

Structures and Problems for Measuring Agricultural Productivity: An Analytical Study

Dr. Tage Ampa¹, Dr. Ram Krishna Mandal^{2,*}

¹Assistant Professor, Department of Education, Dera Natung Govt. College, Itanagar, Arunachal Pradesh, India

²HoD & Professor, Department of Economics, Cooch Behar Panchanan Barma University, Cooch Behar, West Bengal, India

Orcid: 0000-0001-9621-7084

*Corresponding Author

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Abstract— *The concept of agricultural productivity has been widely used to clarify the spatial organization and distribution of agricultural practices, and to glean important insights into how agricultural systems operate across varying spatial contexts. Productivity generally is assessed from two key standpoints: (a) on the productivity of land resources that are used in agricultural practice, and (b) on the productivity of the infrastructure that exists in support of agricultural activity, both interrelated and mutually implicated in overall agricultural success. Objectives: The present research examines the varying contentions associated with measuring agricultural productivity. Methods and Materials: This discussion focuses on the methods used for measuring agricultural productivity, including the Agriculture Productivity Index, and also digs deeper into how agricultural productivity is determined. Results and Discussions: Quality and quantity in the context of productivity are influenced by four main factors—the land, labor, capital and the entrepreneur of the farmer. While land productivity applies primarily to crop-based agriculture, it can also apply to livestock production. There are many measures of productivity that can be calculated but one comprehensive measure is the ratio of the total value of all farm products to the total land area used for agriculture. Conclusion: It is also important to note that different areas within the country exhibit different and divergent problems in relation to agricultural production.*

Keywords— *Spatial organization, Resources, Index, Quality and quantity, Livestock production*

I. INTRODUCTION

Agricultural productivity is an extensive topic that has been studied and explained by many researchers with varying definitions and perspectives. In agriculture, there are many namesake practitioners (agriculturalists, agronomists, economists, and geographers) that study productivity from their particular perspective; thus, produce a variety of definitions. In agricultural geography and economic science, agricultural productivity is normally interpreted as the quantity of output produced per unit of input used, or the output produced per unit of land area, which is an indication of efficiency. The understanding of increasing agricultural productivity is often related to a more appropriate use of the input factors of production, which considers physical resources and socioeconomic institutional and technological factors able to support agricultural

development. The agricultural improvement and developments of a country or region depend largely on enabling the cultivation and production of multiple crops of the agricultural economy. Over the years, there have been massive undertakings and initiatives made to put forth in improving food security and economic stability through reaching higher production and productivity rates in agriculture. Observing agricultural productivity provides important information by showing performance levels in agricultural productivity by region and compared to neighboring regions to understand efficient or inefficient level of output.

By scrutinizing these performance indicators, agricultural development strategies can be conceived and generated, directed at addressing and alleviating regional discrepancies, and inequalities within the agricultural sector

as a whole. In addition, these measurements provide an important opportunity to examine ground realities that contribute to agricultural stagnation, or backwardness, in specific areas, thus leading to more tailored intentions. The spatial examination of agricultural productivity is significant because it highlights the structural dynamics and issues associated with production relations, thus allowing developers to formulate relevant and effective policy measures that engage and direct appropriate policy options. The concept of agricultural productivity has been widely used to clarify the spatial organization and distribution of agricultural practices, and to glean important insights into how agricultural systems operate across varying spatial contexts. Productivity generally is assessed from two key standpoints: (a) on the productivity of land resources that are used in agricultural practice, and (b) on the productivity of the infrastructure that exists in support of agricultural activity, both interrelated and mutually implicated in overall agricultural success. The productivity of land is always tied to and often encumbered with, the productivity of the infrastructure engaged in agricultural production, as Dharmasiri (2011), discusses, highlighting the interrelatedness of these variables.

OBJECTIVES

The present research examines the varying contentions associated with measuring agricultural productivity.

