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Sustainability Through Total Factor Productivity Growth in Agriculture Incorporating Institutional Factors:
A Post-Globalized Indian Scenario

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ABSTRACT

With the increasing population pressure and food insecurity problem in India, and the problem of unsustainable social and economic systems, it was inevitable to shift away the focus of agricultural activities from the traditional system to the modern one. Having followed a series of agricultural policies in India, the role of irrigation and institutional credits cannot be denied upon the growth of output in the sector. There are some studies on the total factor productivity growth (TFPG) in Indian agriculture, but a few studies cover the role of irrigation and bank credit upon agriculture output. The present study computes TFPG out of the institutional roles through public irrigation facilities and commercial bank credit besides traditional inputs in Indian agricultural sector for the post globalized era of 1991-2019. Using the growth accounting approach, the study finds that the institutional factors such as public irrigation facilities and bank finances have contributed significantly to the growth of the agricultural output in India as the values of TFPG have increased over time.

KEYWORDS

agriculture sector, credit, growth, India, irrigation, TFPG, output, sustainability

INTRODUCTION

Agricultural sector in India has experienced major policy shifts from the traditional cultivation practices to modern cultivation practices in respect of all the crops and allied activities. During the early phase of independence, the traditional cultivation practice was not able to feed up the large population size of the country making a major part food insecured. At that time, agriculture sector was dependent upon the vagaries of nature and the facilities of multi-purpose seeds were not available. Mostly the procured seeds by the farmers could not support in growing productivity in the sector. It was thus the scenario that compelled the then Government at the Centre and the associated policy makers, scientists, among the others, to think for drastic policy measures to solve the food insecurity problem

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through making the farming practices less nature dependent as well as one time seed options. It was thus the revolution that happened in the mid 1960's in the name of green revolution made it possible to increase total agricultural production as well as productivity of land through modern agricultural practices where high yielding varieties (HYV) seeds were used, irrigation facilities patronized by the government's initiatives were started, fertilisers, insecticides and pesticides were used, etc. But the productivity could not be increased to the certain height to cater rising population pressure. It was thus necessary to make reforms in the land holdings. The land reform program was started in the early seventies, plots were fragmented to make the intensive use of labour forces, tenancy acts were amended, among others, which further led to increase in the productivity and aggregate quantity of production as a whole. There was a huge revolution in the agriculture sector in India.

But, to have multiple cropping in a given year and to facilitate purchasing capacity of different modern agricultural inputs in the short run as well as long runs there were scarcity of funding. The commercial banks were nationalized in 1969 and 1980 to provide credits to agriculture and allied sectors as priority basis so that the dependence of the farmers upon the village money lenders would be minimised and surplus in the production process could be maximized. In the post liberalized phase, there has been further growth in the sector supported by importing advanced capital goods, foreign capital inflow through foreign direct investment (FDI) channels and opening of new export channels have made the sector to prosper more. The role of different institutional supports through public institutional interventions in the huge growth performance of the sector cannot thus be ignored. As per the data of the Central Statistical Organization (CSO) and the Reserve Bank of India (RBI) the total GDP accountable to the agriculture sector in 1950-51 was around Rs. 5118 crore which reached Rs. 131108 crore in 1991-92 and jumped to Rs. 3087623 crore in 2019-20. The increase was about 24.6 times in the pre-reform phase of forty years and 22.5 times growth in the post-reform phase of thirty years. It is thus evident that the traditional means of agricultural practices could not be able to generate such gigantic growth rates of the agriculture sector in the country; major policy shifts through institutional interventions was the key to the success.

It is now a pertinent issue to discuss how much of the huge growth of the sector is achieved due to the growth in the total factor productivity (TFPG). There has been some good number of studies in this regard available in the literature. The notables among them are Dholakia and Dholakia (1993), Desai and Namboodiri (1997), Mahadevan (2003), Sivasubramonian (2004), Das (2016). The studies analyzed the contribution of the TFPG upon the growth of the agriculture sector in India for the period covering the post-independence phase to a little extent of post liberalization phase. The TFP growth in agriculture results predominantly from public investment in infrastructure facilities like irrigation, electricity, roads, etc. and in agricultural research and extension, education, and human resource development during the pre-liberalization phase. Further the studies show relatively low TFPG in the early phase of liberalization. On the other hand, Desai (2016) estimated TFPG in Indian agriculture and allied sectors for different types of lands for 1981-2008, covering a wider part of the reform phase, and has shown that TFPG for this period ranged between 1% during 1981-1990 to about 1.7% during 2000-2008 which means TFPG was higher during the post reform period than during the pre-reform period. But the studies did not cover contributions of the traditional inputs, land, labour and physical capital, with the institutional factors such as public funded irrigation projects and commercial bank credits for the long arena of post liberalization. As the policy of liberalization allowed the agricultural sector to prosper by means of export opportunities, greater foreign capital inflow, easing industrial protection leading to more agriculture-industry linkages, among others, it is thus required to estimate the contribution of TFPG in the Indian agriculture during the post liberalization phase accommodating wider institutional factors. The present study attempts to take up this exercise.

