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Performance of Productivity of Rice and Wheat Crops in India: A Malmquist Total Factor Productivity Analysis

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ABSTRACT

Measurement of productivity growth is very essential to take appropriate policy decisions for the development of the agriculture sector. The present study measures total factor productivity growth of paddy and wheat in major producing states of India by using Malmquist Index approach of post reform Period-I & II using output and input data of paddy and wheat crops. The compound growth rate as well as trend analysis indicated that the area, production and productivity of rice and wheat crop had continuously increased over the time but at a very steady rate. The productivity analysis revealed that the TFP change had been positive for both paddy and wheat in the overall study period for major producing states of India. From period 1994 to 2016, the mean TFP change has been to the tune of 2.3 per cent for paddy and 4.2 per cent for wheat. The analysis has clearly indicated that it was technical change which contributed to TFP rather than efficiency change. The recent yield stagnation in paddy and wheat are not due to technology fatigue, but could be due to the improper use of inputs or due to less investment in research and extension on varietal improvement in these crops to enhance productivity in less productive states of India. The study calls for policy initiatives for strengthening investments on research and extension for promoting the TFP growth and steps for sustainable input intensification.

Key words: Efficiency change, Productivity index, Paddy, Technical change, Total factor productivity, Wheat

Agriculture is the way of life in developing economies like India. Presently agriculture sector employs more than 60 per cent of the population. In Indian agriculture sector, rice and wheat are two main pillars for the food security in India. These two crops, together account for over 60 per cent of the area and over 78 per cent of the production of food grains in the country (GoI 2016). The combined share of these two commodities reported over 90 per cent of total quantity consumption of cereals in rural India (CSO 2016). India is the second largest producer of both rice and wheat crops in the world. In 2015-16, the country has produced 104.41and 92.29 million tons of rice and wheat, respectively. The productivity of both the crops plays a crucial factor in the present scenario of increasing population and food security with sustainable use of resources. The impressive growth of yield and production of these two crops in post green revolution period has been most important factor in achieving food security and food self-sufficiency in the country (Chand and Haque 1997). There has been a growing concern about the population growth in the country and food grain demand for growing population. By 2030, India's population will exceed 1.5

billion which is 25 per cent more than in 2011-12 and country will need to produce more food resources as urgent as ever (Joshi and Kumar 2011). By providing staple food rice and wheat should play an important role in assuring food security of Indian population. The initial phase of green revolution (mid-1970s to mid-1980s) was marked by the growth in productivity through adoption of high-yielding varieties, sharp increase in the use of inputs like fertilizers, agricultural chemicals, improved seeds, machine labour and expansion in area under irrigation. The second post-green revolution phase, beginning around mid1980s, was characterized by the spread of green revolution technology beyond the traditional green revolution belt of the first phase (Chand and Raju 2008). The effects of green revolution have been believed to be ended in the IGP region by the end of 1980s and numerous policy changes have been taken place in the post reform era (1996-2011). Also, the modern cultivation practices have led to emergence of some visible symptoms of unsustainability in agriculture like nutrient imbalances, depletion of soil micro-nutrients, over-exploitation of groundwater, degradation of land, more frequent emergence of pests and diseases, and, diminishing returns to inputs (Chand *et al*. 2011). This has created apprehensions about the ability of this approach in ensuring the future food security. In this context, a debate has emerged in policy circles — whether the slowdown of agricultural performance is due to technology fatigue or policy fatigue (Planning Commission 2007, Narayanamoorthy 2007). The focus from increasing per hectare productivity has changed to increase in the total factor productivity (TFP). Thebottom-line of the debate is that on one hand increased agricultural income and on the other hand ensuring total factor productivity (TFP) growth are critical to reduce rural poverty. Under this background the paper seeks to examine the total factor productivity of major cereals in major producing states of India.

