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MEASUREMENT OF FARM EFFICIENCY IN AGRICULTURAL SECTOR OF INDIA: A STUDY

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ABSTRACT
While the non-parametric production function is based on linear programming, the parametric production function is estimated using stochastic frontier analysis (SFA). The efficiency is assessed using a non-parametric technique known as Data Envelopment Analysis (DEA) (Charnes, Cooper, & Rhodes, 1978).. The primary benefit of the DEA technique is that it circumvents certain drawbacks of the parametric approach by requiring simply a little portion of a priori assumptions about the functional connection between inputs and outputs (Gadanakis et al., 2015). The goal of the current study was to assess changes in large farms' production and efficiency with different specializations.. **Methods:** Secondary sources of Indian knowledge, such as books, essays, websites, and online journals released over time, are where the information is acquired from. **Result and Discussion:** Different efficiency measures are generally used for farm management: They are Capital Ratios and Income Ratio, Cost Ratios,

Cropping Intensity Index, Crop Yield Index and System Index discussed in this article.
Conclusion: Enhancing productivity and managing agricultural operations requires an understanding of the efficiency of agricultural production. A well-considered method of evaluating the business involves utilising characteristics such as financial performance, resource productivity, and environmental impact.

Keywords: Linear programming, Production function, Capital Ratios and Income Ratio, Cost Ratios, Cropping Intensity Index

INTRODUCTION

One of the most basic metrics is farm efficiency, which is calculated by dividing the total number of acres planted to crops. It is an additional reliable and accurate general agricultural efficiency metric. By dividing the total productive man-work units by the quantity of man-equivalents in the agricultural, one may calculate this metric. In practice, evaluating efficiency and productivity across many industries is crucial because it enables production control. It is therefore turning into an important field of research (Toma et al., 2017). According to Malana and Malano (2006), There are two main approaches for calculating productive efficiency: parametric and non-parametric. While the non-parametric production function is based on linear programming, the parametric production function is estimated using stochastic frontier analysis (SFA). A non-parametric method called Data Envelopment The efficiency is assessed using DEA analysis (Charnes, Cooper, & Rhodes, 1978). The primary benefit of the DEA technique is that it circumvents certain drawbacks of the parametric approach by requiring simply a little portion of a priori assumptions about the functional connection between inputs and outputs (Gadanakis et al., 2015). Consequently, the agriculture industry has frequently used DEA techniques (Syp and Osuch, 2018). Ratios of output to input can be used to compute technical or physical efficiency measures with ease (Farm Management Fact Sheet,).

One of the most important aspects of cropping system research is evaluating the effectiveness of cropping systems. Numerous indicators have been devised to define cropping systems' efficiency (Palniappan, 1985; Menegay et al., 1978). The intensity, productivity, and variety of cropping systems are all described by these indexes. Nevertheless, the majority of these indicators have not been applied regionally, but rather to a single farm. The geographical and temporal scope of cropping patterns must be known for these indices (Ray, Sood, Panigrahy, and Parihar, 2005).It relates to the correct use of the various resources that are available in farming such as land, manpower, machinery, and capital with the purpose of obtaining the highest levels of yields in food production ranging from crops to animal products at the lowest costs and time possible. Thus, it includes numerous procedures and approaches aimed at achieving the reduction of expenses, mitigating the impact on the natural world, and making business running and lucrative.

Resource Management: Optimising use of water, soils, nutrients, and chemicals so that they are able to obtain the highest yields and production rates without regard to the resource base or the consequences on the underground world.

Labour Efficiency: Incorporation of new methods and systems that may reduce or reduce maximum human interjection but give the maximum output, for instance, incorporation of machineries, automation and control of the efficiency of workers.
Energy Efficiency: Measures, which assists in reducing the energy use in farming enterprises, using measures based on efficiency and renewable energy. The primary focus of the International Food Policy Research Institute (IFPRI) is energy intensity-related studies in agriculture and resource utilization.

Financial Efficiency: Measures of financial efficiency can assess the farm's ability to use its financial resources. This furnishes the authorities with the data needed in order not to exceed total expenses for seeds, fertilizers, and equipment for agricultural production.
Technological Integration: It is important to consider introduction of innovation practices, and techniques such as precision agriculture that includes GPS, sensors and data in enhancing the techniques of planting, watering, and harvesting techniques practices.