II. METHODS AND MATERIALS

This discussion focuses on the methods used for measuring agricultural productivity, including the Agriculture Productivity Index, and also digs deeper into how agricultural productivity is determined. Agricultural productivity is generally defined as the ratio of output produced to the input used, which can be produced using multiple formulas. For example, the simplest formula is the output/input ratio, while the more advanced method represents a productivity index, which would include one or multiple measures of inputs considering land area, total production, or any other contextual factors impacting levels of productivity (such as price or variety of crop).

Methodology

This study employs an analytic-descriptive research design to assess the structures, indicators, and challenges of measuring agricultural productivity. The methodology seeks to provide a conceptual and empirical understanding of different ways to measure agricultural productivity while also assessing their limitations and applicability for specific systems of agriculture.

Design: The design for this study is based on a descriptive-analytics study. It utilizes secondary sources, theoretical

models, and existing measurement indices for assessing structures of productivity measurement and inherent problems. The design allows for a comparative-critique of the current literature, as well as providing a comparison of quantitative tools to measure productivity.

Data Sources: The research draws primarily on secondary data from published books, academic journals, reports from international institutions such as the Food and Agriculture Organization (FAO), Organisation for Economic Co-operation and Development (OECD), and government papers, including classified documents. A range of existing classical works (for example, Singh and Dhillon, 2000 and Shafi, 1984) as well as contemporary studies (for example, Dharmasiri, 2011; Ludena, 2010) are utilised in order to construct a holistic framework.

Analytical Tools and Techniques: A variety of techniques for measuring agricultural productivity that are widely used are reviewed and applied conceptually: 1. Simple Output - Input Ratio - assessing relative productivity with an efficiency measurement of total output over total input (yield/input). 2. Productivity Index (PI) - measuring regional output against national outputs to assess relative performance. 3. Total Factor Productivity (TFP) - assessing total efficiency which takes into account a range of inputs (land, labour, capital, water, fertiliser, etc.) in assessing an output measure (e.g., yield, productivity) based on total output. 4. Yield per Unit Area - a measure of productivity that measures yield per hectare; one of the most commonly used productivity indicators (for a single crop report). 5. Input-specific measures - including land productivity, labour productivity, capital productivity, and productivity of intermediate inputs; the measures follow a standard formula. Additionally, consideration is given to the Perpetual Inventory Method (PIM) and current inventory method (CIM) of estimating capital stock; minimal returns analysis is also introduced as a more precise measure of productivity relative to efficiency.

Scope of Analysis

The approach involves: Structural Analysis: Measurement of land, labour, capital and intermediate inputs as structural factors for productivity.

Comparative Analysis: The distribution across regions and types of farms, for the purpose of demonstrating differences.

Problem Analysis: The analysis of other issues such as mixed cropping, unmonitored by-products of the farming process, horticultural outputs being underestimated and technical efficiencies.

Policy Linkages: Linking the results of measurement to the underlying policies in relation to resource use, technology use and sustainability.

Limitations: The study is confined to secondary data, which may contain inconsistencies across regions and between time periods. The intricate nature of agricultural systems, in developing economies, particularly mixed and subsistence farming, brings some inevitable challenges that cause accuracy in measurement to vary these will be noted when considering results.

III. MATERIALS

When Singh and Dhillon (2000) first suggested that 'yield per unit' should be closely examined and seen as a valid indicator of agricultural productivity, it drew considerable interest from the academic community. Not unexpectedly, this suggestion has been widely critiqued, and it has been claimed by a number of other authors that it is an invalid suggestion as it ultimately focuses on land as the sole factor of production, rather than the multitude of other important factors that pertain to agricultural production.

As a result, there is a growing chorus of academics who propose a broader definition of agricultural productivity which considers each of the essential resources of production, specifically, labour or farmer experience, the use of fertilisers, the access to and management of water inputs, and a variety of biological factors that underpin crop production. Due to the aforementioned agreement that average returns per unit of food production is insufficient, it has also been suggested to use marginal returns per unit of food production as a more precise measure instead. This measure is believed to be a more accurate representation of the efficiency of combining any inputs into the production process, assuming 'all else is held constant'. In agriculture, the resources used to achieve production are diverse (land, labour, seeds, manure, irrigation land, etc) and all of these resources are necessary in agricultural practice. In addition to these factors, the role of managerial ability (an intangible but necessary resource) is also an important resource to the overall success of agricultural business success. Just as everything has a certain amount of efficiency associated with it, a given agricultural business will be most efficient when the combination of production inputs is least cost for a given amount of output. Therefore, the ratio of cash values of outputs produced to cash values of inputs used can be simply defined as cost efficiency measures in agriculture.

