Chapter 2

Concept of Agricultural Productivity and Its Measurement

Agricultural productivity is measured as the ratio of agricultural outputs to agricultural inputs. Agricultural productivity is not a synonym of fertility. It is generally used to express the power of agriculture in a particular region to produce crops without regard to whether that power is due to the bounty of nature or to the efforts of the man.

Productivity like disparity is a relative concept. The term productivity has been used in different meanings and has aroused many conflicting interpretations. Some time it is considered as the overall efficiency with which a production system works, while others it is defined as a ratio of output to resources expended separately, or collectively. This term has also incorrectly and interchangeably been used with production. In reality, production refers to the volume of output while productivity signifies the output in relation to resource expended. Production can be increased by employing more resources without increasing productivity. On the other hand productivity can be increased without increasing production by employing less input for the same production level. But it is commonly agreed that productivity is the ability of a production system to produce
more economically and efficiently. Therefore, agricultural productivity can be defined as a measure of efficiency with which an agricultural production system employs land, labour, capital and other resources.

In recent years many attempts have been made to define the connotation of agricultural productivity. Dewett (1966) explains it as, “Productivity expresses the varying relationship between agricultural output and one of the major inputs, like land or labour or capital, Other complimentary 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 an economist at the 23rd annual conference of the Indian society of agricultural economics, some economists suggested that the yield per acre should be considered to indicate agricultural productivity. A number of objections were raised against this view because it considered only land which is just one factor of production while other factors are also responsible, and therefore it was arbitrary to attribute productivity entirely to land and express it per acre of land. It was suggested, for instance, that productivity could also be measured in terms of per unit of labor and different regions compared on that basis. After a thorough discussion, it was generally agreed that the yield per acre may be considered to represent the agricultural productivity in a particular region and that other factors of production be
considered as the possible cause for the variation while comparing it with
the other regions. Pandit (1965) has expressed the connotation of
productivity in these wards.” 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
suggests that increases 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 Saxon incorporates the productivity
as a physical relationship between output and the input which gives rise to
that output. Harring considers productivity in broad terms, to denote the
ratio of output to any or all associated inputs in real term.

There are many different concepts of productivity and still diverse
ways for computing it. The chairman of the international commission on
agricultural typology, 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 and indices should be used to define
   land, labour and capital productivity of agriculture in topological
studies of various orders, about fifty geographers from all over the world responded and suggested various approaches to the measurement of agricultural intensity and productivity. The chairman of commission while evaluating the different views pointed out, that a special study for testing various methods and techniques to be used in the studies of various scales were needed”

Land, labour and capital are various aspect of agricultural productivity. These are the best known partial productivity measures “Land” is viewed as area with different natural attributes. It realizes different rents and varies in purchase price. Labour represents all human services other than decision making and ‘capital the non labour resources employed by one farmer.

It is due to the pressure of population that special attention is given to land productivity. It is the simplest but in some respects the most useful aspect. of agricultural productivity. Maximum production from land can be achieved with available inputs of land measures that can fulfill the pressing demand of the day. Inevitably the inherent chemical and physical properties of land very spatially and impasse varying limits on the agricultural use of the land, although actual use will be defendant upon technology, profit and cultural constraints.
Land productivity is obviously of primary 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 productivity of land does not mean only raising the yields of individual crops. It encompasses the whole output of a farm or country in relation to the total area of farmland, and may be raised also by changing the pattern of production toward more intensive systems of cultivation toward higher value crops.

A distinction must be made between the measurements of agricultural output in terms of calories (or some other measurement of food values) and in terms of money values. For example, if in temperate countries 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 relative prices of cereals and Potatoes. Again, shifting land from the main crop potatoes to the early season potatoes or to the luxury vegetables may will increase its productivity in money terms, but will almost certainly reduce it in terms of calories. Good pasture land used for grazing will usually produce less in calories for human food than if cropped with cereals for direct consumption, but may show higher productivity in money values.
The productivity of labour is a somewhat more complex aspect than land productivity. Labour productivity means the income of the population engaged in agriculture and can be measured in terms of output per worker. It takes into account all the labour which contribute to agricultural production, the labour that is used directly on the farm as well as that used indirectly off the form in producing the materials and services used on agricultural production. The labour input may be expressed as the total number in the 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 grass form output or it may be taken as the value added by labour and other factors in the agricultural sector.