MATERIALS AND METHODS

The study is based on secondary data. The basic input data for the estimation was collected from the reports of "Comprehensive Scheme for Cost of Cultivation of Principal Crops in India" carried out by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi. The states covering almost 80 percent of the production of rice and wheat were taken. The output variable was yield per hectare (kg/ha) along with seven input variables which include usage of seed (kg/ha), chemical nutrients (NPK, kg/ha), manure (q/ha), animal labour (pair hours/ ha), human labour (human-hours/ha), and real costs of machine labour and irrigation deflated by price index of diesel and irrigation respectively. In rice, six inputs were included because of non-availability of quantity of seed for some states in cost of cultivation data. The analysis was carried out for the overall period of 1994-95 to 2015-16, which was divided into two sub-periods; 1994-95 to 2004-15 (period I) and 2005-06 to 2015-16 (period II) corresponding broadly to post-reform Periods-I & II, respectively. To avoid extreme variations, the triennial ending averages were used. The analysis was carried out by using the software DEAP 2.1 (Coelli 1996).

Malmquist productivity index

The Malmquist Productivity Index (MPI) introduced by Caves *et al.* (1982) is based on distance functions. The output oriented Malmquist TFP index measures the maximum level of outputs that can be produced using a given level of input vector and the given production technology relative to the observed level of outputs (Coelli *et al*. 2005). It measures the radial distance of the observed output vectors in the period t and t^{+1} relative to a reference technology. The Malmquist productivity index for the period t is represented by equation (1):

$$M^t = \frac{D^t_0(x^{t+1},y^{t+1})}{D^t_0(x^t,y^t)} \quad \ldots\ldots\ldots (1)$$

Malmquist productivity index is defined as the ratio of two output distance functions taking technology at time t as the reference technology. Instead of using period t's technology as the reference technology it is possible to construct output distance functions based on period (t^{+1})'s technology which can be described as:

$$M^{t+1} = \frac{D^{t+1}_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^t,y^t)} \quad \ldots\ldots\ldots (2)$$

Fare *et al*. (1994) attempt to remove the arbitrariness in the choice of benchmark technology by specifying their Malmquist productivity change index as the geometric mean of the two-period indices, which is defined as:

$$M_0(x^{t+1},y^{t+1},x^t,y^t) = \left[\left(\frac{D^t_0(x^{t+1},y^{t+1})}{D^t_0(x^t,y^t)}\right)\left(\frac{D^{t+1}_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^t,y^t)}\right)\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots (3)$$

Where, the notations x and y represents the vector of inputs and outputs, D_0 denotes the distance and M denotes the Malmquist index. Fare *et al.* (1994) by using simple arithmetic manipulations have presented the Malmquist Productivity Index as the product of two distinct components, viz. technical change and efficiency change as indicated below:

$$M_0(x^{t+1},y^{t+1},x^t,y^t) = \left[\frac{D^{t+1}_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^t,y^t)}\right]\left[\left(\frac{D^t_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^{t+1},y^{t+1})}\right)\left(\frac{D^t_0(x^t,y^t)}{D^{t+1}_0(x^t,y^t)}\right)\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots (4)$$

Where,

$$\text{Efficiency change} = \left[\frac{D^{t+1}_0(x^{t+1},y^{t+1})}{D^t_0(x^t,y^t)}\right] \quad \ldots\ldots\ldots (5)$$

and,

$$\text{Technical change} = \left[\left(\frac{D^t_0(x^{t+1},y^{t+1})}{D^{t+1}_0(x^{t+1},y^{t+1})}\right)\left(\frac{D^t_0(x^t,y^t)}{D^{t+1}_0(x^t,y^t)}\right)\right] \quad \ldots\ldots\ldots\ldots (6)$$

RESULTS AND DISCUSSION

Trends in area, production and productivity of rice and wheat crops in India

The trends in area, production and productivity of rice and wheat crops in India has been shown in (Table 1). The results revealed that rice and wheat area had increased from 423.8 and 251.5 lakh ha in TE 1994-95 to 439.2 and 307.9 lakh ha in TE 2015-16, respectively which showed that area growth rate in rice was slow i.e. 0.01 per cent per annum as compared to wheat i.e. 1.48 per cent per annum. The productivity of rice and wheat in India has continuously increased from 1847 kg/ha to 2402 kg/ha and 2422 kg/ha to 2976 kg/ha respectively, during the study period. During the period of triennium ending (TE) 1994-95, rice and wheat production in India was 783.3 lakh tones and 609.4 lakh tones which increased to 1055.1 lakh tones and 915.6 lakh tones by TE 2015-16 at a rate of 1.05 and 2.77 per cent per annum respectively. During the same period, there was high growth rate in production than the growth rate in the area due to increase in yield.