It is therefore reasonable to assume that higher levels of output indicate an increasingly efficient allocation of resources and, on the other hand, a more efficient allocation of resources means more output levels (Krishnarao, 1960). The productivity of labour is one of the main determinants

of occupational income levels for those workers involved in agricultural activities, revealing the importance of labour efficiency in terms of the entire economy. Broadly stated, labour productivity can be stated in terms of man-hours or days of work to generate a unit of agricultural production. Shafi (1984) noted that labour productivity is measured by total agricultural output produced per unit of labour employed. This measurement is of primary significance in terms of what is potentially the most critical factor of production and thus makes it intuitively obvious and relatively simple to measure. Agricultural productivity can be defined as the "ratio of the index of the local agricultural output to the index of total inputs used in farm production." Additionally, labour productivity is an important determinant of living standards often expressed in total income per person, thus demonstrating its important policy implications. However, it is important to acknowledge that labour productivity only represents part of the actual capabilities of workers or the intensity of worker effort in the production process (OECD, 2001). In the field of agricultural geography, the significance of labour productivity has two major dimensions. To begin with, it significantly affects the national economy and, second, it is one of the primary determinants of the standard of living of the agricultural population (Dharmasiri, 2011). Capital investment - which includes a multitude of expenditures such as land purchase; land development and reclamation; drainage and irrigation infrastructure; livestock purchase; feed, seeds, and farming tools; machinery; and, chemical inputs into crop production - is now seen as a key contributor in increasing agricultural productivity. Significant studies by Jamison and Lau (1982) and Alderman et al. (1996) have explored the linkages between education and wages with agricultural productivity, specifically focusing on how human capital informs agricultural productivity. More recently, Fafchamps and Quisumbing (1998) have conducted extensive research, identifying several indicators of human capital and its implications for agricultural productivity - an important research endeavor that reflects the multifaceted nature of agricultural productivity, particularly in the Pakistani context.

Different ways of measures and formulae

1. Simple Output / Input Ratio: This is the most straightforward measure of the productivity of a single factor of production; we simply total the output and divide by the total input. The input could be labor, or fertilizer, or amount of land,

Formula: Productivity of a single factor of production = Output / Input. Let us take the most important factor of

production in productivity, labor. Labor Productivity (or Productivity of Labor) = Output / Labor.

2. Productivity Index (PI): This measure allows us to compare output of one crop against output of a different crop in relation to the amount of land used. The formula for $PI = [(Y / Y_n) / (T / T_n)]$ where Y = Total output of the selected crops in a specific unit area, Y_n = Total output of the same selected crop at the national level, T = Total area cropped of the specific crop in that specific area, T_n = Total area cropped at the national level.

3. Total Factor Productivity (TFP): Total factor productivity (TFP) expresses productivity of all inputs used in the production of an output at a time. TFP is a broader measure of productivity, which combines all inputs rather than one or two. Formula: $TFP = [(Output) / (Inputs)]$. For example, if a farm is producing one output while decreasing the overall inputs (land, labor, capital, water, fertilizers, etc.) used, TFP would be increasing.

4. Crop Yield per Unit Area: Crop yield per unit area is perhaps one of the most utilized measures of agricultural productivity and is specific to crops. Formula: Yield per hectare = Total yield / Area (in hectares).

5. Extra Measures: Land Productivity: Land productivity is the production per unit of land, i.e., yield per of land.

Labour Productivity: Labour productivity means the quantities of production per unit of labour (or, output per worker hour).

Capital Productivity: Capital productivity means the quantities of production per unit of capital investment.

Gross revenue: The gross revenue is the total income generated from agricultural production.

