Chapter VI

CONCEPTS OF AGRICULTURAL PRODUCTIVITY

"As a general rule ... it is better not to limit productivity indexes that purport to measure change in efficiency to a comparison of output with a single resource. The broader the coverage of resources, generally, the better is the productivity measure. The best measure is one that compares output with the combined use of all resources". - S. Fabricant (1959)

Productivity consciousness has acquired worldwide momentum. Higher productivity is necessary for the survival of any nation. It stands for proper utilisation of available resources to achieve the best result with minimum cost. Improvement in productivity is the only answer to the problems in the agricultural sphere and it is the only path to prosperity. In Malda it assumes special significance owing to the resource gap. In order to overcome the hurdle of shortfall in resources, stepping up of productivity is a must.

Frederick W. Taylor in his "Task Study" said, "Human work can be made infinitely more productive not by 'working harder' but by "working smarter'.

Productivity means the economic yield from each factor of production (land, labour, capital and organisation) and each input (raw materials, fuels, time and knowledge) or an overall yield of the joint factors and resources enumerated above in combination.

Productivity denotes the efficiency with which the various inputs are converted into goods and services. However, it is a multi-faceted concept; no single definition can fully describe it. Technically, it signifies the ratio between the output and input. Productivity is said to be high when more output is derived from the same input, or the same output is obtained from a less input. It is well understood as the ratio of output to input with respect to given resources. When more is produced with the same expenditure of resources it may be termed as effectiveness; when the same amount is produced at less cost it may be termed as efficiency. The word productivity is broad enough to cover both.

In agricultural parlour productivity is not a synonym of fertility. Generally it is used to express the power of agriculture of a particular region to produce crops. In recent years many attempts have been made to define the meaning of agricultural productivity and a considerable amount of literature exist on this subject.

Agricultural productivity refers to the ratio between the output and input. The improvement of agricultural productivity generally implies more efficient use of factors of production like labour, land capital etc. It is also important to remember that productivity is a physical rather than a value concept, which describes the relationship between input and output. According to Dewett, productivity expresses the varying relationship between agricultural output and one of major capital and other complimentary factors remaining the same.

Many economists give their view about agricultural productivity. Some of them suggested, yield per acre should be considered to indicate agricultural productivity. A number of others criticized this concept because it considered only one factor i.e. land which is not the only factor of production. There are many other factors present or it can be said that productivity could also be measured in terms of per unit of labour and capital.

There are several concepts of productivity. Four of them are of relevance here, land productivity, labour productivity, capital productivity and total factor productivity.

a) Productivity of land.

Among the four inputs of production, viz. land, labour capital and organisation, land is most permanent and fixed input. So attention may especially be focussed on the productivity of land. In a developing country productivity of land has a greater importance because the land secure the employment of a large number of population. In places where land resources are limited, the way out for raising the crop production is to keep pace with the growth of population and the demand for improved diets is by raising yields per hectare.

But raising productivity of land, doesn't necessarily mean only raising the yields of individual crops. The productivity of land may be increased by using the same land in different way. To increase the land productivity intensive cultivation system, multiple cropping systems can to be applied. Land productivity may increase also by progressively changing land from low value to high value crops. Japan, China, Taiwan are applying these processes.

There is a distinction present between the concepts of measurement of agricultural output in terms of calories and in terms of money values (M. Shafi) for example if in a certain region land is shifted from cereal to potatoes the output per hectare in terms of calories of human food is likely to increase, but its productivity in terms of money value may change up or down according to the relative prices of cereals and cash crop.

Again shifting of land from main crop potato to luxury vegetables may well increase it's productivity in terms of money, but will almost certainly reduce it in terms of calories (M. Shafi.)

In developing countries with rapid growth of population and with shortage of food supply, the first need may be to maximize the volume of total out-put in terms of calories.