Table 1 Trends in area, production and productivity of rice and wheat crops in India

Year	Rice			Wheat		
	Area (lakh ha)	Production (lakh tonnes)	Productivity (Kg/ha)	Area (lakh ha)	Production (lakh tonnes)	Productivity (Kg/ha)
TE 1994-95	423.8	783.3	1847	251.5	609.4	2422
TE 2004-05	418.9	811.6	1935	260.6	686.3	2633
TE 2015-16	439.2	1055.1	2402	307.9	915.6	2976
CGR Overall	0.01	1.44	1.43	0.92	1.84	0.92
CGR Period-I	-0.21	0.44	0.65	0.20	0.72	0.53
CGR Period-II	-0.05	1.57	1.62	1.48	2.77	1.28

Rice

Eight major producing states of rice i.e. Andhra Pradesh, Bihar, Madhya Pradesh, Odisha, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal which contributed more than 80 percent production of the country has been shown in (Table 2). Currently rice occupied 439.2 lakh ha of area in country, with impressive productivity growth of 1863 kg/ha to 2403 kg/ha during 1994-2016 which occurred at a rate of 1.43 per cent per annum respectively. Highest productivity of rice has been witnessed in Punjab at 3921 kg/ha closely followed by Tamil Nadu at 3324 kg/ha whereas Madhya Pradesh showed lowest productivity (1645 kg/ha) during the period T.E 2015-16. All the major states consistently showed increase in productivity during the study period. Out of eight states, only three states i.e. Andhra Pradesh, Punjab and West Bengal registered more growth rate in productivity in first period than second period and rest of states were vice versa.

Table 2 Trends in productivity of rice in major producing states of India (In Kg/ha, per cent)

States	T.E 1994-95	T.E2004-05	T.E 2015-16	CGR Period-I	CGR Period-II	CGR Overall
Andhra Pradesh	2562	2906	3091	2.11^{**}	0.22^{NS}	1.19^{**}
Bihar	1133	1271	1981	-1.07^{NS}	5.45^{**}	1.99^{*}
Madhya Pradesh	1125	1008	1645	-1.06^{NS}	4.26^{**}	2.72^{*}
Odisha	1364	1236	1768	-0.22^{NS}	1.26^{*}	2.07^{**}
Punjab	3427	3716	3921	1.53^{**}	-0.01^{NS}	1.05^{**}
Tamil Nadu	3146	2457	3324	-1.87^{NS}	1.94^{NS}	0.27^{NS}
Uttar Pradesh	1845	1939	2217	0.02^{NS}	1.47^{**}	0.71^{**}
West Bengal	2050	2514	2802	2.38^{**}	1.26^{**}	1.46^{**}
India	1863	2055	2402	0.65**	1.62**	1.43**

**, *Significant at 1 per cent, and 5 per cent level of significance; NS: non-significant

Wheat

There has been a significant increase in productivity of wheat crop in past 22 years, about 40 percent increase, from 1770 kg/ha to 2976 kg/ha at all-India level during 1994-95 to 2015-16 (Table 3). All states registered steady positive growth in production during the study period. Punjab recorded highest productivity among the states which continuously increased from 3957 kg/ha to 4631 kg/ha during the period 1994-95 to 2015-16. Punjab and Haryana showed higher absolute productivity under wheat cultivation than other states. The growth rate of productivity significantly increased in the country during the overall study period to the tune of 3.18% per annum for the country as a whole. The growth rate in productivity of Punjab and Haryana increased by 0.65% and 0.96 per cent per annum respectively which was less than Madhya Pradesh (2.32%) and Bihar (2.13%) because these states have already reached 95 per cent of their potential yield, whereas a huge yield gaps exists in other states. Even then growth rate in Punjab and Haryana has been positive for last 22 years.