6. Agricultural productivity valuation:

Cap Rate: Cap rate is the capitalization rate used in agricultural land valuations.

Landowner's Share: The proportion of gross revenue that the landowner receives.

Formula: $[(Gross\ Revenue \times Landowner's\ Share) / Cap\ Rate]$.

Example: $[(10,000\ Gross\ Revenue\ per\ acre) \times (0.8\ landowner's\ share) / (0.05\ cap\ rate)]$ would equal $(10,000 \times 0.8) / 0.05 = Rs. 160,000$, the productivity value per acre.

7. Assessment of agricultural productivity

Cap rate: Cap rate is the capitalization rate used for the valuation of agricultural land per acre. **Landowner's Share:** The share of gross revenues that goes to the landowner per acre.

Formula: $(Gross\ Revenue \times Landowner's\ Share) / Cap\ Rate$

For example, gross revenues = Rs. 20000 per acre, the landowner's = 50% of the production value = Rs. 10000 for that acre, and Cap rate = 10%

Therefore, the assessment of agricultural productivity = $[(20000 \times 50\%) / 10\%] = [(20000 \times 0.5) / 0.1] = Rs. 100,000$

Agricultural productivity is computed using the formula, Productivity = (Total Output ÷ Total Input), where "Total Input" are the resources consumed in the production of the agricultural output (land, labor, capital, water, fertilizers, etc.; and "Total Output" refers to the volume of agricultural output (outputs such as crops and livestock).

(<https://openknowledge.fao.org/server/api/core/bitstreams/dcd4edfc-f7d5-4872-8996-5612c87446d6/content>).

IV. RESULTS AND DISCUSSIONS

Quality and Quantity

Quality and quantity in the context of productivity are influenced by four main factors—the land, labor, capital and the entrepreneur of the farmer.

Land Productivity: While land productivity applies primarily to crop-based agriculture, it can also apply to livestock production. There are many measures of productivity that can be calculated but one comprehensive measure is the ratio of the total value of all farm products (crops and livestock) to the total land area used for agriculture. Land productivity measures only the return of output associated with a specific land area used for production agriculture. While primarily applied in crop production, land productivity measures the aggregate land area dedicated to crop agriculture. Land productivity can also be determined by the ratio of area of land planted to the output of crop production, where the area of land is typically measured in form of acres or hectares. When land productivity is measured as a physical yield, for example, yield of crops such as maize are measured in tonne yield, this measure aligns with the return on productivity.

In contrast, when land productivity is expressed in monetary terms, it is often called returns to land. The term captures the financial benefits from agricultural practices undertaken on the land.

$$\text{Land productivity} = \frac{\text{Quantity of output}}{\text{Area used by Crop}}$$

In regard to agricultural production, productivity calculations must account for all crop produced on the specified plot of land during a specified reference time, which may mean a cropping season or year. This is important to consider because, in practice, farmers often grow multiple crops on the same land during the year;

farmers may grow each crop together on that parcel of land or may have a practice of successive cropping with different crops during different seasons. Kelly et al. (1996) described a broader issue regarding the under-valuation of yield and output in developing countries, and ultimately, he and co-authors attribute this under-valuation to not fully accounting for crops that are mixed or that people grow in succession, and not adequately accounting for by-products that may be sold, consumed by the household or used to produce something else out of crops grown for food. Therefore, it is especially important that all crops grown be included in the greater calculation of productivity, especially in developing countries where this type of practice is very common.

Labour Productivity: Labour productivity is an expression used in a formula that defines the amount produced relative to the labour inputs used within the production process. Here, the formula for labour productivity is:

$$\text{Labour productivity} = \frac{\text{Quantity of output}}{\text{No. of Labour Employed}}$$

The accuracy and reliability of the labour productivity measure depends on several factors that include but are not limited to the actual amount of time spent doing agricultural work (including full-time, part-time, or seasonal work, as well as family labour and casual workers), along with the skills and quality of the labour force. Differences in skill and quality can impact productivity, and estimates can be biased if a single wage rate is assigned to all types of workers with differing skill levels and experience. The complexity of labour productivity is not limited to labour factors, as it is often entangled in other influential factors such as land availability and the capital invested. For example, Kelly et al. (1996) note that in situations of labour scarcity and land abundance, producers are likely to implement production systems designed to maximize labour productivity. Capital also plays an important role, as it is directly related to the overall productivity of labour.