When we consider land, then NSA and GCA area come into consideration, So

$$\text{Land Productivity} = \frac{\text{Total agricultural product of a year}}{\text{Net Sown area of the same year}}$$

$$\text{Also, Land Productivity} = \frac{\text{Total agricultural product of a year}}{\text{Gross cropped area of the year}}$$

Here Net Sown area is better than Gross cropped area when we are bothered about partial productivity of Land because NSA capture both yield effect as well as cropping intensity effect while GCA captures only yield effect.

b) Productivity of Labour

If the productivity of land is of primary importance as a determinant of the total level of product, then agricultural production of labour is primary determinant of income of the population engaged in agriculture. Labour productivity is one of the ways to assess agricultural productivity. It can be arrived at by computing the money returned per agricultural worker. Labour productivity indicates the standard of living of the farming population in a certain region. The concept of labour productivity is somewhat more complex than land productivity. It is actually the labour productivity which should help in studying real gains achieved in agriculture in country like India where population pressure is tremendous.

Labour input considers the total number in the labour force. In order to take into account the intensity of labour, the number of man-hours worked in agriculture can also be considered. Similarly the total agricultural output may be taken as the gross farm output, or it may be taken as the value added by labour and other factors in agriculture i.e. the value of fertilizers, pesticides fuel and other inputs from out side the agricultural sector subtracted from the value of the output in order to determine the net contribution of agricultural sector (M. Shafi).

In agriculture, labour productivity has two important aspects. First it mainly affects the national prosperity that means the national income secondly, it naturally determines the standard of living of the agricultural population. In economic perspective national income will be increased if labour get a high wage per hour. Therefore, if a country wants to increase its prosperity it is required a) to encourage technical assistance and improvement to the labour population, which helps to increase the agricultural productivity in an economy and b) to stimulate a continual transfer of labour from low productivity to high productivity region. However there are two ways for raising the farmers standard of living; either, he may be paid more than the prevailing regional or world prices for a given amount of work, or the steps can be encountered to raise his out put. Output per man can be improved also by two ways: a) by giving each farm worker more land and livestock to look after and b) by making each unit and livestock capable of yielding a bigger output.

$$\text{Labour Productivity} = \frac{\text{Total agricultural product of a year}}{\text{Total number of labour force in that}}$$

Here either number of male labour should be converted into equivalent number of female labour or vice-versa.

c) Productivity of Capital

Capital the other major factor of production plays an important role in determining the overall productivity. Capital productivity is a partial concept wherein the change in output is measured due to the impact of capital.

To find out partial productivity of capital we have

$$\text{Capital Productivity} = \frac{\text{Total agricultural product of a year}}{\text{Total gross fixed capital in agriculture that year}}$$

But, capital productivity is complicated to compute and difficult to interpret. This is mainly because of both diversity of farms and the purpose for which capital may be utilized in agricultural production process. Capital is generally utilized for the purchase of land, land reclamation for land improvement, irrigation process, livestock purchase, feeds, seeds fertilizers, agricultural implements and machinery etc.

d) Total factor productivity

Productivity measures are subdivided into partial or total measures. As discussed partial measures are the amount of output per unit of a particular input. But, partial measures of productivity can be misleading, as there is no clear indicator of why they change. For example, land and labour productivity may rise due to increased use of tractors, fertilizer or output mix (move to high value crops). To account for at least some of those problems a total measure of productivity, the Total Factor Productivity (TFP) was devised. TFP is the ratio of an index of agricultural output to an index of agricultural inputs. The index of agricultural output is a value-weighted sum of all agricultural production components. The index of agricultural inputs is the value-weighted sum of conventional agricultural inputs. These generally include land, labour, physical capital, livestock and chemical fertilizers and pesticides. Growth in TFP is referred to as the Solow residual. It is generally considered a measure of technological progress that can be attributed to changes in agricultural research and development (R&D), extension services, human capital development such as education and physical, commercial infrastructure, as well as government policies and environmental degradation (Ahearn., 1998). Change in TFP can also be due to unmeasured inputs or imperfectly measured inputs.

This is the ratio of the output to the total input needed for its production, including not only work hours and capital, but also any other input that might be involved. This might be the investment made in human beings to raise the quality of labour or that made to improve productive knowledge through research and development, or by the introduction of organisational, managerial and social innovations.