Labour productivity is in fact the most common form of measurement and is usually implied in economic discussions when no specific definition is given. In so far as the output per man is one of the major determination of the general level of economic welfare. Labour productivity is a significant yard stick of economic progress. Various measurements of labour productivity may have specific uses in policy formation e.g. with regard to income distribution, occupational distribution of labour force etc.
Increases in the productivity of land and of labour often go hand in hand when crop yields are increased or the pattern 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 form incomes, there is often as a secondary results, and increase in land productivity and total output. In countries with agricultural surplus this problem may be embarrassing, and increased labour productivity may then have to go hand in hand with measures to limit the area under cultivation.

Capital productivity of agriculture is particularly complicated to compute and difficult to interpret. This is largely because of diversity of capital being utilized in agriculture production: for land purchased for improvement, reclamation, drainage, irrigation, farm buildings, mechanical power, machinery and implements, livestock, 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 pattern 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 far 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 on capital in agriculture are less informative than those on land and labour, not because much of this investment especially in less developed countries, consists of non monetized investment stemming from the unpaid labour of the farmers themselves. The terracing of slopes, the bounding of paddy fields, the construction of irrigation ditches are examples of this type of non monetized investment which is of crucial importance for raising both output and productivity. This does not mean, of course that capital is not of vital importance to agriculture. The requirements 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 the 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, say, the milk output of
specialized 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 weight, Solves part of the problem but not all
of it because of the widespread use of livestock, particularly in the less
developed regions, for draft power. A complete accounting of the output
would, therefore, also require the inclusion of the draft power produced by
livestock, the principal input is the capital represented by the livestock
itself. Other inputs include the feeding stuff’s which they consume whether
from grazing or in the form of preserved or concentrated feeds, and the land
which is pasture of cropland is devoted to livestock production.

The above measurement when combined shall not give a very
satisfactory indication of productivity. The simplest and most frequently
used comparison 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 one
country the common breeds of livestock are large and in another small,
differences between the average outputs per animal in the 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 larger breeds was greater than that of the smaller breeds.

The whole output from each hectare of land used for agriculture is known as the overall productivity of land. It is more significant than crop yields per hectare or livestock yields. The individual yields reflect only the efficiency of crop husbandry of livestock husbandry. The overall productivity also take into account the managerial skill with which the various farm enterprises are integrated to increase the total farm output the overall productivity reflects also the opportunities to produce high value crops is 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 40 times greater than those with the least intensive agriculture.

The Measurement of Agricultural Productivity

The assessment of agricultural productivity has engaged the attention of scholars working in different disciplines like geography, economics and agricultural science for a land time; many attempts have been made to measure and quantify agricultural productivity in India as well as in other countries of the world.
The measurement of agricultural productivity is not a simple task as it involves a relationship between inputs and outputs in agricultural production. Input itself is a complex thing which governs farming efficiency. Stamp while attempting to measure crop productivity per unit area emphasized that a real differences in crop productivity are the results partly of natural advantages of soil and climate and partly of farming efficiency. Farming efficiency refers to the properties and quantities of various inputs. The manner in which they are combined and utilized for production and effective market demands for the output.

There is a substantial literature relating to methodological procedures for measuring productivity in agriculture. The measures of agricultural productivity which are most frequently used 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 there of (yield per hectare, output per man hour, Output per unit of capital) The data required to measure the productivity of a single 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 changes in their composition. Owing to the multitudinous utility, experts of agricultural geography have developed techniques, suitable for measurement of agricultural productivity and efficiency.
Thompson (1926) while measuring the relative productivity of British and Danish farming emphasized and expressed it in terms of gross output of crops and livestock. He considered seven parameters. They are:

1. The yield per acre of crops.
2. The livestock per 100 acres.
3. The gross production or output per 100 acres.
4. The proportion of arable land.
5. The number of persons employed.
6. The cost of production expressed in terms of wages & labour costs.
7. Prices relative profitability and general economic conditions.

