganj, East Champaran, Sitamarhi, Madhubani and Darbhanga. Almost all the districts lying in the eastern part forms a compact zone of low productivity with the index value of below 95.63. These districts form a continuous belt along the course of the river Kosi which affects crop productivity adversely by the occurrence of frequent floods in the area.

II. Crop Productivity Regions - 1990-95

During this period, two new districts of Araria and Kishanganj were created which have been included in the study. With the computation of productivity for all the districts of North Bihar Plain, the productivity indices have been categorised in different groups and are shown in Table 4.4.

Table 4.4

<table>
<thead>
<tr>
<th>Productivity Category</th>
<th>Cereals</th>
<th>Pulses</th>
<th>Oilseeds</th>
<th>Cash crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indices</td>
<td>No. of District</td>
<td>Indices</td>
<td>No. of District</td>
</tr>
<tr>
<td>High</td>
<td>Above</td>
<td>4</td>
<td>Above</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>105.98</td>
<td></td>
<td>111.79</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>91.80 to 105.98</td>
<td>10</td>
<td>97.37 to 111.79</td>
<td>9</td>
</tr>
<tr>
<td>Low</td>
<td>Below</td>
<td>6</td>
<td>Below</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>91.80</td>
<td></td>
<td>97.37</td>
<td></td>
</tr>
</tbody>
</table>
(i) Productivity Regions - Based on Cereal Crops Yield Index

Cereals, the most important crops grown in the region, occupy about 4024 thousand ha. and share about 75 per cent of total cropped area. During this period, the highest index value of productivity is found in the district of Begusarai (131.69), and the lowest value is for the district of Bhagalpur (72.17), Appendix D. It is evident from Fig.4.6, that the region of high productivity based on cereal crops lies in western part of the plain to include the districts of West Champaran, Gopalganj and Siwan. Two districts namely, Madhubani and Begusarai also belong to high productivity region lying in northern and southern parts of the region respectively.

The medium productivity regions based on cereal crops with an index value from 91.9 to 106.74 are found in eastern part to include the districts of Kishanganj, Araria, Purnia, Katihar and Madhepura. The two western districts namely, East Champaran and Saran and two districts namely, Darbhanga and Samastipur also have medium productivity. There are five districts which possess low productivity indices. The districts of Sitamarhi, Muzaffarpur and Vaishali form a narrow belt of low productivity. The remaining two districts of low productivity with an index value below 91.9 are Saharsa and Bhagalpur.

(ii) Productivity Regions - Based on Pulse Crops Yield Index

Productivity regions demarcated on the basis of pulse crops are shown in Fig.4.7, and the number of districts belonging to each category are given in Table 4.4. It may be seen from Fig.4.7, that high productivity with respect to pulse crops and with an index value of more than 111.79 forms a crescent-shaped belt extending to cover the districts of East and West
Champaran and Saran in the western part of the region. There are the districts of Kishanganj and Khagaria which are detached from the main region.

There are two main regions of medium productivity with regard to pulse crops in North Bihar Plain where the index values range between 97.37 and 111.79. One region lies in central and southern parts which includes the districts of Muzaffarpur, Darbhanga, Vaishali, Samastipur and Begusarai, and the other lies in the western part extending over to cover the districts of Gopalganj and Siwan. There are two more districts of Araria and Katihar which have medium productivity and lie in a detached form from the main region. The low productivity region forms a continuous belt which spreads over the districts of Sitamarhi, Madhubani, Saharsa, Madhepura, Purnia and Bhagalpur from north to south.