Table 3 Trends in productivity of wheat in major producing states of India (In Kg/ha)

States	T.E 1994-95	T.E2004-05	T.E 2015-16	CGR Period-I	CGR Period-II	CGR Overall
Bihar	1972	1773	2151	-2.04^{NS}	2.13**	2.13**
Haryana	3639	3964	4370	0.87**	0.94**	0.96**
Madhya Pradesh	1598	1601	2749	-0.78^{NS}	6.53**	2.32**
Punjab	3957	4209	4631	0.75^{NS}	1.01**	0.65**
Uttar Pradesh	2347	2631	2650	0.55*	-0.28 ^{NS}	0.60**
India	1770	2645	2976	7.06**	1.28**	3.18**

**, *Significant at 1 per cent, and 5 per cent level of significance; NS: non-significant

Total factor productivity of paddy and wheat

Paddy

The trend in the Malmquist productivity index for the period 1994-95 to 2015-16 was estimated following the methodology outlined earlier. Table 4 presented the movements of TFP, technical change and efficiency change from 1994-95 to 2015-16. The movement of TFP change was aligned more with the movement of the technical progress rather than with the change in efficiency. The results have revealed that the mean TFP change for rice has been to the tune of 2.3 per cent per year during the overall period 1994-2016. The decomposition analysis has indicated that the change in TFP was associated with the technical progress of 2.4 per cent and the deterioration of efficiency to the tune of -0.1 per cent. The mean TFP growth increased from 0.7 per cent in the period I to 4.7 per cent during period II. This TFP change was associated with an improvement in the technical change (from1.1 per cent to 4.3 per cent) and in efficiency (from -0.4% to 0.4%). The TFP change varied considerably across states, with five states (Andhra Pradesh, Madhya Pradesh, Punjab, Tamil Nadu and Uttar Pradesh) out of the total eight states under consideration, posting positive trends and the remaining three states posting negative trends. Across states, the highest change in the TFP has been in Punjab (8.9%), followed by Uttar Pradesh (6.7%). On the other hand, the negative TFP growth ranged between -2.9 per cent in Odisha to -0.3 per cent in West Bengal. The results revealed that the TFP change was associated more with technical change rather than efficiency change at the state level also. The efficiency change remained unchanged i.e. 100 per cent from Period-I to Period-II. It was due to increase in public investment on research and development in post reform period-II which led to technical change. These results are in accordance to Bhushan (2005). The impact of increase in public investment has been highly observed in technologies adopting states like Punjab, Tamil Nadu and Uttar Pradesh which posted high rates of TFP growth during the second period as compared to the first period. On the other hand, only two states Andhra Pradesh and West Bengal had higher trend, where TFP trend were higher during Period-I than Period II. The results also suggested that during the two periods, the TFP change in those states where benefits of Green Revolution reached later were with high level of margins i.e. Bihar and Odisha, the highest absolute increase being in the case of Bihar (by 10.2 percentage points). The increase in the TFP growth of Punjab, Madhya Pradesh, Tamil Nadu and Uttar Pradesh was mainly due to the improvement in technical progress rather than the efficiency growth. The efficiency remained unchanged i.e. no improvement was observed in current input and management factor from Period-I to Period-II.

Table 4 Trends in technical change, efficiency change and total factor productivity change of paddy during two periods, across selected states in India (Per cent)

State	Period-I			Period-II			Overall		
	Efficiency change	Technical change	TFP change	Efficiency change	Technical change	TFP change	Efficiency change	Technical change	TFP change
Andhra Pradesh	100.2	105.2	105.5	100.0	103.0	103.0	101.0	104.3	104.6
Bihar	100.0	94.3	94.3	100.0	104.5	104.5	100.0	97.3	97.3
Madhya Pradesh	99.3	99.1	98.5	101.5	104.3	105.8	100.0	101.5	101.5
Odisha	100.0	94.3	94.3	100.0	99.4	99.4	100.0	97.1	97.1
Punjab	100.0	109.3	109.3	100.0	110.6	110.6	100.0	108.9	108.9
Tamil Naidu	97.2	102.0	99.2	101.5	105.4	106.9	99.3	103.8	103.0
Uttar Pradesh	100.0	103.7	103.7	100.0	111.3	110.3	100.0	106.7	106.7
West Bengal	100.0	101.5	101.5	100.0	97.1	97.1	100.0	99.7	99.7
Mean	99.6	101.1	100.7	100.4	104.3	104.7	99.9	102.4	102.3

A remarkable performance has been noted in Punjab and Uttar Pradesh. In Punjab and Uttar Pradesh, the TFP growth increased in the period I from 9.3 per cent and 3.7 per cent to 10.6 per cent and 10.3 per cent during period-II respectively; with efficiency remaining unchanged. The remarkable performance of these two states is due to the impressive performance of technical progress in these states. On the other hand, in West Bengal, the deterioration of the technical growth from 1.5 per cent to -2.9 per cent, with efficiency remaining unchanged, pulled down the TFP

growth in this state. The increase in TFP growth with practically unaltered efficiency levels points to the upward shift of the production frontier. In that sense, it can be presumed that the low-performing states during period I were trying to catch up with the already progressive states. The analysis has clearly indicated that in general the technical change has been contributing to TFP for paddy crop.