Review of Existing Studies

In order to find the gaps in the literature and to frame its own objectives the study tries to make a systematic literature review in line with some of the special articles on review works in different

topics such as of Centobelli et al (2017), Minhas and Sindakis (2021), Wu et al (2022). At first the study frames methodology in literature review, and, then it presents the series of related works.

Though the present study is not a pure review work on the related field, the present study covers the list of studies which will be helpful in its building. It follows five steps covering five different dimensions of the related works. Step 1 covers up the studies on TFPG in agriculture sector for some of the global perspectives; Step 2 on TFPG in Indian agriculture; Step 3 on the issues of sustainability in agriculture in relation to the TFPG across land types, emission of pollutants and agricultural output; Step 4 and Step 5 on the special attention of the present study covering the impact of irrigation and agricultural credit to TFPG and growth of agricultural output. The coverages of the studies under different steps are now discussed below.

Step 1: TFPG in Agriculture-some global perspectives

In their pioneering work, Coelli and Prasada Rao (2005) did an extensive attempt on measuring the growth in agricultural productivity in 93 countries for the period 1980-2000 using data envelopment analysis and found an annual growth of TFPG in the sector by 2.1 per cent. China was the leading country with an average growth of 6 per cent, while USA was with 2.6 per cent. India went well behind China, USA, Cambodia, Nigeria etc. with a mere 1.4 per cent growth in the study period. The study further recorded that Asia was the leading zone and Africa being the worst zone. Finally, the study revealed that the countries from the lower technical efficiency had come with very high growths and making convergence to the world's highly growing agricultural sector. In a sample of 73 countries for the period 2001-2010, Villoria (2019) has shown that the huge growth in agricultural output in the last thirty years has come from the increases in the efficiency with which both land and non-land inputs are used. The outputs were mainly technology driven which also led to the expansions in the land uses. In a study specific to China, Sheng et al (2019) show that the agricultural TFP of the country has grown at a rate of around 2.4 per cent a year before 2009, which is comparable to the main OECD countries and is double the world average. It further shows that TFP growth accounts for approximately 40 per cent of the country's output growth which suggests that input growth has been the main driver of output growth in the past. The working paper by OECD (2022) observes that TFP has been the main driver of agricultural production growth in most OECD countries over the last decades. It remains a long-term determinant of production, prices, farm incomes, and countries' competitiveness on markets and, overall, of the ability to feed a population with a finished set of inputs.

Step 2: TFPG in Indian Agriculture

The present study reviews the relevant studies in the TFPG growth in Indian agriculture in the following. First, it presents some relevant studies which reveal the declining trends in TFPG in agricultural growth in India and then it reviews studies which reveal the increasing trends in the TFPG. The first list actually covers the period of pre reform and early phase of reform, and the second list covers the period of intensive reform. The role of technology in Indian agriculture has been well anticipated by the studies of Vaidyanathan (1994), Ahluwalia (1996), among others, in removing non price and institutional constraints in the sector. As part of the New Economic Policy, Ahluwalia (1996) identified technology as one of the most important issues, although it played a crucial role in alleviating India's poverty trap in the seventies, its contribution to agricultural growth has not been impressive.

There are various empirical studies showing that the TFPG in Indian agriculture has declined over the years. The important one is of Dholakia and Dholakia (1993) who have observed that the contribution of TFPG to agricultural output growth has declined during 1980-89. But the TFPG had increased at the rate of 1.77 per cent annually during 1967-68 to 1977-78 as against 1.73 per cent during 1978-79 to 1988-89. In another estimation by Fan, Hazell and Thort (1999), the TFPG in

Indian agriculture was at the rate of 1.39 per cent annually during 1970-71 to 1980-81, as against 1.36 per cent for the period 1981-82 to 1990-91. But there was a very high TFPG of 2.67 per cent in the early years of economic reforms. In the exercise for TFPG across Indian states Kalirajan and Shand (1997) show that TFP growth in the pre-reform period was negative in four out of 15 selected states and that, by the end of the decade, it was small for those states where the contribution of TFP growth was positive. And in general, the contribution of technology vis-a-vis output growth declined considerably, especially from 1988 to 1990. Kalirajan et al (2001) discussed in detail the agricultural growth performances and policy issues in India. As general outcome of the effort, the project derived that the agricultural sector's output growth decreased to 2.9 per cent during 1992-1993 to 1998-1999. The two important reasons for the slowdown are the deficiency in developing new high-yielding varieties during the 1990s and a declining environmental quality of land which declined the productivity of the modern inputs.

In an effort, through empirical exercise the study of Sivasubramonian (2004) has shown that the trend growth rate of TFPG in Indian agriculture has declined to 0.88 percent during 1960-61 to 1970-71 and further declined to –0.35 percent during 1970-71 to 1980-81, and during 1980-81 to 1990-91, the growth rate of the TFPG increased to 1.89 percent followed by a declining trend in the phase of 1990-91 to 1999-2000. In the study of estimating TFPG for the crop sector in Indian agriculture Jain, Chand and Singh (2017) observe that the annual growth of total factor productivity in the recovery phase of agriculture, i.e., during 2004-05 to 2011-12 is as high as 5.41.

