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Approaches to the Measurement of Agricultural Productivity: A Critical Review

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Abstract
The Assessment of agricultural productivity has engaged the attention of scholars working in different disciplines like, geography, economics and agricultural sciences for a long time. Many attempts have been made to measure and quantify agricultural /productivity in India as well as in other countries of the world.

Keywords: 'Crop Yield Index. Relationship between output and input. Productivity .coefficient.

Introduction

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 man. On the other hand, fertility denotes the ability of soil to provide all the essential plant nutrients in available form and in a suitable balance for the plant growth.

In recent years many attempts have been made to define the connotation of agricultural productivity and a considerable amount of literature exists on this subject. the Assessment of agricultural productivity has engaged the attention of scholars working in different disciplines like, geography, economics and agricultural sciences for a long time. Many attempts have been made to measure and quantify agricultural productivity in India as well as in other countries of the world. 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 the following seven parameters: (i) the yield per acre of crops, (ii) the livestock per 100 acres, (iii) the gross production or output per 100 acres, (iv) the proportion 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) prices, relative profitability and general economic conditions.

In case of Money Value Index there is 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 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, 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 ton 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 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/hectare under the crops considered. So far as Energy Coefficient is concerned, an 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 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 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

It should be mentioned here, that the Money Value Coefficient does not take into consideration the value of the by-products of the crops but a similar omission of any allowance or the energy of the by-products in the energy coefficient would have a serious affect. It is surmised, that there is nearly as much starch equivalent in the straw produced on a hectare of land as the grain itself. Therefore, it becomes necessary to estimate the production by weight of by-products to the main products of wheat, barley, oats, beans, peas, etc.

The determination of productivity by the productivity coefficient method involves the use of higher mathematics, and the money value coefficient and starch equivalent or energy coefficient poses a practical difficulty. Therefore, Kendall looked for a coefficient which might lead to similar results in productivity and save a good deal of calculations. The method attempts to arrange in sequence any given number of units growing the same range of crops and then assess their agricultural efficiency*. Kendall took the acre yields of ten leading crops in each of the forty-eight administrative countries of England for four selected years. The places occupied by each country in respect to the selected crops were then averaged, and thus 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 co-efficient equal to the number of countries concerned.

Zobel (1950) has attempted to determine the labour productivity. He considered 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 designed with the equation:

Where $\pi = f(P,L)$,

π = Productivity of labour,

P = Production, and

L= Labour utilized.

Enyedi (1964) while describing geographical types of agriculture in Hungary refers to a formula for determining agricultural productivity. His formula for assessing productivity coefficient would be read thus:

$$\frac{\mathbf{Y}}{\mathbf{Y_n}} : \frac{\mathbf{T}}{\mathbf{T_n}}$$

Where

$\boldsymbol{Y}$ = total yield of the respective crop in the unit area,

$\boldsymbol{Y_n}$ = total yield of the crops at the national level,

$\boldsymbol{T}$ = total cropped area of the unit, and

$\boldsymbol{T_n}$ = total cropped area at the national level.

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

Sapre and Deshpande (1964) have attempted to refine further the Kendalls' 'ranking coefficient method'. For this they used 'weighted average of ranks' instead of the simple averaged ranks. Thus, it incorporates the proportion of the crop (area) to the total area of the district. In order to assess the weighted ranks, the ranking position of a crop is multiplied by the magnitude of it to the total cropped area. For example, an enumeration unit A has rank 5 on the basis of yield for Wheat, and Wheat occupies 33 percent of area to the total cropped land; Jowar ranks 3 and occupies 16 percent of the area; rice ranks 4, and occupies 30 percent of the total cropped land.

Thus, the weighted average of ranks for different crops would be : $(\mathbf{5X33}) + (\mathbf{3Xl6}) + (\mathbf{4X30}) = \mathbf{333}$ divided by the sum of the weights as $\frac{\mathbf{333}}{\mathbf{79}} = \mathbf{4.21}$. Kendall's 'ranking coefficient' would be worked out as follows: $\mathbf{5 + 3 + 4 = 12}$ divided by the number of crops taken into consideration as: $\frac{\mathbf{12}}{\mathbf{3}} = \mathbf{4}$.

Saran (1965) has applied Cobb-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:

$$\boldsymbol{Y = AX_1^b X_2^c X_3^d X_4^e \ldots\ldots\ldots\ldots X_n^Y}$$

Where $\boldsymbol{X_1, X_2, X_3, X_4 \ldots\ldots\ldots X_n}$ denote various inputs, like land, labour capital assets and other working expenses. The values of b, c, d, ……. 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 techniques is to express the average yield of various crops on a farm or in a region relative to the yield of same crops on an another farm or in a second region. It can be expressed in the equation form as:

$$\text{Crop Yield Index} = \frac{\sum_{i=1}^{n} \frac{y_i}{y_{io}} A_i}{\sum_{i=1}^{n} A_i}$$

Where

$\boldsymbol{i}$ = 1,2,3,… n are the number of crops considered in an unit area or year.

$\boldsymbol{Y_i}$ = is the yield per acre of crop I, in a farm area or year,

$\boldsymbol{A_i}$ = is the weightage of crop i, denoted by the area under the crop as a percentage of total cropped, and

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

Bhatia (1967) while assessing the changes and trends in agricultural efficiency in Uttar Pradesh during 1953-1963 adopted Ganguli's methods of productivity measurement and has devised an equation which would be read thus:

$$\boldsymbol{(i) I_{Ya} = \frac{Yc}{Yr} . 100}$$

Where

I_{Ya} = is the yield index of crop "a",
yc = is the average acre yield of yield of crop "a" in the component unit and
yr = is the average acre yield of crop "a" in the entire study area

$$(ii) E_i = \frac{I_{ya}.C_a + I_{yb}.C_b + \ldots\ldots\ldots\ldots\ldots\ldots I_{yn}.\ C_n}{C_a + C_b + \ldots\ldots\ldots\ldots\ldots\ldots C_n} \quad \textbf{and}$$

Where
E_i = is the agricultural efficiency index,
$I_{ya}.I_{yb}, etc.$ = are the indices of various crops, and
$C_a.C_b, etc.$ = represent the proposition of cropland devoted to different crops.