Importantly, increases in agricultural yield can be primarily linked to the use of genetically enhanced seeds that have great yield potential and an increase in the use of chemical fertilizers and pesticides, and in some cases, increased irrigation. Higher labour productivity is often correlated with the degree of mechanization in agriculture, as more efficient mechanization reduces the labour needed to farm more land. The differences in estimated labour productivity levels in different countries and regions can in part be explained by the greater degree of mechanized equipment in developed economies than is found in developing regions. In addition, labour costs involve the total of wages and benefits paid to hired labour, plus the estimated wage

for any unpaid family labour and any unpaid labour contributed by the farm owner. Estimating the imputed wage for unpaid labour involves determining wage rates for hired workers with similar characteristics—not a simple exercise. Furthermore, adjusting for changes in labour quality involves complex and nuanced calculations. To that end, matrices have been developed, allowing work hours and hourly wage rates to be categorized, and agrarian workers can be classified by sex, age, education level, and employment status (hired, self-employed, and unpaid family labour). This allows for a comprehensive means to measure labour inputs adjusted for quality.

Capital Productivity: Capital productivity serves as a vital metric that assesses the contribution of capital utilised within the production process to the overall output generated. In agricultural contexts, capital is typically defined as an input that is owned by the farm and is capable of providing various services over an extended duration, often spanning several years. When evaluating capital productivity, it is common for many productivity measures to concentrate predominantly on the tangible assets associated with farming activities, including farm buildings, machinery, and other forms of equipment that are integral to production. The calculation of capital productivity is performed utilizing a designated formula that systematically addresses the relationship between output and capital input.

$$\text{Capital productivity} = \frac{\text{Quantity of output}}{\text{Amount of Capital Used}}$$

To calculate capital input, service flows from capital used in production, need to be estimated. Before estimating capital services, capital stock must be estimated first, which is the value of productive capital used in farm production.

Capital Stock: Capital stock refers to the value of total fixed assets on the farm, including machinery, equipment, buildings, and other structures that provide capital services as inputs into the agricultural production process. Capital stock can also be viewed as the total value of past capital investments made over time. In general, there are two primary ways to estimate capital stock, and they present two different ways of valuing capital assets and their contribution to agricultural productivity. One of the issues with measuring the value of capital used in a specific year, is it is observationally cumbersome to measure. Because of this, a concept must be applied, which is the opportunity cost of capital services used in the production sector. The capital service flow for each capital input component must be calculated by taking the current value of stock and

multiplying it by an estimated rental fee, which provides a value for the capital service from the capital input.

In this case, the implicit rental rates for each asset type are carefully derived by applying the expected real rate of return which is an important indicator of the economic value and efficiency of capital use.

The Perpetual Inventory Method (PIM): Often abbreviated PIM, is predicated upon an increase in the capital stock from the prior year for the purpose of estimating the current year's new investment, while factoring in the obsolescence of productive capital by one year into the future, which is a required process officially termed as capital depreciation. Capital depreciation is usually calculated by asset type, as an example to demonstrate the retailer's operational limitations, farm buildings and structures will have a much longer depreciation time horizon than farm machinery would, which simply reflects the real operational service lives of the two asset types in agricultural production. The perpetual inventory method may be clinically expressed in the following mathematically symbolized manner:

$$K_t = I_t + (1 - \mu)K_{t-1}$$

where K_t refers to the capital stock for the current year. It represents the level of investment at this current point in time. The μ , or replacement rate or depreciation factor, provides a basis for determining the sustainability of capital assets over time.

