MEASUREMENT OF AGRICULTURAL PRODUCTIVITY— A CASE STUDY OF UTTAR PRADESH, INDIA.

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ABSTRACT : Reviewing the earlier methods of measuring agricultural productivity, a significant composite index covering three dimensions, i.e., yield, prices and intensity of agricultural productions, is applied for measuring agricultural productivity per hectare of net cultivated area as well as per agricultural worker in Uttar Pradesh. The higher productivity per hectare of net cultivated area is well-marked in the western part of Uttar Pradesh, particularly in Jamuna-Ganga and Ganga-Ramgange doabs, while lower productivity is found in eastern Terai and Bundelkhand. Similar patterns of productivity per agricultural worker have also been observed in the area.

INTRODUCTION

It is widely accepted that agricultural production is the result of combinations of infra-structural elements, *viz*, physical, techno-economic, socio-cultural, etc. by which agricultural efficiency is influenced. Therefore, the study of agricultural production may be done by considering three different aspects such as output per unit area, output per man-hour and input-output ratio (Stamp, 1960). Input-output ratio indicates the net returns achieved from agricultural production which may, indeed, be utilized for agricultural planning. Agricultural output, per unit area as well as per man hour, indicates significance of intensity of agricultural technology in a particular area.

EARLIER STUDIES

A number of techniques have been used to assess agricultural output, of course, with some of their virtues and shortcomings. Long ago, ranking coefficient of yield of main crops per unit area was applied to assess their efficiency by Kendall (1939), which could be formulated as

$$\frac{r_1+r_2+r_3\ldots+r_n}{n} \quad \ldots\ldots\ldots\ldots\ldots \text{(I)}$$

(where r=ranking of yield of individual crops & n=number of crops).

The above method was also applied in study of 20 countries of the world by Stamp (1960) and on Uttar Pradesh in India by Shafi (1960). By this method the ranking of crops' yield is done merely with the help of per hectare/acre, production without considering agricultural output as a whole.

Another method used for measuring agricultural efficiency was used for the study of Ganga Valley in India and an index of agricultural efficiency was prepared by Ganguli (1938) by multiplying the percentages of crops' share with percentages of crops' yield in an areal unit and later averaging them in to one. It can be formulated into the following three stages to derive at the final equation.

$$I_{yn}=\frac{Y_1}{Y_r}100 \quad \text{.....................} \quad (II)$$

$$E_{1n}=(I_{yn}.\ C_n)/100 \quad \text{...............} \quad (III)$$

$$E_1=\frac{E_{1_1}+E_{1_2}+E_{1_3}...+E_{1n}}{n} \quad \text{.........} \quad (IV)$$

(where I_{yn}=% yield of crop n, Y_1=yield of individual crop in an areal unit ; Y_r=yield of individual crop in the total area ; E_{in}=efficiency of crop n in an areal unit ; C_n= crop land share in% ; E_i = agricultural efficiency of all crops in an areal unit).

Modifying Kendall's approach an equation was prepared by Sapre & Deshpande (1964) by multiplying ranking of crops with that of crop land share divided by the total of crop land share. It can be formulated as following :

$$E_1=\frac{r_1C_1+r_2C_2+r_3C_3...+r_nC_n}{C_1+C_2+C_3...+C_n} \quad \text{...........} \quad (V)$$

(The same notations as given above).

Bhatia (1967) conveniently used the above efficiency index of Sapre & Deshpande with slight modifications. He used Ganguli's percentage yield of crops (*Iyn*) instead of yield ranking of individual crops (r_n) which has been formulated by him as the following.

$$E_1=\frac{Iy_1C_1+Iy_2C_2+Iy_3C_3...+Iy_nC_n}{C_1+C_2+C_3...+C_n} \quad \text{......} \quad (VI)$$

(The same notations as given above).

The above index as formulated by Bhatia was applied for studying agricultural efficiency in India as a whole by Sen Gupta (1968). The yield of crops was considered merely in relation to crop land share which could be termed as 'standardized yield index'. The relative crop importance in various areal units was not identified.