Total factor productivity is clearly a more accurate indicator of the economic efficiency than land or labour or capital productivity. However, mainly because of the difficulties involved in quantifying various intangible inputs to total factor productivity, land and labour productivity is far more widely used. It is important to bear in mind that land and labour productivity, is affected not only by capital input, but also by other factors, which affect the efficient use of both capital and hours of work. These other factors consist not only of investment for education, training, research and development, but also of non quantifiable factors such as the relationship, climate and worker and management attitudes towards productive efficiency and competitiveness.

So to calculate Total factor Productivity (TFP) the following relationship can be used.

$$TFP = \frac{\text{Total production of a year}}{\text{Total of the weighted Input Indices}}$$

To calculate the weighted input indices generally Land, Labour and Capital are given 0.50, 0.26 and 0.24 weight respectively; but this is not a fixed one, it can change with situations. The other method to calculate TFP is to use total differential equation of the various inputs used.

e) Factors Influencing Growth in Agriculture

Researchers originally limited themselves to examining the roles of labour and physical capital in economic growth. The failure to adequately explain growth led them to examine the roles of other factors and to develop endogenous growth theory. Investment in infrastructure has been cited as an important source of growth in agriculture (Jayne *et al.*, 1994). However, Ferreira and Khatami (1996) claim that economic literature has not reached a consensus on the direction of causality between infrastructure and development. Nor can investment be viewed in isolation of policy reform which has been shown to be a vital stimulus of production (Auraujo Bonjean, Chambas and Foirry, 1997; Lachaal, 1994; Lin, 1992; McMillan, Whalley and Zhu, 1989; Wiens, 1983); as have institutions (North, 1994). Public investment in forms of human capital: education, extension, training and technology research have also been shown to increase productivity (Antholt, 1994; Beal, 1978; Evenson and McKinsey, 1991; Pray and Evenson, 1991; Pardey, Roseboom and Craig, 1992; Rosegrant and Evenson, 1992).

Nelson (1964 and 1981) recognized that there are important interactions between capital formation, labour allocation, technical progress and productivity. This calls into question whether the growth due to physical capital can be separated from growth attributed to other inputs. Unless a production technology is a fixed Leontief process, there is always some degree of substitutability among categories of inputs. However, since inputs are not perfect substitutes, the lack of adequate investment can slow down production growth. Estimates of the elasticity of substitution in agriculture between hired labour and capital equipment vary from 0.32 in the short run (Brown and Christensen, 1981) to 1.78 percent (Lopez, 1980) in the long run.

Most measures of TFP incorporate inputs and physical capital, leaving human and social capital, technology, institutions, infrastructure and policy to "explain" growth in TFP. Social and human capital are the on-farm human elements that mediate how policy, technology, institutions and infrastructure affect input and physical capital use. Human capital directly affects whether and how technology will be adopted. Technology choice in turn, affects the inputs and physical capital used. That is, technology is embodied in the types of inputs and how they are used. Social capital affects access to physical capital (e.g. land directly or through land titling and loans) and variable inputs (e.g. through credit or cooperatives).

In general, researchers have estimated TFP and then focused on how one or several of these factors might be driving its growth (Antle, 1983; Nehru and Dhareshwar, 1994; Evenson and McKinsey, 1991; Rosegrant and Evenson, 1992). Usually, they have done so using the change in TFP as a dependent variable in a regression with explanatory variables that represent measures of technology, human capital and policy (which are not easily quantifiable or assignable in constructing the production indices). In the following sections, policy is divided between budgetary policies that affect investment in R&D and infrastructure, political and economic policies and political stability.

Human Capital

Human capital directly influences agricultural productivity by affecting the way in which inputs are used and combined by farmers. Improvements in human capital affect acquisition, assimilation and implementation of information and technology. Human capital also affects one's ability to adapt technology to a particular situation or to changing needs.

Schultz's (1963) classic work attributed between 21 to 23 percent of the growth in U.S. income, between 1929 and 1957, to education of the labour force. Contemporaneously, Griliches (1963) focused on minimizing the unexplained portion of growth in U.S. agriculture by adjusting labour for quality, using education. When he included research and extension expenditure as an input to production, he found that virtually all the "unexplained" growth could be explained by economies of scale, R&D and labour quality changes. Romer (1986) and Lucas (1988) provide theoretical grounds for human capital being the driving force behind economic growth.