OBJECTIVE

The goal of the current study was to assess changes in large farms' production and efficiency with different specializations. Using straightforward conventional efficiency measures, many studies were carried out to determine the production and efficiency of farms (Syp and Osuch, 2018).

METHODS

This study combines quantitative and qualitative methods with an emphasis on descriptive research. Secondary data served as the basis for its design. Secondary sources of Indian knowledge, such as books, essays, websites, and online journals released over time, are where the information is acquired from.

Analysis: The many materials gathered from the many sources have been thoroughly examined, confirmed, and arranged under the relevant topics in order to preserve the necessary presentation and conclusion.

RESULTS AND DISCUSSION

Following efficiency measures are generally used for farm management:

- (A) The Capital Ratios and Income Ratio
- (B) Cost Ratios
- (C) Cropping Intensity Index
- (D) Crop Yield Index
- (E) System Index

The following paragraphs describe these efficiency measures in some details:

(A) (i) The Capital Ratio: These measures include.

(a) $$\text{Net Capital Ratio} = \frac{\text{Total Assets}}{\text{Total Liabilities}}$$

(b) $$\text{Working Capital Ratio} = \frac{\text{Working and Current Assets}}{\text{Intermediate and Current Liabilities}}$$

(c) $$\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}}$$

The working capital ratio and the current ratio show the solvency of the farm business for a medium-term and short-term, respectively, while the net capital ratio can be used to assess the relative level of solvency of the business of different farms over an extended period.

(ii) Ratio between Net Worth and Fixed Capital: The difference between a farm's total assets and total liabilities is its net worth. Put differently, net worth indicates the quantity of reserves and capital that are possessed. If the business is able to maintain its viability as a going concern, its net worth should exceed the value of its fixed assets. If this ratio is more than one, this suggests that the business has resources available to it for working capital and liquidity needs.

(b) $$\text{Debt Equity Ratio} = \frac{\text{Deferred Liabilities}}{\text{Net Worth}}$$

(a) $$\text{Ratio between Net worth and Fixed Capital} = \frac{\text{Net worth}}{\text{Fixed Capital}}$$

This metric indicates whether the farmer's own resources are adequate to cover the cost of the loans obtained from outside sources.

(iii) Ratio between Working Capital **and Total assets:** This ratio will show a farm's effectiveness from a different perspective. A firm needs both working and fixed capital to operate effectively. It is necessary to keep the working capital and other assets in a healthy balance. We may determine how much of the total assets have a suitable level of working capital by using this ratio. By contrasting the actual ratio with the typical ratio intended for the kind of farm under investigation, this may be ascertained. It should be noted that all of the aforementioned ratios need to be modified for price changes in order to be used for comparison across time.

$$\text{Ratio between Working Capital and Total assets} = \frac{\text{Working Capital}}{\text{Total Assets}}$$

Income Ratios: These ratios provide the most often used metrics for assessing a farm's efficiency.

These are:

Rate of turnover: (i) A greater turnover per unit of total assets will suggest a better use of the assets available when there is a capital deficit. Comparing farms run by the same group of farmers requires the application of this ratio. This is so that various farmer groups may afford to own varying overall asset amounts; for example, a self-cultivator will have more assets than a tenant cultivator.

It is equal to

$$\textbf{Rate of turnover} = \frac{\text{Gross Income}}{\text{Total Assets}} \times 100$$

(ii) In a place where land is the scarcest resource, net revenue per acre is an essential efficiency statistic. Net revenue is calculated by deducting the gross value of farm output from all actual and input costs for farm production.

This efficiency metric makes it easier to compare the effectiveness of several farms within the same region, across regions, or at different times. The acreage of each farm may be split between irrigated and non-irrigated land to provide a more accurate comparison. However, dividing out the joint costs of farming activities on the two types of property can be challenging in this situation.

$$\text{Net Income per Acre} = \frac{\text{Total Net Income}}{\text{Area of the Farm}}$$

(B) Cost Ratios: There are three types of cost ratios discussed below:

$$\text{(i) Gross Ratio} = \frac{\text{Total Expenses}}{\text{Gross Income}}$$

$$\text{(ii) Fixed Ratio} = \frac{\text{Fixed Expenses}}{\text{Gross Income}}$$

$$\text{(iii) Operating Ratio} = \frac{\text{Operating Expenses}}{\text{Gross Income}}$$

(C) Cropping intensity Index Cropping intensity on a farm is determined by dividing net area sown by gross area shown. This metric provides insight into the practice of multiple cropping on farms. The formula that follows illustrates it.

$$\text{Cropping intensity Index} = \frac{\text{Gross Area Sown}}{\text{Net Area Sown}}$$

(E) Crop yield index: This indicator is designed to show how a certain farm's output stacks up against the average yield throughout the region. If it were just one crop, the yield on a particular farm could be easily compared to the average production in the region.