Ganguly (1938) 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 and selected crops. Secondly, Gangly tried to obtain the index number of yield. This is found by dividing the yield per hectare for the entire region as the standard, the yield may be expressed as a percentage and the percentage may be regarded as the index number of yield. Thirdly, the proportion of the area a under ‘A’ and the corresponding index number of yield were multiplied. There are two advantage which are apparent by using this method is (a) the relative importance of crop ‘A’; in
that unit of study is assessed as indicated by the proportion of the cropped area which is under, ‘A’ and (b) The yield of crop ‘A’ in comparison to the regional standard. The product thus obtained indicates actually an index of the contribution of crop ‘A’ to the productivity of the unit considered.

Kendall (1939) taking the acre yield of ten leading crops in each of the forty eight administrative counties in England for four selected years, tried on four coefficients, Productivity, Ranking, Money value and starch equivalent or energy, of the four coefficients, The ranking coefficient is probably the easiest to calculate and gives a reasonable the ranking of countries 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 yield, then the sum of the ranks occupied by the unit was divided by the number of the crops considered to obtain the average rank of the unit. Kendall’s money value coefficient was based on the value of crop production of each country (which was obtained by multiplying the volume of production of particular crop by the price) and the results of ten crops for each county were added together and the total was divided by the total acre age 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 per acre under crops on the basis of a prepared table showing the energy value of various crops.

Kendall’s money value coefficient poses one major difficulty that data for certain crops are not available, for example, there are many vegetables and beans which are grown mostly for the consumption on the forms 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 the 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 crop production of each unit area is valued by multiplying the volume of production of a particular crop by the price and then added 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 / hectare under the crops considered. So for as energy coefficient is concerned as index based on nutritional factor ignores local variations because of the absence of data. Kendall, therefore, suggests starch
equivalent as the most suitable unit. While calculation 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 product, 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 milk is used for human consumption. The basic question that arises in this technique is whether the gross starch equivalent of the various crops should be considered or the net equivalent. Net energy refers to the amount of energy for work and body building whereas, a gross figure includes the energy employed in the digestive process of the consuming animal and similar non-realizable forms. Kendall suggested that production of energy be preferred as the gross figures.

Hirsch (1943) has 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 form in a second locality. Zobel (1950) has attempted to determine the labour productivity. He considered the productivity of labour as the ratio of 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 Valkendburg (1952) considered land productivity on the basis of acre yields of eight crops raised vary 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) adopted Kendall’s ranking coefficient by selecting twenty country and nine crops. The countries were placed in order of output per acre 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 total number of countries concerned.

Another approach to measure productivity is to convert the total food production into calories. Quantitative food requirements are usually
estimated in terms of heat units- calories. A physiological calories (also called kilocalorie and abbreviated 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 because it determines the amount of heat and energy needed by the human body.

Stamp (1958) has taken colorific value of form production in measuring the agricultural productivity. He calculated the standard nutrition unit (SNU) by converting all the food production per acre in calories. The British Medical association has carried out an exhaustive enquiry based on all available sources and published a table to show the caloric intake among adults from 2,100 a day for a woman in sedentary occupation to 4,250 for a man engaged in active manual work. For children, the desirable intake is calculated at 800 a day for infants under one year to 3,400 for teenage boy. The average of the different categories worked out at 2,540 Calories a day, taking into consideration the age structure of the population and 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 loss 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.
The Nutrition expert group of Indian council of Medical Research has recommended the daily allowance of Nutrients for Indians. They published a table to show the caloric intake among adults from 1.900 a day for a woman in secondary work to 3.900 for a 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 for teenage boy.