(iii) Productivity Regions - Based on Oilseed Crops Yield Index

Oilseeds account for only 2.16 per cent of the total cultivated area of North Bihar Plain. Only a small area of the region shows high productivity of oilseeds with an index value of more than 107.09. It is evident from Fig.4.8, this region spreads over to cover the southern districts of Vaishali, Samastipur, Begusarai and Bhagalpur. Medium productivity areas of oilseeds cultivation extends with over large parts of the index value in between 88.33 and 107.09 to include the districts of West Champaran, Gópalganj, Siwan, Muzaffarpur, Sitamarhi, Madhubani, Darbhanga, Saharsa, Madhepura, Khagaria and Kishanganj. The low productivity in oilseeds cultivation is found in eastern districts of Araria, Purnia and Katihar and two western districts namely, East Champaran and Saran with an index value which is below 88.33.
NORTH BIHAR PLAIN
Productivity Regions - Based on Oilseeds Yield Index
1990-95

INDEX
HIGH
Above 107.09
MEDIUM
88.33 - 107.09
LOW
Below 88.33

Fig. 4.8
(iv) Productivity Regions - Based on Cash Crop Yield Index

Cash crops constitute an important share in crop cultivation in North Bihar Plain and therefore, may be regarded as the second ranking crops which cover about 7.16 per cent of the total cropped area in the region. Fig.4.9 shows the productivity regions of cash crops and Table 4.4 indicates the number of districts which form a part in each category. It can be seen from Fig.4.9, that cash crops have a high productivity in western part to cover the districts of West Champaran, Gopalganj and Siwan. There are two districts of Madhubani and Begusarai which lie in the northern and southern parts respectively, that also record a high productivity of cash crops.

The medium productivity occurs in ten districts which form the eastern, southern, central and western parts in the plain. In these districts the productivity indices range in between 91.9 and 106.74. The low productivity regions form a narrow belt extending from north to south, encompassing the districts of Sitamarhi, Muzaffarpur and Vaishali. The two other districts possessing low productivity are namely, Saharsa and Bhagalpur.

(v) Productivity Regions - Based on Composite Index

The composite index of agricultural productivity considering all the crops has been worked out for the region. These regions are shown in Fig.4.10, and the number of districts forming the part in each category given in Table 4.5.
NORTH BIHAR PLAIN
Productivity Regions - Based on Composite Index
1990-95

INDEX
HIGH
Above 105.19
MEDIUM
95.11 - 105.19
LOW
Below 95.11

Fig. 4.10
Table 4.5

Productivity Regions - Based on Composite Index - 1990-1995

<table>
<thead>
<tr>
<th>Productivity category</th>
<th>Crop Index</th>
<th>No. of District</th>
<th>Name of District</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Above 105.19</td>
<td>6</td>
<td>Begusarai, West Champaran, Gopalganj, Khagaria, Samastipur, Siwan</td>
</tr>
<tr>
<td>Medium</td>
<td>95.11 - 105.19</td>
<td>7</td>
<td>Saran, Darbhanga, Kishanganj, East Champaran, Vaishali, Muzaffarpur, Araria</td>
</tr>
<tr>
<td>Low</td>
<td>Below 95.11</td>
<td>7</td>
<td>Katihar, Madhubani, Purnia, Madhepura, Bhagalpur, Sitamarhi, Saharsa</td>
</tr>
</tbody>
</table>

The composite productivity index computed for all the crops grown in the region place the district of Begusarai at the top with the index value of 121.26, and the district of Saharsa at the lowest with the index value of 84.81. It may be seen from the Fig.4.10, that high agricultural productivity is found in two different tracts. One tract lies in the western part to include the districts of West Champaran, Gopalganj and Siwan, and the other lies in southern part incorporating the districts of Samastipur, Begusarai and Khagaria.

The medium productivity regions form a compact block to include the districts of East Champaran, Muzaffarpur, Vaishali, Saran and Darbhanga. The districts namely, Araria and Kishanganj have medium productivity with indices ranging from 95.11 to 105.19 which occur in northeastern part of the plain. The low agricultural productivity region spreads over a vast area extending from northcentral to southeastern part of the region to include the districts of Sitamarhi, Madhubani, Saharsa, Madhepura, Purnia, Katihar and Bhagalpur.
III. Crop Productivity Regions - 1995-2000

During 1995-2000, two new districts namely, Supaul and Sheohar were created and they have been included in the study. On the basis of productivity indices computed, all the districts were grouped into three distinct categories (high, medium, and low) and the number of districts falling in each category are given in Table 4.6.