A farm may plant a number of crops in a given year, some of which will yield more than the average yield in the area and some of which will yield less. This makes the crop yield index vital.

The average crop yield in the area is used as a basis (=100) to calculate the yield relative to the crop grown on the specific farm to generate the crop yield index (**Aditya, Harsh).**

(F) **SYSTEM INDIES**

On the other hand, the system index assumed that the distribution of cultivated land on a farm among different crops is not typical for the region. However, on a farm, a crop's net revenue yield per hectare is the same as it is for the whole area. The index is used to calculate the proportion that a farm's revenue will differ from an average farm's if its hectare net income for each crop were equal to the region's total income, given its own percentage distribution of cropped area under different crops. We first compute the relatives for each crop's area as a percentage of the entire farm's area to produce this index, using the base of the total area under this crop in the region as a percentage of the total area under various crops in the region.

. The weights assigned to these relations are then based on the net revenue yield per hectare that each crop in the area produces. The following are some crucial metrics to consider while assessing cropping systems:

Land Use Efficiency or Assessment of Land Use or Land Production Efficiency Indicator: It is necessary to know whether land is efficiently used or not. It can be known by studying the indices like (i) Multiple Cropping Index or Multiple Cropping Intensity (MCI), (ii) Cultivated Land Utilization Index (CLUI), (iii) Crop Intensity Index (CII), (iv) Specific Crop Intensity Index (SCII), (v) Diversity Index (DI), (vi) Diversity Index (DI), etc. Making efficient use of the resources at hand is the primary goal. The primary goal of multiple cropping, which includes both inter and sequential cropping, is to intensify cropping while using the resources that are available in a particular setting. To assess the effectiveness of various multiple cropping systems in terms of land use, a number of indexes have been presented (Ray, Sood, Panigrahy and Parihar, 2005 and Agroroom).

1. Multiple Cropping Index, often known as Multiple Cropping Intensity (MCI): Dalarymple (1971) proposed it. It is the percentage representation of the total acreage that is planted each year in relation to the total area that is accessible for agriculture.

That is, $$\text{MCI} = \frac{\sum Ai}{A} \times 100$$

where A is the total land area that can be used for cultivation, i = 1, 2, 3, ---, n = the total number of crops, and Ai is the area that the ith crop is growing on. Total cultivable area, or MCI, is the total area divided by the whole amount of land that is planted to different crops and harvested in a single year. Alternatively, MCI stands for the total area planted to different crops each year.

divided by net area available for that cropping pattern and expressed in 100. That is,

$$\text{MCI} = \frac{\text{Total area under different crops}}{\text{Net cultivable area}} \times 100$$

2. Cultivated Land Utilization Index (CLUI): The formula for the Cultivated Land Utilisation Index is to multiply the land area products of all crops by the number of days that those crops actually grew, then divide the result by the total amount of cultivated land and 365 days in a year.

$$\text{CLUI} = \frac{\sum Ai\ di}{A \times 365} \times 100$$

i = 1, 2, 3, ------ n, where n is the total number of crops. The variables Ai, di, and A = total cultivated land area available for 365 days, area occupied by the ith crop, number of days the ith crop occupied, and so on. CLUI can be expressed as a fraction or as a percentage. This gives information about the amount of land that is used. The details of intercropping and relay cropping are shown by a land utilisation index larger than one; on the other hand, a land utilisation index of one (100%) shows that the land has been left fallow. The only limitation of CLUI is its inability to account for land that a farmer might have available for farming temporarily.