Shafi (1960) has calculated this under Indian conditions in the twelve villages of eastern Utter Pradesh. The net caloric intake ranges from 1.828 a day (667,677 a year) to 2.175 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 Utter Pradesh The caloric intake per person amounts to about 2000 a day. Where the calories intake drops below 2,000 a day, both standard of living and standard of health are perceptibly lower.

Loomis and Barton (1961) have measured United States agricultural input and productivity in aggregate. To them, aggregate productivity depends upon conceptually consistent measures of agricultural output and input The measures of inputs include all the production factor 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 Makenzie (1962) has measured the efficiency of production in Canadian agriculture by using the coefficient of output relative to input. He mentions that the concept of productivity measurement is difficult to define and even more difficult to quantify. Commen (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.

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

Where \(Y\) = Total yield of the respective crop in the unit area

\(Y_n\) = Total yield of the crop at the national level.

\(T\) = Total cropped area of the unit.

\(T_n\) = Total cropped area at the national level.

Horring (1964) has suggested that the concept of productivity is based not only on the single 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. 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 the national economy as a whole.

The Indian society of agricultural economics, considered the problem and published a series of articles under the broad head 'Regional variations in agricultural development and productivity. Among the contributors Chatterji and Maitreya (1964) have determined the levels of agricultural development and productivity during 1950-51 to 1957-58 in the state of west Bengal taking two crops (Rice and Jute) in consideration. They utilized the acre yield for this purpose. Dhondyal (1964) has measured variations in agricultural development and productivity by selecting three representative districts from the three regions of Utter Pradesh, while assessing the role of credit, Intensive crop enterprises, and the influence of irrigation water during 1962-63.

Garg (1964) worked out the trends in agricultural development with respect to total cropped area, gross irrigated area and food grain production in two districts of Utter Pradesh, viz. Gorakhpur representing eastern region and Meerut from western region and productivity by assessing acreage, production and average yield per acre. of three important crops, viz. Rice,
wheat and sugar cane. This study extends from 1951-52 to 1960-61 covering the period between the first and second five year plans. Gopal Krishnan and Ramkrisna (1964) have taken Andhra Pradesh (1) to measure the degree of variations with respect to (a) agricultural output per acre (Rs.) (b) output per head of agricultural population (Rs.) and (2) to account the causes of variations in each of the twenty districts of the state during 1959-60. The variable relating to the level of output per acre are selected as follows (1) Normal level of rainfall,(2) Percentage of current and old follows (3) Percentage of area under irrigation (4) Percentage of literacy (5) Percentage of population in agricultural (6) Intensity of cropping (7) Percentage of gross value other than food grains and fodder (8) The percentage of area under all crops excluding fodder and food grains, (9) Density of agricultural population per acre and (10) Percentage of total area under commercial crops including rice.

Sapre and Deshpande (1964) modified the Kendall’s ranking coefficient by giving weightage to the area under different crops. The weights for ranks of various 7 crops are proportional to the percentage of cropland under each crop. For example, and enumeration unit ‘A’ has rank 2- on the basis of wheat acre yield and occupies 30 percent of the total cropped area, rank 3 on the basis of rice acre yield and occupies 25 percent of the total cropped area, rank 8 on the basis of gram acre-yield and
occupies 10 percent 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 \( 2 + 3 + 8 = 13 \) divided by the number of crops as \( 13/3 = 4.3 \)

The Indian society of agricultural statistics, organized a symposium on the topic, Measurement of agricultural productivity at the 17th annual conference of the society held at Jaipur in 1964. The research papers contributed by different scholars appeared in the society’s journal viz in journal of the Indian society of agricultural statistics, in the succeeding issue of the 1965, Sharma (1965) while defining the concept of 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 food grains, fruits and vegetables, sugarcane, and edible seeds, Hē suggests that the output of these commodities be converted into calories. While considering the other non-food crops such as cotton and other fibers the only common measure being the value which involves the pricing of different products. For evaluating value of production, farm, harvest or wholesale price have the definite significance, Hē 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 of area.