Table 4.6

<table>
<thead>
<tr>
<th>Productivity Category</th>
<th>Cereals</th>
<th>Pulses</th>
<th>Oilseeds</th>
<th>Cash crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indices</td>
<td>No. of District</td>
<td>Indices</td>
<td>No. of District</td>
</tr>
<tr>
<td>High</td>
<td>Above</td>
<td>7</td>
<td>Above</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>106.45</td>
<td></td>
<td>105.97</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>92.53 to 106.45</td>
<td>6</td>
<td>93.93 to 105.97</td>
<td>6</td>
</tr>
<tr>
<td>Low</td>
<td>Below</td>
<td>9</td>
<td>Below</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>92.53</td>
<td></td>
<td>93.93</td>
<td></td>
</tr>
</tbody>
</table>

(i) Productivity Regions - Based on Cereal Crops Yield Index

During the period 1995-2000, cereals covered an area of about 77 per cent of the total cropped area of North Bihar plain. The highest productivity of cereals, with an index value of 127.7, has been achieved by the district of West Champaran and the lowest recorded for the district of Darbhanga with an index value of 75.55 (Appendix D). It may be seen from Fig.4.11, that there are two tracts of high productivity, one lies in western part of the plain to include the districts of West Champaran, East Champaran, Gopalganj, Siwan and Saran, and the another lies in southcentral part and includes the districts of Khagaria and Madhepura.
Productivity Regions - Based on Cereal Crops Yield Index
1995-2000

NORTH BIHAR PLAIN

INDEX

HIGH

Above 106.45

92.53 - 106.45

LOW

Below 92.53

Kilometres

0 25 50 75
The medium productivity region occurs in eastern part and spreads over the districts of Kishanganj, Purnia and Katihar. Another a narrow belt of medium productivity with respect to cereals extends over the districts of Sheohar, Muzaffarpur and Samastipur. In these regions, the productivity indices range between 92.53 and 106.45.

The low productivity areas with the index value of below 92.53 are scattered over the plain. The six districts, namely, Sitamarhi, Madhubani, Darbhanga, Supaul, Saharsa and Araria of the northern portion of the plain form a continuous belt of low productivity. The remaining districts having low productivity are namely, Vaishali, Begusarai and Bhagalpur.

(ii) Productivity Regions-Based on Pulse Crops Yield Index

Pulses constitute 3.12 per cent of gross cultivated area in the region. It is evident from Fig.4.12, that pulses have recorded high productivity in seven districts of the region. The districts of Khagaria and Bhagalpur, in South eastern part, Vaishali and Samastipur, of southern part, and three districts of East Champaran, Siwan and Purnia, in north western, western, and eastern parts respectively come under the category of high productivity regions.

The medium productivity region, with the index value ranging between 93.93 and 105.97 are found in the northwestern districts of West Champaran and Gopalganj, central-north part to include the districts of Madhubani, Supaul and Madhepura, and central and southwestern districts of Muzaffarpur and Saran.

There are eight districts which characterise with low productivity with an index value of 93.93 to include the districts of Sitamarhi, Sheohar, Darbhanga, Saharsa, Begusarai, Araria, Kishanganj and Katihar.
(iii) **Productivity Regions - Based on Oilseed Crops Yield Index**

Oilseeds cover only 2.32 per cent of the total cultivated area of North Bihar Plain. The districts of Muzaffarpur possesses the highest productivity with an index value of 150.64, and the lowest index (64.01) value is recorded by the district of Vaishali. The high agricultural productivity is found to form a continuous belt which extends over the districts of Siwan, Saran, Muzaffarpur, Samastipur and Begusarai (Fig.4.13). It is evident from the Fig.4.13 that medium productivity region forms a compact belt extending over the districts of Madhubani, Darbhanga, Supaul, Saharsa, Madhepura, Khagaria and Bhagalpur. Two districts are detached from the main region and lie in the western part.