Wheat

Similar trend of total factor productivity growth was seen in wheat crop (Table 5). The mean TFP change for wheat has been to the tune of 4.2 per cent per year during the overall period 1994-2016. While decomposing the TFP growth into its component, it was found that this growth in wheat crop has been associated with the technical progress of 4.4 per cent and the deterioration of efficiency to the tune of -0.2 per cent which showed the movement of TFP change was aligned more with the movement of the technical progress rather than change in efficiency. The mean TFP growth increased from 0.2 per cent in the period I to 10.7 per cent during period II. This TFP change was associated with an improvement in the technical change (from 0.7 per cent to 10.5 per cent) and also improved efficiency change (from -0.4% to 0.2%). This underlines the fact that efficiency which is due to operations of scale or management factor could not catch up with the technical progress, and was pulling down the TFP growth. The TFP change varied considerably across states, except Haryana all states under consideration, posted positive trends. Among these states, the highest change in the TFP has been in Punjab (10.7%), followed by Madhya Pradesh (6.7%). On the other hand, only Haryana (-0.5%) showed negative TFP growth. The TFP change was associated more with technical change than with efficiency change at the state level also. The two states i.e. Madhya Pradesh and Punjab presented positive technical change with no-change in efficiency, while for Bihar and Uttar Pradesh, technical change of 1.9 per cent and 2.6 per cent respectively was coupled with efficiency change of -0.2 per cent and -0.6 per cent respectively. Haryana posted decline in technical change and TFP but there was no change in efficiency during the overall period. Thus for wheat crop, one has to pay increased attention towards the factors that could influence the efficiency as well along with the factors that result in technical progress. The impressive technological change in all states was observed which posted high rates of TFP growth during the second period as compared to the first period. The results have also suggested that during the two periods, the TFP change in the latter group of period were with high level of margins, the highest absolute increase being in the case of Haryana (by 16.5 percentage points). This indicates that these states have great potential to increase their wheat productivity by improving technical change. Further, states such as Bihar, Haryana and Uttar Pradesh has shown an improvement in the technical progress during the second period, turning TFP from negative to positive. A remarkable performance has been noted in Punjab. In Punjab, the increasing TFP growth in the Period-I has increased further during period-II (from 6.8% to 15.9%) with efficiency remaining unchanged. This remarkable performance mainly is due to the impressive performance of technical progress in Punjab. On other hand, Bihar improved their efficiency from Period-I to Period-II i.e. -1.9 percent to 1.8 per cent. This implies that technological progress is still very important to agricultural productivity growth for low technology states, which can be seen from the frontrunner state Punjab.

Table 5 Trends in technical change, efficiency change and total factor productivity change of wheat during two periods, across selected states in India (Per cent)

State	Period-I			Period-II			Overall		
	Efficiency Change	Technical Change	TFP change	Efficiency Change	Technical Change	TFP change	Efficiency Change	Technical Change	TFP change
Bihar	98.1	98.9	97.0	101.8	105.3	107.2	99.8	101.9	101.6
Haryana	100.0	95.5	95.5	100.0	112.0	112.0	100.0	99.5	99.5
Madhya Pradesh	100.0	103.0	103.0	100.0	113.0	113.0	100.0	107.5	107.5
Punjab	100.0	106.8	106.8	100.0	115.9	115.9	100.0	110.7	110.7
Uttar Pradesh	99.8	99.5	99.3	99.3	106.6	105.8	99.4	102.6	102.0
Mean	99.6	100.7	100.2	100.2	110.5	110.7	99.8	104.4	104.2

Increase in TFP growth: Whether growth in input use or technological change

The result of TFP change in paddy and wheat during the study period revealed that in the selected states, there is no efficiency change i.e. input growth has not taken place and it is the only technological progress or modern agriculture (i.e. technical change) which has led to TFP change. Further strengthen the results, the growth in input use was analyzed for primary inputs namely irrigation, fertilizers, human labour and machine labour covering both periods. In paddy, there was negative growth in use of human labour among all states during both periods (Table 6). Moreover, the use of human labour declined in Period-II relative to Period-I. The growth in use of machine labour turned positive in period-II, implying more technical change in Period-II in paddy production. The human labour was replaced by machine labour. The growth rate in use of fertilizers have been positive, though the growth in magnitude varied widely across study states. Four states have negative growth in irrigation in production of paddy during second period

