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State-wise comparative analysis of different cost components and factor productivity of paddy in India during last decade

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ABSTRACT

The present study attempts to evaluate state-wise variation in various cost components of paddy in India as well as the technological change in rice cultivation and its key factor contributor during 2000-01 to 2009-10. State level secondary data of input use and output of paddy has been accessed for the given period of time. For assessment of different cost components over the year, the exponential growth rates and instability of different cost components has been calculated using simple Logest estimates while the state-wise total factor productivity for paddy have been computed using Divisia Tornqvist-Theil index model. The study evaluates that although there has been a stagnancy in the overall productivity of crop sector in India due to excessive use of inorganic fertilizer, insecticides and pesticides, still a combination of organic and inorganic mix package of practice for paddy in different states of India has been highly visualized. A marked technological change in rice cultivation has been observed in the state of Madhya Pradesh (5.40%), Kerala (3.74%) and Karnataka (3.18%). With the rise in operational cost of paddy including the hiring rate of tractors and power tillers, farm mechanization has still become the prime contributor in different states of India. Despite of a sharp increase in the human labour wage rate, the contribution of human labour still dominates the overall farming situation in India. Irrigation factor becomes the prime contributor with a negative impact on productivity change as most of the region has cultivated rainfed rice. The contribution of fixed factor has gone up as the opportunity cost of land has been increased day by day.

Keywords *:* Cost components; factor contributor; growth; instability; technological change; total factor productivity

1. Introduction

Rice is the major cereal crop grown in India. It covers nearly a one-fourth of the gross irrigated area in India (Chatterjee *et al*., 2013), with vastly diverse conditions from below the sea-level in parts of Kerala state to, on the hills up to an elevation of almost 3000 m above mean sea level in Himachal Pradesh, Jammu and Kashmir states (Nirmala *et al*., 2009). In India, this diverse rice growing conditions are mainly classified into five major ecologies namely, Irrigated, Uplands, Rainfed Lowlands, Deep water and Coastal wetlands with a wide level of variation in input use as well as cost structure. However, a serious concern has been raised on the long run sustainability of the productivity effects of Green Revolution technologies under irrigated ecosystem due to degradation of natural resource-base. Many studies (Flinn and De Datta 1984; Cassman and Pingali, 1995, Nambiar, 1988, Pingali *et al.*, 1997, Greenlands, 1997; Yadav, *et al.*, 2000, Dawe *et al.*, 2000; Kumar and Yadav, 2001) have reported that rice yields were either declining or stagnant after the 1980s under the intensive irrigated rice systems due to various resource-degradation problems. Most of these studies were however largely based on experimental data designed with a specific objective under controlled environments (fixed nutrient doses, variety, other management practices, *etc*.) in the research farms and adaptive research trials. Keeping this view in mind, the present study attempts to evaluate the regional variation in various cost components of paddy across all major paddy growing states of India during 2000-01 to 2009-10. Also the study tries to evaluate the technological change in rice cultivation and its key factor contributor through computation of total factor productivity (TFP) of rice across the major paddy growing states of India over the period under study which has been identified as the correct measure of productivity impact for technical change (Evenson and Pray, 1991).

To add further, the country, India has its wide variation in the topography, agro-climatic condition, rhythm of precipitation along with irrigation on availability are the major sources of variation in rice production. At the same time, socio-geographic characteristics, particularly access to modern agricultural inputs including availability of credit, information technology, communication, market roads *etc*. are equi-important determinants of variation in agricultural production. Kannan (2011) while measuring TFP growth and its determinants in Karnatakian agriculture India, concluded that the government expenditure on research, education and extension, canal irrigation, rainfall and balanced use of fertilizers are the important drivers of crop productivity in Karnataka. It is necessary that both public and private investment should be enhanced in agricultural research and technology, and rural

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infrastructure for sustaining productivity growth in the long run.

The present study has strictly followed the modern concept of costs as proposed by the Commission for Agricultural Costs and Prices (CACP), Ministry of Agriculture, Govt. of India and has accessed the state wise data of different cost components of paddy over 2000-01 to 2009-10 from the periodical reports/issues of CACP (Anonymous 2003, 2007) and official website of Directorate of Economics and Statistics (DES), Ministry of Agriculture, Govt. of India (eands.dacnet.nic.in). Subsequently, the total output indices for paddy while calculating the total factor productivity (TFP_{Rice}) across different states of India has been computed using the state-level area, production and farm harvest price data (collected from DES website) of rice over the period (2000-01 to 2009-10) under study. The various cost components used here are as follows:

Cost A1: It covers all actual expenses of cash and kind incurred in production of paddy by the owner. It includes various components like:

i) Value of hired human labour (both casual and attached labour)
ii) Value of hired bullock labour
iii) Value of owned bullock labour
iv) Value of owned machinery labour
v) Hired machinery charges
vi) Value of seed (both farm produced and purchased)
vii) Value of insecticides and pesticides
viii) Value of manure (owned and purchased)
ix) Value of inorganic fertilizer
x) Depreciation on implements and farm buildings
xi) Irrigation charges
xii) Land revenue, cesses and other taxes
xiii) Interest on working capital
xiv) Miscellaneous expenses (Artisans etc.)