Jamison and Lau (1982) explored the role of farmer education and extension on farm efficiency. They found that farmer education and extension were not only important to enhancing production on Thai, Korean and Malaysian farms, but that there was an interaction effect between education and extension. In contrast, they found physical capital had an insignificant impact on production and profits. On the other hand, some researchers are finding evidence that returns to education are low, especially for those who stay in agriculture. In their summary of the findings on the determinants of rural poverty for six country studies based on econometrically estimated income equations, Lopez and Valdes (2000) conclude that the return to education in farming is surprisingly small in most cases. An increase in one year in the average level of schooling raises per capita annual income of the family by less than US$ 20 per person in most cases. The main contribution of education in rural areas appears to be to prepare young people to emigrate to urban areas and towns.

Using an econometric approach, Nehru and Dhareshwar (1994) examined sources of TFP growth in 83 industrial and developing countries for the period 1960-1990. They found that human capital formation was three to four times more important than raw labour in explaining output growth. Using human capital as a separate variable, they found that the countries with the fastest growing economies have based their growth on factor accumulation (human capital, labour and physical capital), not growth in efficiency or technology.

Research and Technology Transfer

Research increases the set of available technologies, hence agricultural R&D expenditures are used as a proxy for agricultural technological change. However, the development of technology does not always result in its adoption. In some cases this may be because the technology being developed is not appropriate, that is, it does not meet the needs of agricultural producers. Hence, researchers focus on public expenditure as an explanatory variable in TFP growth. Additionally public research has been shown to lead private research (Chavas and Cox, 1992).

Several caveats arise in focusing on public R&D to explain growth in agricultural TFP. Public R&D expenditures are used as proxy for R&D results, yet there is not an exact correspondence between expenditures and technology. Even when technology is produced, researchers may have different goals than farmers, e.g. yield maximization rather than profit maximization or risk minimization or improvement in commercial crops rather than staple crops. Additionally, when an appropriate technology does result, the process of technology adoption in agriculture is widely recognized as one that occurs over many years in which some adopt quickly and others wait for extension or the results of their neighbours to convince them to adopt.

Bearing this in mind, researchers have found that public investment in developing and extending agricultural technology is justified by the high rates of return to such investment. In a survey of studies on Asia, Pray and Evenson (1991) found rates of return to national research investment from 19 to 218 percent, returns to national extension investment from 15 to 215 percent and returns to international research investment of 68 to 108 percent. A report of the Taskforce on Research Innovations for Productivity and Sustainability indicated that the returns to research, though variable, were always high, from 22 to 191 percent. Using an index number approach to calculate TFP for several crops in India, Rosegrant and Evenson (1992) and Evenson and McKinsey (1991) used econometric analysis to identify sources of growth in TFP. Rosegrant and Evenson (1992) found that public research accounted for 30 percent of growth and extension for about 25 percent, with rates of return for each respectively of 63 percent and 52 percent. Evenson and McKinsey (1991) found that public investment in India in research accounts for over half of growth, while extension contributes about one-third and infrastructure accounted for very little growth. They calculated internal rates of return of 218 percent for public research, 177 percent for public extension and 95 percent for private research expenditures in India.

Block (1994) compares econometric estimates of TFP for Sub-Saharan Africa between 1963 and 1988. He uses three different methods of aggregating agricultural output: official exchange rates, purchasing power parity and wheat units. He finds that one-third of the growth in agricultural TFP in Sub-Saharan Africa is due to research expenditures. In India, Rao and Hanumantha (1994) attribute continued growth in agriculture, despite a sharp decline in physical capital formation, to better utilization of existing infrastructure, fertilizer and high yielding varieties.

While the returns to research are high, the technology is not always adopted. For example, high yield varieties (HYV) of wheat and rice have been introduced on less than one-third of the 423 million hectares planted to cereal grains in the Third World. Specifically, in Asia and the Middle East 36 percent of the grain area was HYV, 22 percent in Latin America and one percent in Africa (Wolf, 1987). This implies there is much potential for increasing agricultural productivity using existing technology. However, the use of HYV requires increased use of fertilizer, but external debt in Latin America and poverty and inadequate water supply in Africa have made fertilizer use and hence HYV unprofitable. Jahnke, Kirschke and Lagemann (n.d.) also attributed low adoption of HYV in Africa to lack of appropriate technology development and few extension services directed to women. Additionally, nontraditional crops have rarely been the focus of improved varieties or technology and potential exists to develop them to increase agricultural production.