The low productivity occurs mainly in the districts forming the eastern block of the plain. The other districts of low productivity with the index value less than 87.67 are namely, West Champaran, Sheohar, Sitamarhi and Vaishali.

(iv) **Productivity Regions-Based on Cash Crops Yield Index**

Cash crops constitute the second rank in the cropped area, and accounts for about 7 per cent of the gross cropped area of North Bihar Plain. Two separate areas of high productivity can be recognised from Fig.4.14. One of them lies in the northern part to include the districts of Madhubani, Supaul, Araria and Kishanganj, and they represent mainly the jute growing area. Other areas lie in the central and southern parts extending over the districts of Muzaffarpur, Samastipur, Begusarai and Khagaria. The area of medium productivity in cash crops are scattered over the entire plain. The three districts of northwestern part form a tract of high productivity.
NORTH BIHAR PLAIN
Productivity Regions - Based on Oilseeds Yield Index
1995-2000

INDEX

HIGH
Above 110.17

MEDIUM
87.67-110.17

LOW
Below 87.67

Fig. 4.13

Kilometres
The low productivity areas with respect to cash crops and an index value of below 93.8 are also scattered over the districts of Kishanganj and Katihar which forms northeastern and southeastern parts, the district of Saharsa occupies the central part and Sitamarhi lies in northern part. The districts of Gopalganj, Siwan and Saran also form low productivity area and lies in southwestern part of the plain.

(v) Productivity Regions - Based on Composite Index

The composite index of agricultural productivity was computed considering all the crops grown in the study area. Productivity regions based on composite index are shown in Fig.4.15 and the number of districts which fall in each category of productivity are given in Table 4.7.

<table>
<thead>
<tr>
<th>Productivity category</th>
<th>Crop Index</th>
<th>No. of District</th>
<th>Name of District</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Above 104</td>
<td>7</td>
<td>Khagaria, Samastipur, Muzaffarpur, Siwan, East Champaran, Begusarai, West Champaran</td>
</tr>
<tr>
<td>Medium</td>
<td>95 - 104</td>
<td>7</td>
<td>Madhubani, Madhepura, Bhagalpur, Supaul, Gopalganj, Saran, Purnia</td>
</tr>
<tr>
<td>Low</td>
<td>Below 95</td>
<td>8</td>
<td>Darbhanga, Sheohar, Katihar, Saharsa, Vaishali, Araria, Kishanganj, Sitamarhi</td>
</tr>
</tbody>
</table>

A spatial pattern of productivity based on considering all the crops shows, that the district of Khagaria with index value of 115.24 has the highest productivity and the district of Sitamarhi can be put to lowest
NORTH BIHAR PLAIN

Productivity Regions - Based on Composite Index
1995-2000

Fig. 4.15
productivity with the productivity index of 86.25. Fig.4.15, shows that the high agricultural productivity region occurs to form a narrow belt which extends from southern part to the northwestern and southwestern parts of the plain. The districts included in this belt are namely, Khagaria, Begusarai, Samastipur, Muzaffarpur, East Champaran, West Champaran and Siwan. There are two areas characterised with medium productivity with the index values in between 95.02 and 104.46 to include the districts of Madhubani, Supaul, Madhepura, Purnia and Bhagalpur and a small tract which includes the districts of Gopalganj and Saran.

There are some scattered patches of districts which have low productivity with index value less than 95.02 and extend over the districts of Kishanganj, Araria, Katihar, Saharsa, Darbhanga, Vaishali, Sheohar and Sitamarhi.


With the assessment of the spatial analysis of agricultural productivity, it was further attempted to compute the changes by ascertaining the growth in productivity during the period of 1985-90 and 1995-2000 in North Bihar Plain.