Step 3: Sustainability of TFPG in Agriculture

Computing the TFPG across different land types in India for the period 1981-2008 Das (2016) shows that the TFPG was around 1 per cent during the pre-reform period and for the post reform period up to 2008 the average TFPG was 1.7 per cent. The study further established that the crops covered under irrigation facilities have more productivity. Also, that the environmental quality of the land has been the key factor to the declining productivity of land. In this connection, the study of Das and Mukherjee (2020) reveal that there is long run association between methane emission, a greenhouse gas responsible mainly for agricultural malpractices, and agricultural output in the OECD, low- and middle-income countries in the world for the period 1981-2012. Also, in short run, the study finds that methane emissions make a cause to agriculture output for OECD and low-income countries. The result clearly indicates the unsustainable agricultural practices at the global level. In continuation of the study, Jiang et al (2020) did forecasting of methane emission and agricultural output and find that, except the OECD group, all the remaining groups display increasing trends of methane emission, but unquestionably, all the groups display increasing trends of agricultural output, where middle- and upper middle-income groups hold the upper berths. The forecast emission is justified to be sustainable in major groups under both methods of estimations since overall growth of agricultural output is greater than that of methane emission. OECD report (2022) well accepts the importance of the TFP in explaining the huge growth of the agricultural sector in the world' highly developed economies, but the report also alerts that, in the future, technological change, and more generally TFP growth, will be critical to adjust to global changes and to shift to a more environmentally friendly agriculture without socially unacceptable transition costs. Hence, the policies should be targeted to reduce levels of pollutions related to agricultural practices to increase TFP in the sector in order to attain the sustainability in the growth of the sector. Study by Villoria (2019) on the sustainability of the TFP increase in agriculture observes that TFP increase has led to unsustainable land use patterns in the relatively developed zones in the world. The study thus makes the projections of the land needing to satisfy projected growth in TFP per capita during 2018–2023 that the current rates of TFP growth are insufficient to prevent further land expansion, reversing in most cases the in-sample trends in land contraction observed during 2001–2010.

Step 4: Irrigation and TFPG in agricultural output in India

In a report by Bhattarai and Narayanamoorthy (2003) showed that irrigation facilities in India have helped in TFPG and growth of agriculture output in India. Further there has been the negative correlation between rising irrigation facilities and reducing poverty levels in the country. In another study, Jin et al (2012) investigate the impact of irrigation on crop productivity, land prices and cropping intensities in India and show that irrigation has a strong and significant impact on all these outcomes with the dominant effects on cropping intensities. The results provide support for continuing investments to improve access and quality of irrigation in India. For the impact of drip irrigation on crop production, yield rates and cost of production in Southern India, Kumar and Palanisami (2010) have found that drip irrigation and micro irrigation have a significant impact on resources saving, cost of cultivation, yield of crops and farm profitability. In an NITI Ayog's report on Doubling Indian Farmers' Incomes by 2022 in order to maintain sustainable livelihoods, Chand (2017) recommended for prolonged strategies on developmental initiatives, technology and policy reforms in the agriculture sector. There are the technological sides like the improvements in the quality of seeds, quantities of fertilizers, irrigation, power supply etc. which will be required for growth in the agriculture sector of the country. On a study on cotton production in Rajasthan state in India, Verma et al (2021) have shown that fertilizer, human labour and irrigation water are positively and significantly affecting the cotton production and TFG in the sector. In another study, Verma, Singh and Jitendra (2021) did the similar work of different cereals in Rajasthan and found the significant contribution of TFPG upon the productions of the selected cereals. In an extensive report on the trends and progress of agricultural sector in India since independence Pathak et al (2022) have shown the huge growth of the sector in the 75 years of independence and the important factor among all is the technological advancements, although there are still some bottlenecks so far as reaching the sustainable development goal is concerned. Keeping in mind that the irrigation facilities play an important role in improving smallholder agricultural production and/or productivity, household food security and rural poverty reduction in the developing countries the study by Jana and Sinyolo (2022) assess the impact of irrigation access on household welfare in the saline zone in West Bengal, India, and the results indicate that irrigation access has a significant positive impact on improving household welfare in the zone.

Step 5: Agricultural credit and TFPG in agricultural output in India

Das, Senapati and John (2009) in an occasional paper have shown that the direct agriculture credit amount has a positive and statistically significant impact on agriculture output. These results reveal that even though there are several gaps in the present institutional credit delivery system in India, agriculture credit is still playing a critical role in supporting agriculture production in the country. In another study, Narayanan (2015) examines the relationship between formal agricultural credit and agricultural GDP in India using state level panel data for 1995-96 to 2011-12 and found that the input use is sensitive to credit flow, whereas GDP of agriculture is not. Credit appears to be an enabling input, but one whose effectiveness is undermined by low technical efficiency and productivity. The study by Khan, Fatima and Jamshed (2017) shows that agriculture gross domestic product is highly responsive to an increase in agricultural credit; a unidirectional causality is observed from Agricultural credit to agricultural output in India.