Current inventory method (CIM): The Current Inventory Method (CIM), on the other hand, is based mainly on a precise count and valuation of capital goods which might be amended for the estimated average age of capital goods in use, substantively, with regards to the accounting period or agricultural season. The Continuous Inventory Method (CIM) is a method for estimating capital stock that is usually preferred for estimating capital stock with great detail, but it requires a considerable amount of data inputs that may not be universally available, regarding an accounting period or agricultural season, in comparison to the more straightforward current inventory method. The ultimate utilization of either inventory measure - the Continuous Inventory Method or the Current Inventory Measure - depends upon the data that has been collected, and made available, for an analysis of the asset and will rely significantly on deciding upon an arbitrary service life of the asset considered. Productivity of intermediate inputs: Productivity of intermediate inputs is critically indicative of the agricultural production process and represent goods and services in the production process that will be transformed,

or that will be completely used, during a specific accounting period or agricultural season.

In agriculture, intermediate inputs include a wide variety of purchases made by farmers for the raw material and supplemental inputs that are used in agricultural production, and these inputs are essential to the efficiency and output of any agricultural enterprise. Intermediate inputs may include all kinds of things from energy, oil and lubricants to seeds, fertilisers and soil amendments, pesticides and herbicides, plus services such as repairs and maintenance, etc. Because intermediate inputs differ in their nature, it's useful to be able to combine their input into a single unit of measure, usually applied in terms of dollar value.

The value of intermediate inputs is usually defined by the price paid by the farmer which may include some combination of the financial elements of subsidies and taxes along with the costs of production. With respect to inputs, it is possible to measure and calculate the productivity of intermediate inputs, through a somewhat specific formula, which will express the degree of efficiency with which the intermediate inputs are converted into agricultural products. To measure the productivity of intermediate inputs, you can use the following:

$$\text{Productivity of intermediate inputs} = \frac{\text{Quantity of output}}{\text{Total Expenditure on Intermediate inputs}}$$

Application of Fertilizer: The same idea of measuring inputs applies to each input you measure,

and this applies to any other production too if there are differences too. In other words, fertilizers have differences in the amount of active ingredient put into the fertilizer. The amount of active ingredient matters significantly in the efficacy of a pesticide or any of agricultural inputs, as these contribute to overall productivity and sustainability of agriculture.

Multiple inputs and outputs: Productivity can only be measured by measuring productivity against multiple inputs, which the relationship between outputs and inputs to produce an output. To measure productivity, you must have aggregated outputs, which typically occurs when you aggregate the inputs to a monetary value process with a functional price mechanism for measuring outputs and total productivity. The total equation of productivity can be calculated from a weighted formula or some simple average with the introduction of inputs in a different context if allows or relevant. The aggregated inputs into a monetary value are common in economic territories, especially when

applicable to your entire cost of production or overall cost of inputs.

Issues Regarding Technical Efficiency

Input Type and Quality: In support of the statement that production efficiency can only be assessed with the assumption that the agricultural operation or firm is operating at its technical efficient frontier, refer to the works of Grosskopf (2002), Nishimizu & Page (1982), Fare et al. (1989), and others. It is worth noting that agricultural productivity is, at its essence, a function of two primary items: the type and quality of input into the production process and the degree to which those inputs are integrated into the production process and ultimately utilized. The former item reflects the production technologies utilized, and the latter reflects technical efficiency of the production process.

Improvements related to Productivity: Productivity improvements are often and perhaps too simply attributed to efficiency improvements; this attribution is almost certainly misguided. For example, Ludena (2010) estimates the advances associated with agricultural productivity in Latin America and the Caribbean between the years 1961 and 2007 can be attributed largely to technological changes, whereas the changes in efficiency during the same period were negative. Estimates often arise from a general ambiguity on how to define technical efficiency, how to differentiate between efficiency and technological change, and how the two relate to productivity.

Policies in Agriculture: Given the limited availability of our natural resources - including land, water, and current environmental conditions - the development and implementation of effective agricultural policy is [...]the productive capacity agricultural lies in... In fact, one should expect similar or higher physical productivity and significant financial returns from improved use of existing technologies rather than simply transferring to newly developed technologies. Although new technologies may increase short-run productivity, new technologies may be at a higher cost and impose higher costs on the environment. Agricultural practices and policy applications can differ widely from one country or region to another based, in part, on the varied characteristics, quality, and accessibility of agricultural inputs including soil, rainfall, and skill qualifications of the labor force in agriculture.