Khusro (1965) 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) has applied cob-Douglas Production function approach for the measurement of productivity. The common purpose of this function is to express input output relationship between several inputs and one output in the agricultural systems. The function takes the following form.

\[ y = A x_1^b x_2^c x_3^d x_4^e \cdots x_n^y \]

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

\[ \text{Crop yield index} = \frac{\sum_{i=1}^{n} \frac{y_i}{y_0} A_i}{\sum_{i=0}^{n} A_i} \]
Where

\( i = 1, 2, 3, \ldots, n \) are the number of crops considered in an unit area or year,

\( y_i = \) is the yield per acre of crop \( i \), in a farm area or year,

\( a_i = \) is the weightage of crop \( i \), denoted by the area under the crop as a percentage of total cropped, and

\( y_{io} = \) is the average yield per acre of crop \( i \), at the group of farms, or entire region or the base year.

Shafi (1965) has assessed the productivity on the basis of labour population engage in agriculture. According to him it can be computed by dividing the gross production in a unit area by the number of man hours or less precisely by the numbers employed in agriculture. In order to assess the productivity on the basis of population engaged in agriculture it can either by obtained by dividing the total production with of the number of workers, or a reverse index be applied where the total numbers of workers per unit of production is assessed.

Agarwal (1965) has adopted Factorial approach while measuring agricultural efficiency in Baster district of Madhya Pradesh. In this approach a number of human controlled factors relating to agricultural production as crop superiority, crop commercialization, crop security land
use intensity and power input have been selected, excluding the
environmental factors.

Buck (1937) assessed the agricultural progress in China by adopting
approach of Grain equivalent. For this purpose he converted all the
agricultural products into kilograms of grain equivalent in order to select as
a unit of measure a kilogram, with whatever kind of grain was predominant
in the region. A modification is this method was attempted by Clark and
Haswell (1967) by expressing the output in terms of kilograms of what
equivalent per head of population.

Dovring (1967) has measured the productivity of labour in the
United States agriculture in aggregate since 1919 to 1954 as a whole, as well
as commodity wise. Bhatia (1967) while assessing the changes and trends in
agricultural efficiency in Uttar Pradesh during 1953-63 adopted Gangulis,
method of productivity measurement and has devised an equation which
would be read thus:

\[(1) \quad I_{ya} = \frac{y_c}{y_r}.100\]

Where \( I_{ya} \) is the yield index of crop \( a \)

\( y_c \) is the average acre yield of crop \( a \) in the component unit and

\( y_r \) = is the average acre yield of crop \( a \) in the entire region and
(2) \[ E_i = \frac{I_{ya} C_a + I_{yb} C_b + \ldots - I_{yn} C_n}{C_a + C_b + \ldots + C_n} \]

Where \( E_i \) = is the agricultural efficiency index

\( I_{ya}, \ I_{yb} \ldots \) are the indices of various crops and \( C_a, \ C_b \ldots \)

represent the proportion of cropland devoted to different crops.

Shafi (1967 and 1969) applied Stamp’s Standard nutrition Unit technique for measuring the efficiency of agriculture in India. He has considered the district as the areal unit, and has selected all the food crops grown in India. Noort (1967) considered Net total productivity, (being the relationship between the net product and factor input) as a method for the measurement of field productivity and also to assess comparison, in time or in space the purpose of this measure is to account changes in labour and capital inputs in agriculture.