Earlier, Buck (1937) used relative crop importance for his landuse study of China giving the term of 'grain equivalents' for various crops in relation to a staple food. The Food & Agricultural Organization (F.A.O.) of the United Nations (1960) also prepared an International Grain Equivalent Index assessing different crops in relative price value of wheat. Such relative importance of grains was also used for preparing crop equivalents by changing them into caloric significance by Stamp (1960) and Shafi (1972). At another place, agricultural prices and their regional variations which influenced the cropping patterns and yields, were considered in discussing agricultural productivity per unit area by Bhat & Learmonth (1968). An useful index of calculating agricultural productivity of Sutlej-Ganga Plains was formulated by changing the production in money value per areal unit with the ratio of whole region by Hussain (1976).

INDICES FOR AGRICULTURAL PRODUCTIVITY

With reference to the above discussion, it is pertinent to consider standardized yield index, alongwith the relative importance of crops. It will not only present an emphasis of certain crops in an areal unit but also emphasise their relative weightage. Again, it should be pointed out that the earlier studies took into consideration the gross cultivated area. Actually the emphasis should be on net cultivated area for considering agricultural productivity, as the relationship between net cultivated area and gross cultivated area is not the same in all the areal units. Thus, it can precisely be suggested that three dimensional study into yield, relative importance and intensity of crops will be significant for measuring the true shape of agricultural productivity. It can further be supported by a study of output per agricultural worker.

The present paper reviews the utility of certain indices, which may be applicable in the study of agricultural productivity in Uttar Pradesh.

(1) Standardized Yield Index (*Isyi*) : It is more or less the same as used by Bhatia in the name of index of agricultural efficiency (*Ei*). It may be expressed as :

$$Isyi = Ei \ldots\ldots\ldots\ldots\ldots\ldots \text{(VII)}$$

Table 1 : THE CROP EQUIVALENT COEFFICIENTS ON THE BASIS OF THREE CROP PROFILES FOR 1970–71.

Crops	Equivalents based on crop rates	Equivalents based on National income	Equivalents based on caloric significance	Mean coefficients
1. Wheat	100.0	100.0	100.0	100.0
2. Rice	42.7	141.7	79.3	87.8
3. Gram	40.5	73.3	99.5	77.1
4. Millets	22.7	43.7	75.7	47.4
5. Maize	40.6	83.8	117.8	80.7
6. Sugarcane (Gurh)	440.6	412.4	437.2	430.7
7. Barley	30.0	77.8	106.9	71.6
8. Peas	47.4	54.3	86.2	62.6
9. Arhar	89.3	95.9	176.1	117.1
10. Ground nut	95.7	110.0	108.0	104.6

Sources : (*1*) *Average crop price list for the year 1970-71 used ;* (2) *State income from grains received from National Income Unit of C.S.O.*

(2) Weighted Crop Equivalent Index (*Iwei*) : For assessing relative crop three alternatives have been considered, namely, market price, trade importance and caloric significance. Per hectare values of crops have been reduced equivalent to wheat calculating their coefficients, as wheat is the most important cereal produced in the State. The mean of the above three alternative coefficients (*Ge*) reduced to State average will signify the relative crop importance which is shown in table 1 .

Obviously, when the various crops are reduced equivalent to wheat, some crops like sugarcane, arhar and ground nuts find more importance than wheat, whereas millets and peas remain far below. Further, to derive at the weighted crop equivalent index, the equivalent coefficients (*Ge*) are weighted with the percentage share of crops in various areal units, for which the index may be formulated as :

$$Iwei = \frac{Ge_1.C_1 + Ge_2.C_2 + Ge_3.C_3 ... + Gen.Cn}{C_1 + C_2 + C_3 ... + Cn} \quad \text{(VIII)}$$

(3) Cropping Intensity Index (*Ici*) : Physical assessment of intensity of cropping per unit area is obviously pertinent for evaluation of agricultural productivity. The cropping intensity index (*Ici*) can be prepared by dividing the percentage of total cropped land of an *i* th component areal unit by corresponding data of the State and by multiplying the whole with 100 for deriving the results into percentage. The procedure can be expressed as :

$$Ici = (t/T) . 100 \quad \text{(IX)}$$

where t=percentage of total cropped land in relation to net area shown in a component areal unit and T=corresponding data for the State similarly derived.