RESEARCH PHILOSOPHY AND DESIGN OF THE WORK

The extracts of the studies show that irrigation facilities and institutional credit facilities have positive impacts upon growth and productivity in the Indian agriculture sector. However, there has been no such studies available in the literature which emphasise upon the impact of institutions such as public irrigation facilities and institutional (bank) credit upon the total factor productivity growth in Indian

agriculture for an extended period of globalization in India. Once these two factors are combined with the other traditional inputs used in agricultural production, the scope of further technological progress arises which leads to the growth in the sector. The present study has tried to fill the vacuum in the literature by considering the objective of computing TFPG out of the institutional factors through public irrigation facilities and commercial bank credit in the presence of the traditional inputs in Indian agricultural sector for the post globalized era of 1991-2019 using the growth account approach (GAA).

METHODOLOGY

To reach the ultimate outcome of the research, the study is designed as-first, theoretical framework on the measurement of TFP, second, data and empirical methodology, third, results, fourth discussion, fifth, focussing socio-economic sustainability, and finally conclusions with policy recommendations.

THEORETICAL FRAMEWORKS OF MEASUREMENT OF FACTOR PRODUCTIVITY GROWTH

There are three leading approaches for estimating the TFPG available in the microeconomics and macroeconomics literature. They are the Production Function Approach, Growth Accounting Approach as traditional methods and the most recent one being the Non-parametric Approach or the Data Envelopment Approach.

In the Production Function Approach, TFPG indicates technical progress, which represents shift in the production function or the cost function over time. However, since the outward shift in the production function is equivalent to the downward shift in the cost function (as the duality theory suggest), another way to estimate the TFP growth is in terms of the difference between the changes in total cost and the weighted changes in total input prices. Thus, the TFPG measure from the production function is equal and opposite in sign to the TFPG measure from the cost function. However, different economists pointed out that there are various problems associated with the production function approach like multicollinearity, autocorrelation, and degree of freedom (Saikia, 2009).

Solow (1957) was the first to propose a growth accounting approach (GAA) where TFP is measured as a residual factor, which attributes to that part of growth in the output that is not accounted for by the growth in the basic factor inputs. This approach approximates the technological change mainly by the rate of change of total factor productivity indices. The TFP index is measured as the ratio of the index of net output and the index of total factor inputs. The index of total factor inputs is derived as weighted average of indices of three primary inputs relevant to the agriculture type of activities, labour, capital and land with relative income shares of the three factors as respective weights. It is a pertinent issue regarding the availabilities of the data on factor shares in the agriculture sector, whereas these data are readily available for the industries. The key feature of the GAA is separation of change in production on account of changes in the quantities of factors of production from residual influences, which include technological progress, learning by doing, etc.

The Nonparametric Approach, developed by Chavas and Cox (1988, 1990), identifies a group of implied linear inequalities that a profit-maximizing (or cost minimizing) firm must satisfy and estimates the rate of technological change using linear programming. Data Envelopment Analysis (DEA) falls under this category.

All the three approaches have their respective merits and demerits. However, in the growth literature, the GAA is the most popular one in the empirical aspect because of its easy computability.

Let us discuss the theoretical framework of the growth accounting approach in detail where labour augmented technological progress is considered.

Suppose the production function is of the form having two basic inputs, labour (L) and capital (K), having a time dimension in it, is-

$$Y(t) = [K(t)]^{\alpha}. [A(t).L(t)]^{\beta} \quad (1)$$

Where Y(t) is the total production in an economy in some year, *t*.

K(t) is capital in the economy in some year, *t*

L(t) is labour which is simply the number of people in work which is further assumed as a constant fraction of an growing population force in the economy, in some year, *t*.

A(t) represents multifactor productivity which is often generalized as technology in some year, *t*. The main intention is to calculate the contribution of A(t) by the residual method as proposed by Solow.

α and β are the respective output elasticities of the factors.

To get the changes of all the variables (dependent and independent) over time we take derivatives in both sides of the production function with respect to time and the transformed relation is as follows-

$$\partial Y/\partial t = (\partial Y/\partial K).(\partial K/\partial t) + (\partial Y/\partial L).(\partial L/\partial t) + (\partial Y/\partial A).(\partial A/\partial t) \quad (2)$$

Here all the first terms in the right hand side expressions are the marginal productivities of K, L and A respectively. Let us calculate their expressions and replace in the above expression-

$$\partial Y/\partial K = \alpha[K(t)]^{\alpha-1}. [A(t).L(t)]^{\beta} = \alpha[K(t)]^{\alpha}. [A(t).L(t)]^{\beta}/K(t) = \alpha Y(t)/K(t) \quad (3)$$

Similarly, for labour,

$$\partial Y/\partial L = \beta[K(t)]^{\alpha}. [A(t).L(t)]^{\beta-1} = \beta[K(t)]^{\alpha}. [A(t).L(t)]^{\beta}/L(t) = \beta Y(t)/L(t) \quad (4)$$

And

$$\partial Y/\partial A = \beta[K(t)]^{\alpha}. [A(t).L(t)]^{\beta-1} = \beta [K(t)]^{\alpha}. [A(t).L(t)]^{\beta}/A(t) = \beta Y(t)/A(t) \quad (5)$$