Table 6 Growth in input use in paddy production in study states during TE 1994-95 to 2015-16 (Per cent)

States	Human Labour		Machine Labour		Fertilizer		Irrigation	
	Period-I	Period-II	Period-I	Period-II	Period-I	Period-II	Period-I	Period-II
Andhra Pradesh	-1.66	-4.55	-4.79	8.77	0.51	1.40	-1.22	1.77
Bihar	-0.35	-1.89	4.53	3.70	1.71	2.74	23.93	15.56
Madhya Pradesh	-1.95	-1.62	-2.23	16.79	-3.49	11.43	5.83	-29.54
Odisha	0.16	-0.50	8.43	12.28	5.14	0.15	16.02	-7.42
Punjab	-1.09	-2.54	-1.03	0.43	1.91	0.63	0.04	-4.52
Tamil Nadu	-0.58	-4.96	0.68	4.62	2.56	0.41	5.98	-1.17
Uttar Pradesh	-0.63	-1.71	-0.58	7.12	2.33	3.40	6.77	4.38
West Bengal	0.64	-1.59	0.90	13.83	-1.01	-1.41	-0.13	4.93

Table 7 Growth in input use in wheat production in study states during TE 1994-95 to 2015-16 (Per cent)

States	Human Labour		Machine Labour		Fertilizer		Irrigation	
	Period-I	Period-II	Period-I	Period-II	Period-I	Period-II	Period-I	Period-II
Bihar	-4.28	-0.36	3.58	2.28	0.83	1.96	1.04	2.11
Haryana	-1.65	-0.91	-2.65	1.24	1.90	-0.75	1.12	3.34
Madhya Pradesh	-1.13	-2.91	-4.25	7.26	1.71	1.52	2.75	0.85
Punjab	-7.14	-6.46	-0.37	0.65	1.11	0.89	-3.00	-8.72
Uttar Pradesh	-1.65	-2.56	-1.85	0.73	1.63	1.02	2.55	-2.64

Note: Fertilizer (nutrients) in kg, human labor in man hours, and irrigation and machine labors in nominal price. Thereal costs of machine labour and irrigation deflated by price index of diesel and irrigation respectively

Table 8 Trend in cost and factor share of partial input used in paddy production

States		Growth rate (%)			Growth rate of factor share (%)		
		Period-I	Period-II	Overall	Period-I	Period-II	Overall
Andhra Pradesh	Current	4.8	11.6	6.8	-2.0	0.7	-1.4
	Capital	8.0	11.7	7.8	1.0	0.8	-0.5
	Labour	4.1	11.7	7.7	-2.6	0.7	-0.6
	Land	6.3	10.6	8.0	-0.6	-0.2	-0.3
Bihar	Current	4.5	10.8	6.6	1.3	0.8	-0.4
	Capital	5.7	11.8	7.9	2.5	1.7	0.8
	Labour	7.9	13.8	9.0	4.6	3.4	1.9
	Land	4.1	11.3	6.0	0.9	1.2	-1.0
Madhya Pradesh	Current	5.0	15.8	8.4	5.2	0.8	-0.5
	Capital	4.4	15.0	7.3	4.6	0.0	-1.6
	Labour	5.1	14.1	8.2	5.3	-0.7	-0.8
	Land	0.1	14.9	8.9	0.3	0.0	-0.2
Odisha	Current	6.9	10.4	6.9	3.0	0.1	-0.6
	Capital	11.4	9.9	9.0	7.3	-0.4	1.4
	Labour	8.6	17.1	10.3	4.6	6.1	2.6
	Land	3.8	9.9	7.0	0.1	-0.4	-0.5
Punjab	Current	6.9	9.5	6.8	-2.1	-1.1	-2.2
	Capital	9.3	5.5	6.0	0.1	-4.7	-3.0
	Labour	5.2	13.4	8.9	-3.6	2.5	-0.3
	Land	8.2	11.8	9.6	-0.9	1.0	0.3
Tamil Nadu	Current	7.0	13.5	7.8	4.4	2.1	1.3
	Capital	12.9	9.3	9.5	10.2	-1.7	2.8
	Labour	3.9	9.9	6.5	1.4	-1.2	0.0
	Land	6.2	6.2	5.7	3.7	-4.5	-0.7
Uttar Pradesh	Current	7.0	11.5	8.7	3.8	1.0	0.7
	Capital	8.7	12.4	9.7	5.4	1.8	1.7
	Labour	7.0	13.8	8.7	3.8	3.1	0.7
	Land	6.4	10.9	8.6	3.3	0.5	0.6
West Bengal	Current	6.8	13.7	8.4	3.9	2.5	1.0
	Capital	10.5	8.3	6.6	7.6	-2.4	-0.6
	Labour	7.4	14.8	9.4	4.5	3.6	1.9
	Land	2.6	10.4	6.9	-0.2	-0.4	-0.4