Composite Index of Agricultural Productivity (*Iei*) : Lastly, the composite index of the above three indices can also be adjusted by multiplying them together dividing the results by 10^4 for reducing it in percentages. Thus, a single composite index of productivity (*Iei*) will be found for determining agricultural output per unit of net area sown, which can be formulated as under :

$$Iei = (Isyi . Iwei . Ici) / 10^4 \quad \text{(X)}$$

(4) Agricultural Worker Index (*Iwi*) : Such an index would conveniently be applicable to ascertain usefulness of the above findings, termed as composite index of agricultural productivity per agricultural worker, the index can be worked out by dividing the percentage of agricultural workers per unit area with the corresponding figures of the State and multiplying the whole by 100, which can be formulated as :

$$Iwi = (Wi/Wr) . 10^2 \quad \text{(XI)}$$

where Wi=percentage of agricultural workers per unit sown area and Wr=corresponding data for the State similarly derived.

Now a composite index of agricultural productivity per agricultural worker may be arrived at by dividing the former with *Iwi* and multiplying the results by 100. Thus, the new equation for composite index of agricultural productivity per agricultural worker may be formulated as :

$$Iewi = (Iei/Iwi) . 10^2 \ldots\ldots\ldots\ldots\ldots\ldots \text{(XII)}$$

UTTAR PRADESH A CASE STUDY

The above agricultural productivity indices can be applied for studying their usefulness and suitability in analysing agricultural productivity of Uttar Pradesh. The State comprises 54 districts, out of which 48 districts belonging to the plain area are considered. Each district is treated as an areal unit (Fig. 1). The larger part of Uttar Pradesh is agriculturally advanced, where problems related to security of food grains are growing due to unbalanced land-population ratio. The area under study covered 294 thousand sq. km (8.93 per cent of the country) and 88 million population (13.65 per cent) in 1971. The population density was about 300 persons per sq. km. The population growth rate during the last decade (1961–71) was 19.82 per cent which was appreciably higher for its poor socio-economic structure. 75.3 per cent of the total working population was engaging in agricultural activity. Inspite of adequate rainfall (average 1000 mm per annum) and fertile soils of interfluvial areas, Uttar Pradesh has been declared a deficit area in food grains. The average increase rate of food grains in U. P. during the last 20 years was only 1.07 per cent as compared to 2.6 per cent

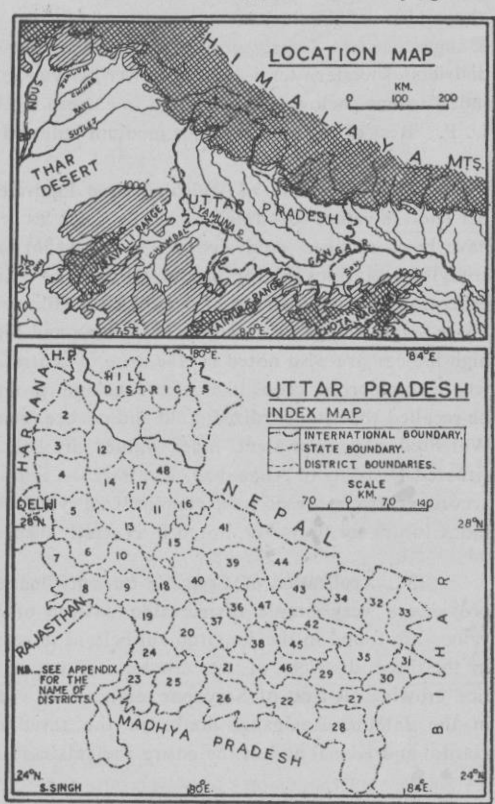

Fig. 1

of India as a whole. It was perhaps due to improper agricultural planning.

The net cropped land (net area sown & fallow) is 18.13 million hactares of which 40.3 per cent is irrigated mainly by tubewells and canals and 31.4 per cent is sown more than once. About 80 per cent of the total cropped land (net cropped land and area sown more than once) is occupied by cereals and pulses.

(1) Application of Standardized Yield Index : Such indices depict only variability of yield and crop land shares under various crops. Very high and high (i.e., about 110) index values are marked in the fertile Ganga-Yamuna doab, where wheat & sugarcane are largely grown (Fig. 2A). The index values are also high in the districts of western terai and the Lower Saryu-Ganga doab. The low and very low index values (below 100) are noted in eastern terai area and rugged southern part of U. P. Rest of the area contains medium index value.