Hence,

$$\partial Y/\partial t = \alpha.Y(t)/K(t).(\partial K/\partial t) + \beta.Y(t)/L(t).(\partial L/\partial t) + \beta.Y(t)/A(t).(\partial A/\partial t) \quad (6)$$

Since growth factor of any variable is a proportional changes of the variable with respect to the last period (as base values), hence, the above expression can be transformed to the following by dividing both sides by Y-

$$[\partial Y/\partial t]/Y = \alpha. [Y(t)/K(t).(\partial K/\partial t)]/Y(t) + \beta. [Y(t)/L(t).(\partial L/\partial t)]/Y(t) + \beta. [Y(t)/A(t).(\partial A/\partial t)]/Y(t)$$

$$\text{Or, } [\partial Y/\partial t]/Y(t) = \alpha. (\partial K/\partial t)/K(t) + \beta. (\partial L/\partial t)/L(t) + \beta. (\partial A/\partial t)/A(t) \quad (7)$$

The expression shows the decomposition of the total output growth among three components. The first two are the contributions of capital and labour and the third one is the effect of technological progress. The contribution of the third factor gives rise to the concept of total factor productivity growth which is the residual of total output growth and the growth of the two inputs, K and L. In the terminology as used in the growth literature it is known as the Solow Residual. Hence, the TFPG is thus-

$$TFPG = \beta. (\partial A/\partial t)/A(t) - \{\alpha. (\partial K/\partial t)/K(t) + \beta. (\partial L/\partial t)/L(t)\} \quad (8)$$

$$\text{Or. } TFPG = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \frac{\dot{K}}{K} - \frac{\dot{L}}{L} \tag{9}$$

The residual is that part of the output growth not explainable by the measurable changes in the amount of capital and the number of workers in the activity.

Now suppose that the production function (1) stands for the agriculture sector with three essential inputs, land (T), labour (L), and capital (K), and two institutional factors, public irrigation projects (R) and bank credit (C). The production function then can be rewritten as-

$$Y = A^{(1-\alpha-\beta-\gamma-\delta-\theta)} K^{\alpha} L^{\beta} T^{\gamma} R^{\delta} C^{\theta} \tag{10}$$

Here, the powers of each of the factors represent their corresponding output elasticities. The TFPG for three inputs will be calculated by the following expression-

$$TFPG(3) = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \frac{\dot{K}}{K} - \frac{\dot{L}}{L} - \frac{\dot{T}}{T} \tag{11}$$

If there are four factors, the additional factor being the irrigation facilities (R) as one of the institutional facilities, then the TFPG for four inputs will be calculated by the following expression-

$$TFPG(4) = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \frac{\dot{K}}{K} - \frac{\dot{L}}{L} - \frac{\dot{T}}{T} - \frac{\dot{R}}{R} \tag{12}$$

Again, adding the fifth factor, or second institutional factor, bank credit (C)as another institutional facility, the TFPG will be calculated as-

$$TFPG(5) = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \frac{\dot{K}}{K} - \frac{\dot{L}}{L} - \frac{\dot{T}}{T} - \frac{\dot{R}}{R} - \frac{\dot{C}}{C} \tag{13}$$

As additional inputs to the production activity explains a part of the variation in the total output growth of the sector, the values of the residuals will be going down with the number of inputs added to the system. Hence, TFPG (5) < TFPG (4) < TFPG (3) < TFPG (2).

The present study under the aim of estimating the productivity contributions of the institutional factors, R and C, in Indian agricultural sector will estimate equation (11, 12 and 13).

DATA AND EMPIRICAL METHODOLOGY

It is a pertinent issue regarding the availabilities of the data on factor shares in the agriculture sector, whereas these data are readily available for the industries in order to compute the TFPG. In that situation, the respective factor shares can be proxied by the output elasticities of the three factors as Solow pointed out that the working of the competitive market conditions would allow the factor prices to be equated to their respective marginal productivities. The present study follows the elasticity approximations in place of the factor shares in computing the trends of the TFPG through institutional

factors in the agriculture sector in India for the post reform phase, 1990-91 to 2019-20. Data on agricultural GDP is taken from the Reserve Bank of India (RBI) and Central Statistical Organization (CSO) of India. Data on total land used (in crore hectres) are taken from the database of the RBI. Total agricultural employment (L) is calculated from the International Labour Organization (ILO) data on percentage of total population in the age range of 15-64 years engaged in agricultural activities. The data on capital used in agriculture is computed from the data on the gross fixed capital formation (GFCF in Rs. crore) in the sector from the Ministry of Statistics and Programme Implementation (MOSPI) of the Government of India. The data on Public Irrigation (Rs. Crore) is obtained from the Hand Book of Statistics on State Government Finances of RBI and www.ceicdata.com . Finally, data on commercial bank credit (in Rs. Crore), used as the proxy of all credit due to the easy availability of the data, is taken from the Basic Statistical Returns of RBI.