Production Technology: Production technology is intrinsically defined by the specific outputs and resources available for production. For any given agricultural product, there may be several production technologies, representing distinct economic, environmental and agronomic conditions in their particular context. For example, the nature of soils, rainfall patterns, and other key inputs, all show structural

differences in regions such as Southeast Asia. A production frontier is achieved when the inputs available are used in a manner to achieve maximum efficiency. An agricultural holding is achieving its production frontier, when it has achieved the highest possible level of technical efficiency. More formally, as described by Odhiambo & Nyangito (2003), an agricultural holding is technically inefficient if - based on its current use of inputs - it cannot produce the most possible output it could. Whereas an agricultural holding is technically inefficient if it is observed it is using more inputs than it should considering what it is producing. The idea of technical efficiency is important to agricultural economics, because it gives a basis to the need for different productivity targets to evaluate an agricultural operation holistically.

This idea also considers multiple dimensions, the resource and input base, which includes the technology used in farming, and how far a given agricultural holding is from the best idea of the most efficient producers in that industry. It is entirely possible for a given agricultural holding to be technically efficient; it may have been able to realize its own potential maximum output level. It could also show low productivity, compared to a less technically efficient farm, simply because the less technically efficient farm has access to better quality inputs that allow that farm productivity to be higher. A farm can be considered technically inefficient if it has not produced the maximum level of output that could reasonably be expected given the type of inputs available, as defined by the Food and Agricultural Organization of the United Nations in 2017.

Meteorology and Geological Change: The complex interplay of meteorological factors and geological change is fundamental to the intricacy of the problem of agricultural productivity but is amplified by the scale of the economic context within which the situation lies.

The processes involved in determining relative prices, the adjustments in production in response to changes in prices, the complex inter-sectoral relationships in agriculture, and the sophisticated value relations among potential factor inputs and the final agricultural products powerfully affect the general productivity problem; however, as Krishnarao pointed out in 1960, a number of complex problems arise as one tries to evaluate and compare returns to investment and factor inputs in agricultural production.

Problems of Measurement in Agriculture

1. High Variation in Types of Agriculture: i) In developing countries like India, there are widely diversified agricultural systems including hybrids, cash crops and food crops.

ii) This variation in the types of crops grown makes measurement very difficult for reason that these crops

contribute in various degrees to total food and income output.

2. Necessity of Total Output Returns: i) To obtain an accurate measure of the productivity total, all output returns of the farm must be included, namely, the output of main crops, by-products, total returns from home produced articles consumed and returns due to unsold stock.

ii) To omit any of these items in the calculation leads to under-measurement of the total productivity of the farm.

3. Troublesome Mixed Cropping: i) Where mixed crops are grown or several crops are put on the same area at the same time, measurement is very difficult.

ii) It is very difficult to isolate the yield and/or value of each of the crops that may be grown on an area.

iii) Thus Hopkins and Berry (1994) showed in Niger that if the returns to labour were measured on the basis of the returns from the major crop grown, then the productivity costs were under-estimated by not less than 20 per cent, and the addition of the returns of secondary crops gave a more accurate idea of the total measure of productivity.

4. Under-Measurement of Return of Horticultural Crops. i) Horticultural crops (fruits and vegetables, etc.) are usually grown on smaller areas than the cereals or cash crops.

ii) Because of their small area and new habit of production, horticultural crops are usually omitted from the measure of productivity.

iii) This means, therefore, that the actual income returns to the farmer are less than on account of the horticultural measurement, and it has the effect of concealing the economic importance of the increasing value of horticultural products for the diversification of high value produce.

5. Omitting the Correlation in the Agricultural Operations: i) outputs of one agricultural operation are, in many cases, either directly or indirectly the feeds of another agricultural operation. Thus, hay grown on crops can be used as stock feed.

ii) Unless, however, these movements of stock-feeds for which the farmer is not regarded as responsible are but incompletely passed through the accounting system, the productivity accounting will be but a partially truthful measure and below the level required for a true appreciation of productivity.

iii) The measurement of productivity comprehensively must include all operations in the whole agricultural system.