(2) Application of Weighted Crop Equivalent Index : Such an index, where per hactare values of different crops such as rice, sugarcane, ground nuts, arhar have been reduced equivalent to a significant crop, proves an important tool for studying variations in crop productivity. The entire western Uttar Pradesh with the exception of some districts of Rohilkhand (Bijnor, Pilibhit and Shahajahanpur) and lower Saryu-Ganga doab, enjoys very high and high index values (above 110). Very high indices are also noted in the area of central terai (Sitapur, Kheri and Gonda) where commercial crops like sugarcane and ground nuts find reference. But it may be recalled that standardized yield indices are generally low in this part of the State. Weighted crop equivalent index values are either low or very low in the centrally situated Districts of Allahabad, Rai Bareilly, Sultanpur and Pratapgarh, which are in accordance to, more or less, standardized yield index values noted earlier. Medium index values are, however, noted in centrally dispersed districts (Fig. 2B).

(3) Application of Cropping Intensity Index : Assessment of cropping intensity provides a very simple distribution pattern of values. Very high and high index values are found in the longitudinal belt of upper and middle Ganga-Jamuna doab, in the three districts of western terai (Rampur, Pilibhit and Nainital) and in the rice-growing districts of Saryupar terai. Low and very low index values are available in the Jamuna-Ramganga doab, in the three districts of central terai (Sitapur, Hardoi and Kheri) and in the entire Bundelkhand region (Fig. 2C).

APPLICATION OF COMPOSITE INDEX OF AGRICULTURAL PRODUCTIVITY

When the above three indices are combined together for visualizing their composite spirit, interesting results pertaining to agricultural productivity per hactare of net cropped land, are found. The values of the composite index are grouped into

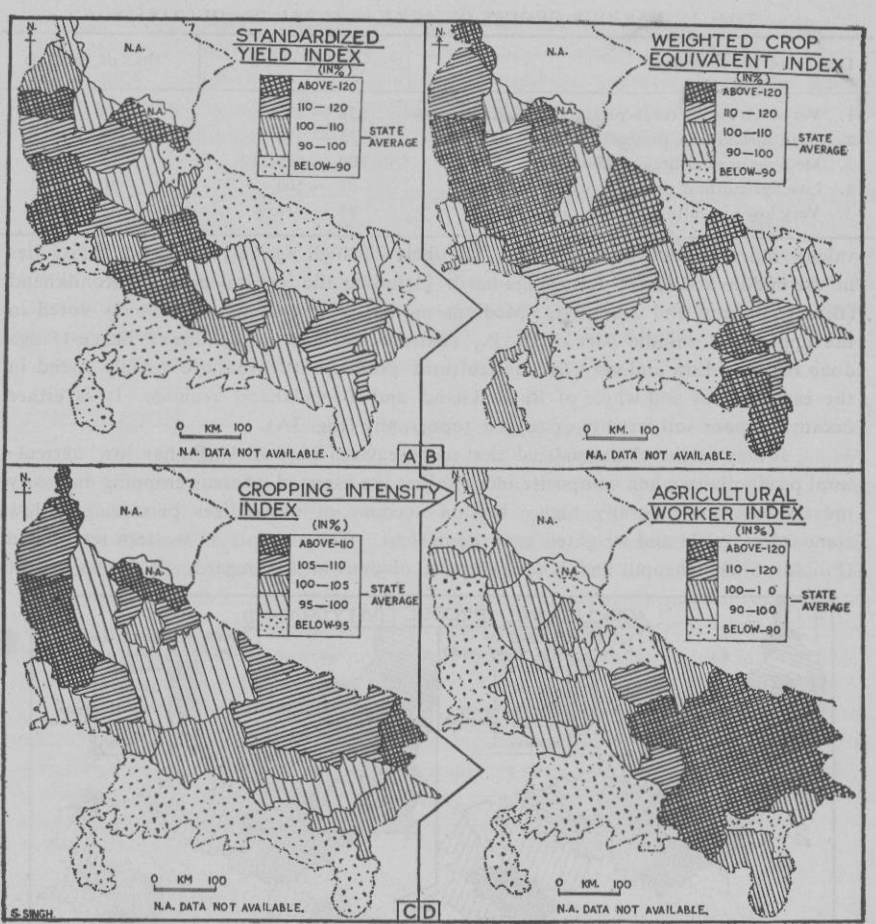

Fig. 2

five categories for the sake of convenience, on the basis of semi-interval method. The number of districts falling in various groups are given in table 2.