(i) Cereal Crops

The cultivation of cereals, constitute one of the most significant group of crops, and recorded a positive growth of 0.77 per cent during the period concerned. The area devoted to cereal crops during 1985-90 was 4005.3 thousand ha. which increased to 4036.08 thousand ha. during the period of 1995-2000.
A districtwise growth in crop productivity of cereals shows, that the district of Madhepura shows the highest positive growth of 29.77 per cent, which is followed by the district of Khagaria and Katihar, where growth rate has been to the tune of 24 per cent. The other districts which recorded the positive growth in productivity of cereals are namely, Muzaffarpur (13.05 per cent) Purnia (10.39 per cent), West Champaran (8.51 per cent), Gopalganj (4.73 per cent), Vaishali 2.54 Per cent), Saran (1.4 per cent), Saharsa (0.92 per cent) and Siwan (0.12 per cent). A negative trend of growth in cereal crops productivity was recorded in the district of Begusarai (-25.17 per cent) and which is followed by the Darbhanga district (-21.74 per cent). The districts of Samastipur and Madhubani recorded a growth in negative order of -13 per cent. The other districts which recorded a negative growth in productivity of the cereal crops are : Bhagalpur (-10.66 per cent), East Champaran (-2.84 per cent) and Sitamarhi (-2.35 per cent).

(ii) Pulse Crops

Pulses have shown a decrease of -3.41 per cent in cultivation. The area brought under cultivation in pulse crops during 1985-90 was about 247 thousand ha. which very sharply declined to 163 thousand ha. during 1995-2000. With regards to the growth in agricultural productivity, the district of Bhagalpur (29.35 per cent) recorded the highest positive growth which is followed by the districts of Purnia and Khagaria, where the growth rate has been 29.31 and 24.68 per cent respectively. A lowest positive growth has been recorded in Begusarai (0.17 per cent) which is followed by the district of Katihar (0.27 per cent) and Vaishali (0.86 per cent). The other districts which show an increase in productivity under pulse crops are namely, East Champaran (16.01 per cent), Madhepura (4.46 per cent) and
Saharsa (1.09 per cent). A large number of districts show a decrease in productivity with respect to pulses. The highest being -37.22 per cent in Sitamarhi which is followed by the district of Muzaffarpur and Siwan, where rate of decrease has been -24.15 and -18.37 per cent respectively. The other districts which have recorded negative growth are namely, Saran (-16.18 per cent) Darbhanga (-15.88 per cent), West Champaran (-10.15 per cent), Gopalganj (-5.08 per cent), and Samastipur (-4.91 per cent). The district of Madhubani shows a marginal decrease of -0.01 per cent.

(iii) Oilseed Crops

The cultivation of oilseeds increased from 111.15 thousand ha. in 1985-90 to 121.39 thousand ha. during 1995-2000 at the rate of 8.86 per cent. A trend of growth in oilseeds productivity shows, that a positive growth has been in the districts forming central and western parts of the region are namely, Muzaffarpur, Saran, Siwan, Madhubani, East Champaran, Gopalganj, Darbhanga, and Samastipur. The district of Katihar lying in the eastern part of the plain also records a positive growth. The negative growth occurs in central, northern, southern and northeastern parts with the exception of West Champaran district which forms northwestern part of the region.

(iv) Cash Crops

Cash crops which are considered in the second important crops of the region covered 347.6 thousand ha. of land during 1985-90 show an increase in area to the extent of 370.34 thousand ha. with the growth rate of 6.54 per cent. The district of Khagaria recorded the highest positive growth rate in productivity, whereas the district of West Champaran recorded a marginal growth of 0.79 per cent. The other districts which show increase in
productivity (during 1985-90 and 1995-2000) are namely, Bhagalpur (34.12 per cent), Muzaffarpur (32.24 per cent), Sitamarhi (19.16 per cent), Madhepua (12.52 per cent), Purnia (6.19 per cent), Katihar (5.54 per cent) and Darbhanga (1.72 per cent). These districts belong mainly to the jute growing areas of North Bihar Plain. The highest negative growth has been recorded in the Gopalganj district (-24.86 per cent) which is followed by the districts of Saran (-18.26 per cent), Begusarai (-10.63 per cent), Saharsa (-4.65 per cent), Siwan (-2.82 per cent) and Madhubani (-0.63 per cent). These districts form part of the sugarcane belt of the region.