To compute TFPG, at first, output elasticities of all the five factors are calculated year wise using the formulae given as follows-

$\alpha = (\partial Y/\partial K).(K/L)$ for capital
$\beta = (\partial Y/\partial K).(K/L)$ for labour
$\gamma = (\partial Y/\partial K).(K/L)$ for land
$\delta = (\partial Y/\partial K).(K/L)$ for irrigation
$\theta = (\partial Y/\partial K).(K/L)$ for credit

Then the average values of the elasticities can be estimated using the OLS regression technique. To calculate the contribution of three factors, K, L and T, the last two factors are omitted and the values of the elasticities are estimated by the following model-

$$\text{Model I: } \log Y = \mu + \alpha \log K + \beta \log L + \gamma \log T + \omega \quad (14)$$

where ω is the random disturbance term in the three-factor model.

To calculate the contributions of fourth factor (R) we omit the credit factorand the values of the elasticities are estimated by the following model-

$$\text{Model II: } \log Y = \mu + \alpha \log K + \beta \log L + \gamma \log T + \delta \log R + \xi \quad (15)$$

where ξ is the random disturbance term in the four-factor model.

$$\text{Model III: } \log Y = \mu + \alpha \log K + \beta \log L + \gamma \log T + \delta \log R + \theta \log C + \varepsilon \quad (16)$$

where ε is the random disturbance term in the five-factor model.

After getting the estimated values of all the elasticity, the formulae for TFPG are used to get the contributions of the factors in the total growth of agricultural output in India.

RESULTS

Let us present the descriptive statistics in terms of the average values of the five factors of agricultural production, land, labour and capital (as non-institutional factors) and irrigation spending and commercial bank credit (as institutional factors). The average land under agricultural production is around 19-20 lac hectres in all the three sub-periods (upper part of Table 1). The average amount of labour used is 19.5 crore in 1991-2000, it increases to 21.4 crore in 2001-2010 but it decreases to 18.9 crore in the 2011-2019. The average value of capital use increased over the three sub-periods. Starting from the average value of Rs. 30220 crore in 1991-2000, it jumped to Rs. 293821 crore in

2011-2019. The contribution of irrigation factor and bank credit have also increased over the periods making a foot print on increasing institutional interventions in the agricultural sector.

On the output side, the total value of agricultural income (or the contribution of the agriculture sector in total GDP) in the country has also increased over the periods. It can thus be derived that the agricultural GDP is associated with the non-institutional and institutional factors of the sector. But how much they have contributing potentials to the total quantity of output can be examined by the values of the output elasticity of all the five factors of production. Lower part of Table 1 explains this.

It is observed that the output elasticity of land has gone up from the first phase to the second one and thereafter goes down in the third phase. But, for all the four remaining inputs, the values of the output elasticity have gone down in the second phase. The downward trend of elasticity is maintained for labour and capital in the third phase, but that for irrigation and bank credit, the average elasticity has gone up in the same phase. We thus obtain a mixed result in terms of the output elasticity for all the selected factors.

TFPG Measurements Through the GAA

It is clear from the values of the output elasticity of all the five inputs that the impacts of two institutional factors, public irrigational facilities and bank credit facilities, upon the quantity of agricultural output are positive and increasing. This result influences us to go for estimating the TFPG in the Indian agricultural system by incorporating these two institutional factors besides the three primary inputs of production, T, L and K. Using Model I, II and III following equation 14, 15 & 16 and TFPG equations, 11, 12 & 13, the TFPG for three, four and five inputs are computed and their average values are calculated for each of the four periods. The trends of the TFPG for all the three sets of inputs and the growth rate of agricultural output are presented in Figure 1 for the entire period and the results of mean TFPG are given in Table 2.

It is observed from the figure that the trend of the growth rate of agricultural output and the trends of TFPG for all the three sets of inputs are declining in the first phase after liberalization, they then started rising in the middle decade but take downward trends again in the last phase of the study period. Further it is observed that the trend of TFPG for three inputs (T, L & K) is greater than that of for four inputs (T, L, K & R) which is again greater than that under five inputs (T, L, K, R & C).

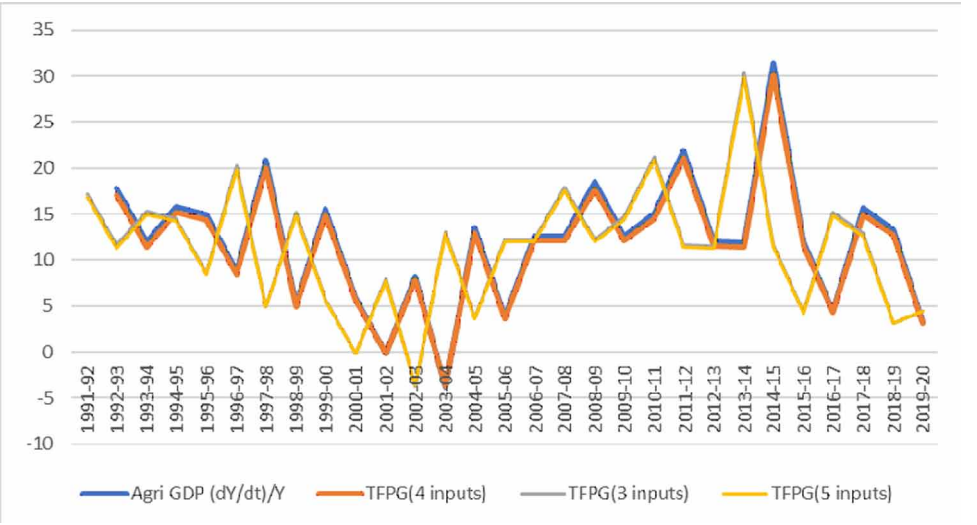
Now come to the discussion on the phase-wise average values of TFPG across different sets of inputs referring to Table 2.