The trend of regional variability depicts that a belt of very high agricultural productivity lies continuously in the upper and middle Ganga-Yamuna doab, in eastern terai districts (Nainital, Rampur & Moradabad) and in lower Saryu-Ganga doab. These are the areas where standardized yield index and weighted-crop equi-

Table 2: VARIOUS GROUPS OF AGRICULTURAL PRODUCTIVITY

Degree of productivity	Index value	No. of districts
1. Very high agricultural productivity	130 — above	16
2. High agricultural productivity	115 — 130	6
3. Medium agricultural productivity	100 — 115	5
4. Low agricultural productivity	85 — 100	10
5. Very low agricultural productivity	85 — below	11

valent index values are also high. The belt of high agricultural productivity lies in the middle and lower Ramganga basin including the central part of Rohilkhand (Bijnor, Badaun and Bareilly). Medium agricultural productivity is being noted in the upper and middle part of U. P., central terai and in the lower Saryu-Ganga doab region. Low and very low agricultural productivity areas are mainly found in the eastern terai and whole of Bundelkhand and Baghelkhand regions. It is either because of poor soil fertility or rugged topography (Fig. 3A).

It may further be visualized that north-eastern part of U. P. has low agricultural productivity when composite index values are assessed whereas cropping intensity index values are generally high. It is on account of low indices pertaining to low standardized yield and weighted crop equivalent. The example of western terai area (Pilibhit, Shahajahanpur and Kheri) is quite obvious in this regard. It grows wheat

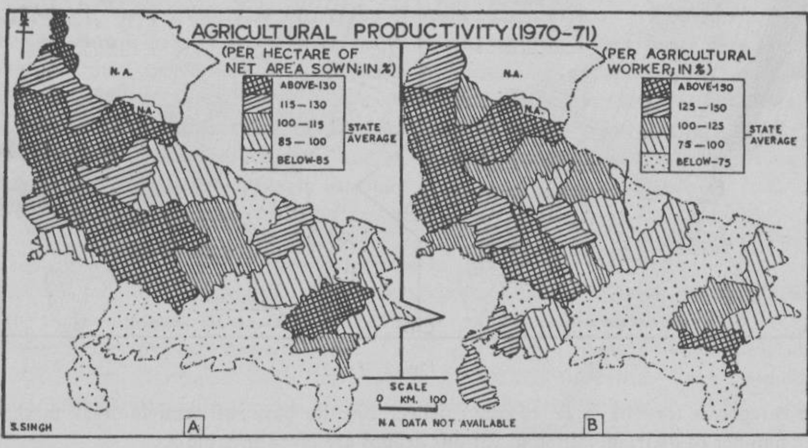

Fig. 3

in abundance. But the agricultural productivity is low because of low standardized yield and cropping intensity indices. It may be realized that agricultural productivity can be improved in such areas by giving more emphasis on commercial crops.

(5) **Application of Agricultural Worker Index :** Composite index of agricultural productivity per agricultural worker will be helpful for distinguishing variations in distribution patterns (Fig. 2D). Generally the productivity per agricultural worker is also higher where agricultural productivity is higher. Both agricultural workers as well as agricultural productivity are higher in the upper and middle Ganga-Jamuna doab. Both are also high in the Rohilkhand Division of western terai and the lower Saryu–Ganga doab. Agricultural productivity as well as productivity per agricultural worker are low in the eastern terai area. But perceptible variations are visualized in the Bundelkhand area of southern Uttar Pradesh. Here agricultural productivity is very low, but such is not the case with productivity of agricultural workers. The composite index of agricultural productivity per agricultural worker reveals that the values are higher in some western parts of this area (Jhansi & Hamirpur). This is because of very large number of workers engaged in agriculture (Fig. 3B).

CONCLUSION

Various techniques have been employed to assess regional variations in agricultural productivity, such as output per unit area, output per man-hour, input-output ratio measured by ranking coefficients of crops per unit area, weighted index, production function respectively. Analysis of these methods makes it clear that a composite index of agricultural productivity can successfully be made out of standardized yield index, weighted crop equivalent index and cropping intensity index. Further, a composite index of agricultural productivity per agricultural worker may be arrived at by employing agricultural worker index, which will be a suitable tool for ascertaining usefulness of earlier techniques.

The application of various indices for studying agricultural productivity of Uttar Pradesh conveniently brings forth typical regional variations. The results arrived at by employing composite index per agricultural worker obviously tally with the above, excepting in the areas where number of workers engaged in agriculture is far above the average, such as the case in Bundelkhand region.

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