To have further in-depth analysis on cultivation cost, the various inputs used in production of paddy and wheat were classified into four sub-groups: current inputs, capital inputs, labour, and land. The share of above four subgroups of inputs has been summarized on two aspects – growth in input use and their share in total value of output (factor share). Current inputs were seed, fertilizer, manure, insecticides, interest on variable cost; Capital inputs were draft animal, irrigation, machinery, depreciation, interest on fixed capital; Labour input was human labour. The land revenue involved the value of land resources (both owned and hired) as well as other charges on land (Table 8, 9).

Table 9 Trend in cost and factor share of partial input used in wheat production

States		Growth rate (%)			Growth rate of factor share (%)		
		Period-I	Period-II	Overall	Period-I	Period-II	Overall
Bihar	Current	3.9	11.0	6.3	0.5	1.4	-0.5
	Capital	7.2	9.2	6.8	3.8	-0.2	0.0
	Labour	5.0	15.8	8.1	1.6	5.9	1.1
	Land	5.1	12.0	5.9	1.7	2.4	-0.9
Haryana	Current	6.9	7.3	6.0	0.7	-0.6	-1.5
	Capital	8.9	9.6	8.7	2.5	1.4	1.0
	Labour	5.6	12.4	8.7	-0.5	4.0	1.0
	Land	6.3	9.8	8.3	0.1	1.6	0.6
Madhya Pradesh	Current	4.3	9.7	6.8	-1.7	-0.3	-2.9
	Capital	8.0	9.9	8.1	1.8	-0.1	-1.8
	Labour	5.2	13.4	8.4	-0.9	3.0	-1.5
	Land	5.8	10.2	10.0	-0.3	0.2	0.0
Punjab	Current	6.3	7.9	5.8	-0.7	-0.4	-1.8
	Capital	9.2	6.5	8.0	2.1	-1.7	0.2
	Labour	-2.3	7.4	4.3	-8.7	-1.0	-3.2
	Land	6.2	9.1	7.8	-0.8	0.6	0.1
Uttar Pradesh	Current	4.5	9.4	6.8	1.5	2.7	0.2
	Capital	8.4	7.2	8.3	5.3	0.7	1.6
	Labour	5.0	12.3	8.1	2.0	5.5	1.4
	Land	5.6	10.6	8.4	2.6	3.9	1.8

While comparing growth rates of current and capital inputs during overall periods in paddy cultivation, except Madhya Pradesh and West Bengal, the growth of current inputs was less than the growth of capital inputs. The growth rate in expenditure on current inputs ranged between 6.6 to 8.7 per cent whereas the growth rate in expenditure on capital inputs ranged between 7.8 to 9.7 per cent; implying low growth in inputs. This clearly reveals sluggishness in input growth which is visible through no change in efficiency in study states. The growth rate of current, capital, labour and land inputs have increased in all states from Period-I to Period-II only due to the effect of price rise. The growth rates have been worked out at current prices taking cost of cultivation in value terms. The expenditure on labour inputs has increased in study states, the highest in Odisha and West Bengal (10.3% and 9.4%, respectively). The surge in expenditure on labour can be explained in the light of usual increase in agricultural wages in recent years than that of their physical use in cultivation of crops, be it labour intensive crop. This indicates that agricultural policies should be tilted towards sustainable intensification of inputs so that the TFP can increase, through both input growth and technological progress.