Public Investment and Policy

Public policy and budgetary decisions regarding infrastructure also have a profound effect on agricultural production. The financing aspects of public R&D and human capital development were discussed above, but both physical and institutional infrastructure affect the development and transfer of technology. For example, irrigation systems and roads may be required to make a technology profitable to implement. Reforms in pricing policy or the marketing system may be needed to provide incentives.
A serious conflict arises with structural adjustment reforms. Budget cuts in public services often accompany market reforms. While fiscal restraint may be required to stabilize the economy in the short run, cuts in human capital development, public R&D, and infrastructure have a detrimental long-term effect on productivity growth. Policy makers need to choose carefully to mitigate the deleterious impacts of budget cuts on future growth.

Using an econometric approach, Jayne *et al.* (1994) demonstrated the complementarity of public policies and public investments in facilitating the use of new technology. They point to the sharp decline in public investments and growth in Zimbabwe during the 1980s. Pal (1985) underscores the complementarity of public policy towards investment in irrigation technology and private variable input use.

The importance of policy reform is increasingly viewed as fundamental for agricultural productivity gains. Liberalizing markets so prices can send proper signals to producers is the fundamental objective of structural adjustment programs in developing countries and policy reform in economies in transition. Assigning property rights is viewed as a means of promoting development through the efficient and responsible use of resources (North, 1994) and therefore underlies the distribution of capital in economies in transition, land reform and most land policy. Block (1994) discusses the complementarity of economic reform and technical change, but cautions that policy reform offers a one-time effect.

An example of the relation between policy reform and productivity is the implementation of China's "responsibility system" (RS) in 1980-81, which linked productivity to material reward, resulted in increased crop yields "for every major crop" (Wiens, 1983). McMillan, Whalley and Zhu (1989) calculated that in response to the RS and price reforms, output in the Chinese agricultural sector increased by over 61 percent between 1978 and 1984. They attribute 78 percent of the increase to the RS and 22 percent to higher prices for crops. They calculate the RS increased productivity in agriculture by 32 percent. Lin (1992) calculated that 42 to 47 percent of the growth in agricultural output was attributable to the RS during the same period.

In another example, price reforms in Egypt implemented in 1986 resulted in increased wheat and maize yields from 1987 to 1993. Rice production increased by 62 percent, while yields increased by 42 percent (Khedr, Ehrich and Fletcher, 1996). Bevan, Collier and Gunning (1993) contrast the performance of agriculture in Kenya and Tanzania. In Kenya where there was little intervention production of food and cash crops increased by 4.6 and 5.5 percent per annum, respectively. In Tanzania, where policies controlled prices and taxed export crops, agricultural production stagnated until policy reforms were instituted in 1984.

Using an econometric approach to estimate TFP for the United States dairy industry 1972-1992, Lachaal (1994) examined how protectionist policies in the form of direct subsidies to agriculture reduced productivity growth in the United States dairy industry. Lachaal showed that government subsidies encouraged using materials at the expense of feed and raised the cost of production by 1.8 percent for each 10 percent increase in subsidy. The subsidy policy was the source of technical inefficiency, creating biases that distorted factor usage.

Political Stability and Conflict

Another aspect of policy that can influence or hinder agricultural production is the political situation. In a study of the productivity growth of 83 industrial and developing countries between 1960 and 1990, Nehru and Dhareshwar (1994) found that the economies that perform the worst are those involved in wars (particularly civil wars) and those that have the most price distorting policies. They explore a variety of policy variables and find that apart from political stability and the initial endowments of a county, virtually no other policy variable is associated with growth.

The World Food Summit Plan of Action items 2 and 3 (1996b) recognize the role of government in providing an environment conducive to investment, through guarantee of rights and law as well as policies encouraging investment. Corruption is the extreme case where law enforcement breaks down and incentives are lacking. While long-standing institutionalized bribery can be seen as simply an added cost of doing business, pervasive corruption and violence increase risk and result in capital flight, disinvestment and jeopardize assistance.