Table 1.
Average values of the variables of their bases and output elasticity of the factors

	Base Values					
	Land	Labour	Capital	Irrigation	Bank Credit	Agri GDP
Mean Base Values(1991-2000)	0.19	19.47	30220.6	6775.00	29092	277454
Mean Base Values(2001-2010)	0.19	21.40	65915.3	28846.60	169565	648593
Mean Base Values(2011-2019)	0.20	18.92	293821	65431.67	784553.6	2248915
Mean Base Values(1991-2019)	0.19	19.96	124336	32589.69	311984.5	1017266
	Values of Different Output Elasticity					
Mean Elasticity(1991-2000)	8.96	7.26	1.96	1.68	1.30	-
Mean Elasticity(2001-2010)	20.62	-3.95	0.73	-0.20	-0.09	-
Mean Elasticity(2011-2019)	1.11	-28.26	-23.46	2.13	0.75	-
Mean Elasticity(1991-2019)	9.94	-7.53	-6.41	1.23	0.98	-

Source: Author's own calculations

Figure 1.
Trends of TFPG for all sets of inputs and growth rate of agricultural output Source: Computed and drawn by the author



It is observed that the average TFPG under three factors, T, L & K, has decreased from 11.31 per cent in the first phase to 11.16 per cent in the second phase, but it increased to 11.70 per cent in the third phase. In overall, the average TFPG under the three primary factors is 11.38 per cent which means about 11.38 per cent of the total growth of agricultural output is explained by the technological changes. But the trends of the average TFPG shares are rising when we incorporate the two institutional factors (R & C) one by one. The average TFPG with four factors including the public irrigation facilities has increased from 10.54 in the first phase to 11.05 in the second phase and then to 11.58 in the third phase. On the other hand, the average TFPG with five factors including the public irrigation and bank credit facilities has increased from 10.43 in the first phase to 10.93 in the second phase and then to 11.46 in the third phase.

Now focus on the average changes in the TFPGs from three factors to four factors, four factors to five factors and finally, from three to five factors. Results in Table 2 show that there is 0.77 per cent reduction in the average TFPG in the first phase when irrigation as the fourth factor is introduced.

Table 2.
Average values of TFPG in different factor combinations

	TFPG in 3 factors (T, L, K)	TFPG in 4 factors (T, L, K, R)	TFPG in 5 factors (T, L, K, R, C)	Mean TFPG Change from 3 to 4 factors	Mean TFPG Change from 4 to 5 factors	Mean TFPG Change from 3 to 5 factors
Mean TFPG Values(1991-2000)	11.31	10.54	10.43	-0.77	-0.11	-0.77
Mean TFPG Values(2001-2010)	11.16	11.05	10.93	-0.12	-0.12	-0.11
Mean TFPG Values(2011-2019)	11.70	11.58	11.46	-0.12	-0.12	-0.12
Mean TFPG Values(1991-2019)	11.38	11.26	11.15	-0.12	-0.12	-0.12

Source: Author's own calculations

This means, the contribution of irrigation facilities is 0.77 per cent in the growth of the agricultural output in the first phase. But in the next two phases, the average fall in the TFPG is 0.12 per cent which further means irrigation facilities have contributed about 0.12 per cent in the average growth of the agricultural output. After adding the fifth factor, the bank credit, the average contribution of the factor is about 0.11 per cent in the first phase, it increased to 0.12 per cent in the next two phases. The changes of the average TFPG from three to five factors remain more or less same like the results from the three factors to four factors.

DISCUSSION

In order to compute the TFPG out of the two institutional factors, public irrigation and bank credit, besides the non-institutional factors, the study has derived the values of different output elasticities with respect to the factors in three different phases. It finds that the output elasticity of irrigation and bank credit on the average elasticity is positive in the entire phase, getting a little bit negative in the second phase, they have gone up in the third phase. The recovery phase in the agriculture sector has happened in the third phase making large investments in the irrigation projects and increasing banking facilities which ultimately helped in the increase in TFP.

The trends of TFPG are rising in the first phase of the 21st Century. As the number of inputs are added the magnitudes of TFPG goes down. This is a common phenomenon as evidenced in the Solow (1957) growth model that as an economy goes for increasing the number of inputs, the explanatory powers of the inputs in the final phases will be going down. In other words, the magnitudes of the residuals capturing the TFPG will be going down. The decline in the initial phase of liberalization may be due to adjustment failure with the international market. One of the important causes of sharp increase in the TFPG and growth of output in the sector in the middle phase is the high rate of increase in the terms of trade of the agricultural products (Chand, 2019). Further, the decline in the final phase may be due to the recessionary situation in the global market including India.