The trend analysis indicated that the area, production and productivity of rice and wheat crop has continuously increased over time but at a very steady rate. During the period 1994-95 to 2015-16, the productivity analysis revealed that the TFP change has been positive for both paddy and wheat in the overall study period for major producing states of India. But the TFP change was more positive in wheat as compared to the paddy. Among paddy producing states except Bihar, Odisha and West Bengal all the states had accounted for positive TFP change, the highest change in the TFP has been in Punjab (8.9%), followed by Uttar Pradesh (6.7%). On the other hand, except Haryana all wheat producing states showed positive TFP growth, the highest change in the TFP has been in Punjab (10.7%), followed by Madhya Pradesh (6.7%). Second period marked more prominent positive change of TFP in both paddy and wheat as compared to the first period. The increase in the TFP growth is mainly due to the increase in the technical change rather than due to efficiency change. The study established that there is no conclusive evidence for a technology regress in case of paddy and wheat; rather there is evidence of technological progress over the years. In Punjab and Haryana, it is the policy fatigue rather than technology fatigue which has resulted in yield stagnation. Moreover, these states have already exploited 95% of their potential yield, but still the results of TFP are encouraging which resulted in positive technological change though at a slow pace. No doubt TFP growth improved in paddy and wheat across all states but not at pace with demand of staple food, it will adversely affect the long-term growth as well as the national food security and household nutritional security.

Further, emphasis on attainment of self-sufficiency in staple food in every state could be a reason for low or stagnant TFP in those crops. Rather there is a need to promote regional specialization based on the comparative advantage of the region Along with technical progress, the policies should be aligned to improve the technical efficiency of cultivation. In the light of the evidences existing on the positive role of research investment in technical progress and extension expenditure on efficiency change, the agrarian policies need to favour increased flow of resources towards the research and extension system so as to effect TFP growth through both technical and efficiency changes.

LITERATURE CITED

Bhushan S. 2005. Total factor productivity growth of wheat in India: A Malmquist approach. *Indian Journal of Agricultural Economics* **60**(1): 32-48.

Caves D W, Christensen L R and Diewert W E. 1982. The economic theory of index numbers and the measurement of input, output and productivity, *Econometrica* 1393-1414.

Chand R and Haque T. 1997. Sustainability of Rice-wheat crop system in Indo-Gangetic region. *Economics and Political Weekly* **32**(13): A26-30.

Chand R and Raju S S. 2008. *Instability in Indian Agriculture*. Discussion paper No NPP 01/2008, National Professor Project, National centre for agricultural economics and policy research, New Delhi-110 012.

Chand R, Kumar P and Kumar S. 2011. Total factor productivity and contribution of research investment to agricultural growth to agricultural growth in India. Policy Paper No 25. National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi.

Coelli T J, Rao D S P, O'Donnell C J and Battese G E. 2005. *An Introduction to Efficiency and Productivity Analysis*. Springer, New York, USA.

Desai M B and Namboodiri N V. 1997. Determinants of total factor productivity in Indian agriculture. *Economic and Political Weekly* **32**(52): A165-71.

Fare R, Grosskopf S, Norris M and Zhang Z. 1994. Productivity growth, technical progress, and efficiency change in industrialized countries. *The American Economic Review* 66-83.

Government of India. 2016. Agricultural Statistics at a Glance, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi

Joshi P K and Kumar P. 2011. Food Demand and Supply Projections for India. Mimco, International Food Policy Research Institute, New Delhi.

Kumar S and Anwer M E. 2015. Estimation of productivity and efficiency of rapeseed and mustard production in India. *Economics Affair* **60**(4): 809-820.

Kumar S and Chand R. 2014. *Research resource allocation across disciplines and states in Indian Agriculture: An Illustration using composite scoring approach*. New Delhi: National Centre for Agricultural economics and Policy Research, Mimeo.

Narayanamoorthy A. 2007. Deceleration in agricultural growth: Technology fatigue or policy fatigue? *Economic and Political Weekly* **42**(25): 2375-2379.

Planning Commission. 2007. Report of the Steering Committee on Agriculture for Eleventh Five Year Plan (2007-2012), Government of India, New Delhi.

Suresh and Reddy. 2016. Total factor productivity of major pulse crops in India: Implication for technology policy and nutritional security. *Agricultural Economics Research Review* **29**: 87-98.