Sinha (1968) has adopted a standard deviation formula to determine agricultural efficiency in India. In the study he selected all the twenty-five major crops grown in the country which were grouped into cereals, pulses, oilseeds and cash crops and specific yields per hectare of cereals, pulses and
oilseeds were taken. In case of cash crops their monetary values were calculated (in Rs) per hectare by incorporating wholesale market price. Finally, the standard scores were computed and to give them weightage, this values were multiplied by the acreage figures i.e. the area of cultivation under the crops

Shafi (1972) while measuring the agricultural productivity of the great Indian plains modified the Enyedis formula. In the modified 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 crops. The formula would be read thus. \[ \frac{y_w/t + y_r/t + y_m/i/t}{n} : \frac{(y^w/t + y^r/t + y^m/i/t) - n}{n} \]

Where \( y_w, y_r, y_m \)---n= total yield of various crops in the district

\( y_w, y_r, y_m \)---n= total yield of the various crops at the national level

\( t \) = total area under different crops in the district and

\( T \) = Total area under different crops at the national level

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

\[ C_p = \frac{C_o}{S_n} \]

Where

\( C_p \) = carrying capacity

\( C_o \) = caloric output per square mile

\( S_n \) = standard nutrition for ingestion in calories per person/annum.

He expressed it as a percentage of the carrying capacity in the entire region to obtain index numbers, which give a measure of the agricultural efficiency of the areal unit relative to the entire region. The above may be expressed as.

\[ Iae = \frac{Cpe}{Cpr} \times 100 \]

where

\( Iae \) = the index number of agricultural efficiency of an enumeration unit.

\( Cpe \) = the carrying capacity in terms of population in the component enumeration unit.

\( Cpr \) = the carrying capacity in the entire region.
The Indian society of agriculture statistic in its 30th annual conference held at Bhubaneswar (Orissa). India, discussed some aspects an agricultural productivity in the Indian context. Raheja, et al (1977) have measured the impact of high yielding varieties based on 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 the level 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 food grains and related inputs like, the application of fertilizer, proportion of area sown more than once and gross irrigated area.

Nangia et al (1977) 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, technological and institutional which hold responsibilities for the productivity variations. Bhalla (1978) has considered output per person on constant average price for measuring productivity of labour in Indian agriculture in order to account for nineteen crops during the trienniums 1962-65 and 1970-73 for each district of India Singh (1979)
devised a method of presenting a two-dimensional picture of agricultural productivity comprising two components viz. intensity and spread considering three variables (1) yield (2) grain equivalents, and (3) cropping system in the districts of the state of Andhra Pradesh. Accordingly, a relative share of intensity and spread for each micro unit (District) has been computed to the micro unit (state) separately for the above three variables with the help of equation that have been derive.

Agricultural productivity may be defined as the “ratio of index of local agricultural output to the index of total input used in farm production” (Shafi, 1984). It is, therefore, a measure of efficiency with which inputs are utilized in production, if other things being equal. Agricultural productivity here refers to the returns from arable land or cultivable land unit. Kawagoe and others have used a method of Production function approach for measuring agricultural productivity among different countries (Kawagoe et al. 1985). Jorgenson et al. (1987) used a cost function approach for each major sector of the US economy to estimate rates of sectoral productivity growth and concluded that productivity growth has been more rapid in agriculture than in other sectors. Lewis et al. (1988) used a production function approach to calculate productivity growth rates for agriculture and for the reminder of the Australian economy (industry plus service) and concluded that the rate of productivity growth in agriculture had been
higher than for the reminder of the economy. Jamison and Lau (1982) and Alderman et al. (1996) have examined the relationship between the level of education and wage with the crop productivity. A study conducted by Fafchamps and Quisumbing (1998) has also identified how various facets of human capital affects the crop productivity in Pakistan.

Agricultural productivity is frequently associated with the attitude towards work, thrift, industriousness and aspirations for a high standard of living, etc, (Singh and Dhillion, 2000). Vanloon, Patil and Hugar in (2005) developed an indicator for measuring crop productivity by using primary product yield or conventional yield. Goksel and Ozden (2007) have applied the TFP with Cobb-Douglas production function in agriculture to analyze the agricultural productivity in Turkey. Dharmasiri (2009) has attempted to measure the agricultural productivity in Sri Lanka by using Cobb-Douglas Function. These are some of the methods for measuring agricultural productivity. They have devised different formulae with different components. Each model has different data requirements and is suitable for addressing different questions and has strengths and weaknesses.
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