Shafi (1972) while commenting on the formula presented by Enyedi in determining productivity index of an area with reference to the national scale pointed out that there are certain cases where the results obtained by the formula are influenced by the magnitude of the area under a particular crop when the yield of the district is either the same or is less than the national yield. For example, when the yield of the district is the same as the national yield even then the district, by the computation of the formula, has a higher productivity coefficient than that of the national scale.

Example:

Yield of wheat in the district (B) =15 qnt./ha.
National yield of wheat = 15 qnt./ha.
Area of the district under wheat = 15,000 ha.
Area under wheat at the national level = 10,00,000 ha.
Total crop area of the district = 50,000 ha.
Total crop area at National level = 5.7 million ha.

By applying the formula

$$\frac{Y_.}{Y_n} : \frac{T}{T_n}$$

$$= \frac{2,25,000}{15,00,000} X \frac{57,00,000}{50,000} = 1.71$$

Productivity co-efficient $= 171 - 100 = +71\ percent$

The example shows that the district (B) although having the same yield of wheat as the national yield is shown to be 71 percent more productive which is hardly tenable.
Similarly there may be a case when the district yield is less than the national yield, but the area under that particular crop whose productivity coefficient is to be determined is more than in the instance cited by Enyedi. In this case too, although the district yield is less, its productivity index would be higher than the national level.

Example :

Yield of wheat in the district (C) = 12 qnt./ha.
Yield of wheat at the national level = 15 qnt./ha.

Area of wheat in the district = 20, 000 ha.
Area of wheat at the national level = 10,00,000 ha.

$$Y = 2,40,000\ qnt$$
$$Y_n = 1,50,00,000\ qnt$$
$$T = 50,000\ ha$$
$$T_n = 5.7\ million\ ha$$

According to the formula the result of the productivity index of the district (C) would be as follows:

$$= \frac{2,40,000}{1,50,00,000}\ X \frac{57,00,000}{50,000} = 1.82$$

Productivity Coefficient = 182-100 = 82 percent

It will be seen that although the productivity of the district with regard to wheat is less than that of the national level, the formula shows that the district is 82 percent more productive than the national level.
Taking the same example which Enyedi has quoted, if only the yield of wheat per hectare is decreased (the yield of wheat in the district per hectare is taken to be less than the figure cited), and other things remain equal, the productivity coefficient of the district again would be higher than the national level.

Example:
Yield of wheat in the district = 12 qnt./ha.
Yield of wheat at the national level = 15 qnt./ha.
Area of wheat in the district = 15, 000 ha.
Area of wheat at the national level = 10,00,000 ha.
Total crop area of the district = 50, 000 ha.
Total Crop area at the national level = 5.7 million ha.

According to the formula the productivity coefficient of the district with respect to
Wheat $= \frac{1,80,000}{1,50,00,000}\ X \frac{57,00,000}{50,000} = 1.37$
Productivity Coefficient $= 137 - 100 = +37\ percent.$

It will be seen from the above measurement that in a particular district although the yield per hectare of a crop may be equal to the national level or even less than the national level, the productivity index with respect to that crop is higher than the national level.
The writer made in attempt to modify the formula wherein the productivity coefficient of a particular crop may be in conformity with higher or lower yield per hectare of that crop in the district relative to the national level.
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 crop 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:

$$\left[\frac{Y_w}{t} + \frac{Y_y}{t} + \frac{Y_{mi}}{t} \ldots\ldots\ldots\ldots\ldots\ldots n\right] : \left[\frac{Y_w}{T} + \frac{Y_r}{T} + \frac{Y_{mi}}{T} \ldots\ldots\ldots\ldots\ldots\ldots n\right]$$

Or

$$\frac{\sum^{n} Y}{t} : \frac{\sum^{n} Y}{T}$$

Where

$y_w\ y_r\ etc.,=$ Total yield of the respective crop in the district,

$y_{wI}\ Y_r\ etc.,=$ Total yield of the respective crop in the district level,

$t =$ area planted under the crop in the district, and

T = area planted under the crop at the national level.

Singh (1972) has evolved a new technique for the measurement of agricultural efficiency, which consists of the measurement of carrying capacity per unit area in terms of population in relation to output per unit area. The method would be read in the equation form as :

$$(i)\ C_p = \frac{C_0}{S_n}$$

Where

$C_p =$ is the carrying capacity.

$C_O =$ is the caloric output, and

$S_n =$ is the standard nutrition for ingestion in calories per person/ annum.

$$ii)\ I_a^e = \frac{C_{pe}}{C_{pr}}\ X\ 100$$

Where

$I_a^e =$ is the index number of agricultural efficiency.

$C_{pe} =$ is the carrying capacity in terms of population, in the component enumeration unit and

$C_{pr} =$ is the carrying capacity in the entire region.

The Indian society of Agricultural statistics in its 30th Annual Conference held at Bhubaneswar (Orissa) India, discussed some aspects on 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 etal. (1977) have accounted the level of increase in the yield 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.

Conclusion

From the above it is clear that many attempts have been made to define the agricultural productivity and considerable amount of literature exists on this subject. There are many different exists on the subject. There are many different concepts of productivity and still more ways for computing it. Productivity of agriculture so for as has been looked at from different private of view, such as land, labour and capital. There are the best known partial productivity measures.

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