To make comparisons of the TFPG among different input combinations the study has computed the average values of TFPG in different phases across the input combinations. It is obtained that the average TFPG for the non-institutional factors (T, L & K) has gone down from Phase I to Phase II but increased a little bit in Phase III. But, incorporations of the two institutional factors (R & C) produce positive results in all the three phases. The average TFPG with four factors including the public irrigation facilities has increased from 10.54 in the first phase to 11.05 in the second phase (an increase of 4.8%) and then to 11.58 in the third phase (an increase of 4.8%). Comparing the changes from Phase I to III, the increase in the average TFPG due to irrigation is 9.87 per cent. After adding bank credit with irrigation, the average TFPG has increased from 10.43 in the first phase to 10.93 in the second phase (an increase of 4.8%) and then to 11.46 in the third phase (an increase of 4.84%). Further, from Phase I to III, the average increase in TFPG is 9.9 per cent. This phenomenon justifies the significant impact of the institutional factors in increasing the growth of the agricultural output in India. The period of 2011-2019 has been the phase of very high contributions of the institutional factors in the Indian agricultural sector so far as the public irrigation facilities and formal financial facilities as the component of institutional factor is concerned.

Though there are certain studies on the impact of irrigation and credit facilities to agriculture sector in India, as mentioned, no study has gone through the computations of the TFPG in the sector using up to date data. Therefore, the results that the present study has derived go partially in accordance with results obtained by the studies such as Bhattarai and Narayanamoorthy (2003), Kumar and Palanisami (2010), Jin et al (2012), Verma et al (2021), Das, Senapati and John (2009), Narayanan (2015), Khan, Fatima and Jamshed (2017). Further extension of the study can be made by using the latest data of the years 2020 and 2021.

Achieving Socio-Economic Sustainability

Socio-economic sustainability largely depends upon, among others, the growth of agricultural sector especially when we talk about a developing country like India. Due to lack of sufficient agricultural growth of output and its utilization a vast area of the population are under nourished and under poverty line. Hence, increasing agricultural productivity has been the principal objective of the policy makers. As a result, there is rising income and wealth inequality in the society which forbids the attainment of sustainable development goals in these regards. As having scarcity of resources, the use of some institutional factors such as public irrigation, institutional credits etc. may work as the panacea of increasing productivity growth in the sector.

It is inferred from the above analysis that the institutional factors such as public irrigation facilities and bank finances have contributed significantly to the growth of the agricultural output in India. And the high impacts of these factors are in the phase of 2011-2019. The governments of the country and its provinces may thus put emphasis upon more irrigation projects and easy bank credits to the agriculture sector to enable its further growth. It will not only make the sector healthy in terms of growth but also be helping in achieving the goal of sustainable development in the country.

CONCLUSION AND POLICY RECOMMENDATIONS

The conclusion section of the study consists of three sub sections capturing theoretical implications, managerial implications and ideas for future research. These are all discussed below.

Theoretical Implications

Importance of institutional factors to the growth of agricultural output in the modern world cannot be denied. Public irrigation facilities and bank credit in the agricultural sector in any country like India are the important contributors to the growth in agriculture so far as modern agricultural practices are concerned. These two factors become the key to the technological upgradations in the agricultural sector. The Government of India as well as the state governments emphasise upon the allocations of these two inputs for the advancements in the productivity in the agricultural sector.

Managerial Implications

The available studies related to any developing countries like India is scarce in the existing literature. The present study has attempted to examine how much the institutional factors such as public irrigation facilities and bank finances do have any impact on the growth of agriculture output in India. It computed the TFPG using the growth accounting approach and finds that the institutional factors such as public irrigation facilities and bank finances have contributed significantly to the growth of the agricultural output in India as the values of TFPG have increased over time and the magnitudes of TFPG have gone down as the residual values from the total growth figures using fourth and fifth factors as the different components of institutional factors are considered.

Policy Recommendations

Since the two institutional factors have positive impacts upon the growth of agricultural output in India, the central and state governments of the country should focus more upon public irrigation projects and providing more bank credit with concessional interest rates. But to invest more on irrigation sector the governments require funds which is also insufficient in the post Covid era. Thus, an alternative policy instrument may be the public private partnerships in the new irrigation projects which will not only make the agriculture sector healthy in terms of productivity growth but also be plateful in achieving the goal of sustainable development in the country.

Ideas for the Future Research

Though the study has drawn an important conclusion on the relevance of the irrigation and banking as the institutional facilities in the growth of the Indian agricultural sector, it is not taken for granted that the similar results will be applicable to all of its states, union territories and regions. The present study can thus be extended to the state levels to get a general conclusion on the positive impacts of the institutional facilities upon the productivity growth in their agricultural sectors.

Disclosure Statements

The author discloses that the research work is original and there is no conflict of interest in carrying out this work. Further, the author did not have any funding source behind the completion of the work.

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