3. Crop Intensity Index (CII): The crop intensity index assesses the relationship between the overall area and time of available land, which includes land that is temporarily accessible for cultivation, and the actual land usage by farmers in terms of area and time for each crop or group of crops. In order to calculate the entire amount of temporarily accessible land area and the amount of time these land areas are actually used, the area and duration of each crop are added together and divided by the total amount of farmers' available cultivated land area and time periods. CII and CLUI have a same fundamental concept. With an appropriate sample plan in place, the latter approach offers more versatility in terms of computing and evaluating cropping pattern data and vegetable yield.

$$\text{CII} = \frac{\sum ai.ti}{AOT + AjTj}$$

Where i equals 1, 2, 3,...n, n = the total number of crops a farmer grew in that time frame. ai = the area that the ith crop occupies. Ti= total amount of time spent on ith crop. The whole amount of cultivated land that a farmer has available for use within a specified time period is known as AOT. j can be 1, 2, 3,... M, Aj, and Tj represent the jth field's land area, time under cultivation, and so on. The total number of fields that a farmer is able to use for farming temporarily during time T is M. When A CII of one indicates that land resources or area have been completely used; a CII of less than one indicates underutilization. CII indicates how many times a field is planted with crops in a given year.

. The calculation entails multiplying the result by 100 after dividing the total cultivated area by the net area of the farm, region, or country.

$$\text{CII} = \frac{\text{Gross cropped area}}{\text{Net area}} \times 100$$

This is the disadvantage of CII: long-grown crops that are left on the field for extended periods of time. Since time is not taken into account, long-duration crops like cotton and sugarcane would have low cropping intensity even though they will remain in the field for longer.

4. Index of Specific Crop Intensity (SCII): SCII is a subset of CII. It calculates the area and time allotted to each crop or set of crops in relation to the overall area that farmers have at their disposal.

$$SCII = \frac{ak.tk}{AOT+ ai\ ti}$$

where tk is the total amount of crops cultivated by the farmer within a certain time period, T such as field crops or vegetable crops. ak is the area that the kth crop occupies. ti is the ki^{th} crop's duration. This method may be used to calculate the intensity index of field crops, like rice, vegetables, etc.

5. Diversity Index (DI): By calculating the reciprocal of the sum of squares of the gross revenue obtained from each farm to its total revenue in a single year, it calculates the number of farm goods planted in a given year.

$$DI = \frac{1}{\sum(yi/y_N)^2}$$

where yi is the gross revenue of the ith crop produced in a year, and N is the total number of crops grown on a farm. yN is the total income from all crops grown in a given year.

6. Harvest Diversity Index (HDI): This is calculated by substituting the value of each harvest for the value of each agricultural enterprise in the DI calculation.

$$HDI = \frac{1}{\sum(yi/y_N)^2}$$

In this case, yi is the gross value of the ith crop that is grown and harvested annually. y_N is the total agricultural value that is sown and harvested in a given year.

7. Simultaneous Cropping Index (SCI): The HDI is multiplied by 10,000, then the result is divided by the MCI.

$$SCI = \frac{HDI \times 10{,}000}{MCI}$$

8. Relative Cropping Intensity Index (RCII): The Relative Cropping Intensity Index, or RCII for short, is a variation of the Cropping Intensity Index (CII) that establishes the space and time given to a single crop or set of crops in relation to the area where production time is actually employed for all crops. The denominator of RCII is equal to that of SCII, while the numerator of RCII is equal to that of CII.

$$RCII = \frac{ak.tk}{\sum ai.ti}$$

According to these indices, a farmer would be considered a vegetable grower if their relative vegetable intensity index was 50%. monitoring the movements of various crops throughout farms of various sizes and determining whether cropping patterns are the same across farm size strata. The degree and intensity of land cultivation were also indicated by these metrics. However, none of these indices address productivity, thus they cannot be used to compare different cropping systems or evaluate how well they use resources other than land [**https://agriinfo.in/important-indices-694/**].

9. Crop Equivalent Yield (CEY): A large range of crops and cultivars are included in a multiple cropping series. Comparing the economic yield of several crops is a difficult task. The yield of rice, for instance, cannot be compared to that of grain cereals, pulse crops, and other crops. In some situations, economic returns—either gross or net—can serve as the foundation for comparison. It is also possible to translate the yields of several crops into the equivalent yield of a single crop, such the wheat equivalent yield, for a trustworthy comparison. It is also possible to calculate the production of protein and comparable carbohydrates (Lal and Ray, 1976 and Verma and Modgel,1983). The formula for figuring out wheat equivalent yield (WEY) was developed by Verma and Modgel in 1983. Equivalent yields of crops (CEY): Depending on the produce's price, the yields of several intercrops are converted into an equal yield of any one crop [Agroroom: https://www.agroroom.in/2023/11/unit-i-cropping-systems-definition.html?m=1 (accessed on 12.06.2024)].