6. Biases due to Ignorance of the Difference in Quality and Variation:

i) The non-recognition of the differences in the quality of land, mixtures of crops and differences in degrees of inputs causes exceeding biases in the estimates of the productivity.

ii) According to Kelly et al. (1996), the existence of such biases would distort the estimates of the microeconomics profitability as well as macroeconomic performance of agriculture.

7. Quality and efficiency of Inputs: i) The productivity is not only a measure of the quantity of inputs, i.e. inputs (land, labour, capital, etc.) but is also a measure of the quality of the input and efficiency with which they are used.

ii) Thus the productivity of land, for instance, would be measured also in terms of fertility of soil, the form of the soil, climatic conditions, as well of course, the question of management and the efficiency with which modern technique has been applied to the agricultural industry (Kelly et al, 1996).

8. Necessity for Holistic Productivity Measure: i) A productivity measure which is meaningful must measure in holistic totality all outputs and inputs which need not be hitherto measured (e.g. by-products of all kinds, horticulture (small scale) internal transfers (animal)) if a true understanding of productivity is desired.

ii) This holistic productivity measure has investigation as to the total productivity and accomplishes the essential idea which is the true expression of efficiency in all degrees of agricultural systems in developing countries, etc.

V. SUGGESTIONS

1. Placing ever-increasing pressure on farmers and agricultural producers is the increasing demand to feed the increasing global population more food, with the increasingly decreasing available land and resources. It requires a specialized and coordinated human effort to manage the inputs required to fulfill the needs of agricultural production while also maintaining the ecological assets that sustain the agricultural productivity of knowledge and sustainable practice.

2. The current forces of globalisation and the emergence of corporate farming should not be allowed to challenge the importance of millions of small and marginal farmers and agricultural labourers, who together are the foundation of the agricultural economy in India. The interests of these marginalized groups should be robustly protected, and this can only be achieved by enabling farmers through appropriate empowerment, using innovative approaches and skills that can contribute to sustainable agriculture.

3. The rise of information technology is creating a transformational revolution in all areas of life, including agriculture, and is an unprecedented opportunity to improve agricultural productivity. Low-cost, simple, and well-designed information technology solutions can help educate farmers to provide them with important information they can access to assist their farming activities. Information technology can also serve as an effective market information network and can give farmers real-time updates on climatic, pest, and disease surveillance information that is critical to agricultural productivity.

4. The current institutions that seek to circulate agricultural information within the country, including institutions like the Indian Council of Agricultural Research Institute (ICAR), State Agricultural Universities (SAUs), and Krishi Vigyan Kendras (KVKs) and a variety of non-governmental and private sector actors, should consider creating a better network instead of starting an institutional vehicle anew. This alternative option would facilitate the circulation of important information and knowledge, ensuring that information is transferred freely and efficiently to the end users (Rani, 2007).

VI. CONCLUSION

It is also important to note that different areas within the country exhibit different and divergent problems in relation to agricultural production. Such issues can consist of low rainfall, poor environmental conditions, low groundwater retention, inappropriate land, excess rainfall or flooding, prolonged drought, and poor identification of the best cropping options in accordance with soil conditions. Agricultural productivity levels are most evident in the northeastern states of the country, which seem to experience the most challenges to sufficient levels of agricultural productivity due to low groundwater retention, and groundwater retention is what is needed to aid in producing any crops or meeting the water demands of crops.

The South Eastern region of the country has a high potential for agricultural production because of the amount of land available for future expansion of additional cultivation. To provide policy makers with the evidence to make future decisions on agricultural expansion options, the existing pattern of spatial distribution of the country's agriculture can guide the identification of potential agricultural development zones. There is much research to be done on developing nutrient-dense crops resilient to climate change. Agricultural curricula must embed economic viability, global competitiveness, social equity, and environmental sustainability. Agricultural education must participate in the global social compact to address societal demand.

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