Again some of the measures are as follows:

(i) Gross income: This statistic, which shows the size and volume of agricultural industry, may be used to assess how well farmers perform in similar farming situations. The value of items utilized for domestic consumption during the accounting period, the closing stock of both finished and unfinished goods, and the revenues from sales made during the period are added to determine gross income. The opening stock of finished and unfinished items at the start of the accounting period, the cost of buying inventory to be employed in production during the accounting period, and other variables are taken into consideration in these calculations.

(ii) Cash income: This measure shows how much money a farmer may utilise to finance various agricultural innovations. Cash paid for various farm operations is deducted from the overall cash receipts from sales and the rental income from agricultural resources. That produces the revenue in cash.

(iii) Net operating income: Deducting different operating expenditures from the gross income as specified in (i) yields this information. Operating expenses (ii) include the cost of seed, fertilizer, manure, and insecticides; charges for canal irrigation; taxes (not including land revenue); depreciation on working assets; rent on leased land; fees for hiring bullock labor; the value of hired labor; and the operational costs of owned farm machinery (including tube wells) minus depreciation.

Therefore, revenue received by the farmer after deducting all costs spent in running his farm, except for depreciation on working assets, is not considered operational income. This excludes income from labour from owned bullocks.

(iv) Net farm income: It is what remains after actual fixed costs associated with farming are paid and the fixed asset depreciation (such as buildings, machinery, and irrigation systems) is subtracted from the profit on operations. So, if there are no maintenance costs involved with using their own bullock crew, net agricultural revenue is the total amount of money a farmer makes in their capacity as a capitalist, laborer, renter, and entrepreneur.

(v) Surplus over variable costs: The gross income is subtracted from the total amount of variable costs to determine the surplus. We call this going back to the fixed resources.

(vi) Returns to management: The operator gets compensated for his management services with these. On the surface, this indicates that all costs attributed to or paid for different inputs (primary or intermediate) that belong to third parties or to the operator directly must be subtracted from gross income.

(vii) Returns to Labour and management: This metric clearly indicates the farm operator's entire income as an entrepreneur and as the provider of work for the family. As a result, we determine its value by multiplying the value of family labour that is imputed by Returns to Management. This metric can be used to compare labour productivity.

(viii) Return to Capital & Management: Capital efficiency can be evaluated with the use of this statistic. To find the return to management, depreciation on fixed capital and fixed expenses are added. It is evident from the previous explanation of the farm efficiency metrics that the ratio-based measurements should be applied if comparisons with other farms are to be conducted. The aggregate measurements are essentially what demonstrate the total amount of money earned on a farm. Only when the other farms are exact replicas of the farm under consideration will the aggregate metrics allow comparison with other farms.

CONCLUSION

Enhancing productivity and managing agricultural operations requires an understanding of the efficiency of agricultural production. A well-considered method of evaluating the business involves utilising characteristics such as financial performance, resource productivity, and environmental impact. Measurement adheres to the concepts of data collection and evaluation techniques and demands a high degree of precision. Productivity can rise noticeably when innovative and technological approaches, such as precision farming and data analysis, are adopted. Furthermore, because successful farming methods ought to be able to endure longer, support the land, promote biodiversity, and use less chemicals, sustainability shouldn't be disregarded. Farm efficiency is measured continuously, meaning that it is necessary to frequently reevaluate its current state and compare it to its prior state. The points show that by continuous improvement of efficiency, farms may raise their output and help improve the sustainability of the agricultural world when economic and environmental goals create a coherent approach. Thus, One may contend that determining a farm's efficiency status from an economic and environmental standpoint involves a difficult procedure that combines quantitative data collecting, processing, human observation and tools designed to make use of the information.By doing this, the farms would learn how to enhance each of these areas, increasing their productivity and sustainability. However, a farm's technical and managerial skills play a significant part in determining how efficient it is. On larger farms, efficiency is influenced by both the owner's and the workers' performance. In numerous blocks, the Cultivated Land Utilisation Index (CLUI) is low (less than 0.5), indicating significant room for improvement. Since the area is left fallow during the summer, it would be beneficial to cultivate a summer crop (Ray, Sood, Panigrahy and Parihar, 2005).

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