Cost A2: Cost A1+ Rent paid for leased-in-land

Cost B1: Cost A1+Interest on owned fixed capital (excluding land)

Cost B2: Cost B1+ Rental value of owned land (net of land revenue) and Rent paid for leased-in-land

Cost C1: Cost B1+ Imputed value of family labour

Cost C2: Cost B2+ Imputed value of family labour

Cost C2 (Revised): Cost C2+ Additional value of human labour based on use of higher wage rate, *i.e.* statutory wage rate or actual market rate whichever is higher (as derived from cost study data)

Cost C3: Includes the managerial cost @ 10% on Cost C2 (Revised) [Cost C2 (Revised) + 10% of Cost C2 (Revised)]

Cost of Production: It is defined as cost per unit of output. It is calculated by multiplying the ratio of Value of Main Product to Cost of Cultivation and the ratio of Value of Main and By-product to Derived Yield

The technological change in paddy cultivation across different states of India over the year has been evaluated by calculating the total output indices, total input indices and total factor productivity indices of rice over 2000-01 to 2009-10 using DivisiaTornqvist-Theil index model and subsequently the step-wise multiple regression analysis between relative change in output and that of relative change in different input used in the production system has been performed for each states in order to judge the best factor contributor for paddy cultivation over the last decade.

MATERIALS AND METHODS

The entire research methodology approaches two major sections. Firstly, the growth rates and instability of different cost components across major paddy growing states in India over the year has been calculated using simple Logest estimates with the following exponential form as proposed by Lewin (1970) earlier on his article on compound interest and again that has been modified by Lewin (1981) himself.

$$Y = ae^{bt}$$

where the dependent Y-value is a function of the independent time period (t), b is the growth factor over time t, a is the intercept term (constant).

The significance t-test of growth rate at 5 per cent level has been calculated from the following equation as:

$$t_{cal\ (0.05)} = b / se\ (b)$$

where b is the growth coefficient and se (b) represents standard error of the growth coefficient b. $t_{cal\ (0.05)} > t_{tab\ (0.05)}$ denotes the significance of growth factor at 5 per cent level.

Coefficients of Variation (C.V.) of different cost components of paddy over the year has been deflected by the following formula of instability and compare it between trended and detrended variables as used by Cuddy and Della Valle (1978).

$$I_x = CV\left(\sqrt{1-\overline{R^2}}\right)$$

Where I_x refers to instability measures and represents deflected or weighted coefficient of variation. The term $(1 - R^2)$ indicates unexplained proportion of the trend line serving as weights.

Secondly, the total factor productivity of paddy over the last decade (2000-01 to 2009-10) has been calculated by computing total output indices, total input indices for paddy across twelve major paddy growing states of India namely Andhra Pradesh, Assam, Bihar, Haryana, Karnataka, Kerala, Madhya Pradesh, Orissa, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal. DivisiaTornqvist-Theil index model, a modified translog homogeneous production function has been used to calculate the TOI, TII and TFPI as proposed by Diewert (1976) with its usual functional form:

Total Output Index (TOI)

$$TOI_{t-1} = \prod_{j} \left(\frac{Q_{jt}}{Q_{jt-1}} \right)^{\frac{\left(S_{jt} + S_{jt-1}\right)}{2}}$$

Total Input Index (TII)

$$TII_{t-1} = \prod_{i} \left(\frac{X_{it}}{X_{it-1}} \right)^{\frac{\left(S_{it}^{'} + S_{it-1}^{'}\right)}{2}}$$

The equation can be simplified as:

Tornqvist Aggregate Output Index is given by:

$$\text{Tornqvist Ln}\left(\frac{Q_{jt}}{Q_{jt-1}}\right) = \frac{1}{2}\sum_{j=1}^{n}\left(\frac{P_{jt}Q_{jt}}{\sum P_{jt}Q_{jt}} + \frac{P_{jt-1}Q_{jt-1}}{\sum P_{jt-1}Q_{jt-1}}\right)\text{Ln}\left(\frac{Q_{jt}}{Q_{jt-1}}\right)$$

Similarly Tornqvist Aggregate Input Index is given by:

$$\text{Tornqvist Ln}\left(\frac{X_{it}}{X_{it-1}}\right) = \frac{1}{2}\sum_{i=1}^{n}\left(\frac{C_{it}X_{it}}{\sum C_{it}X_{it}} + \frac{C_{it-1}X_{it-1}}{\sum C_{it-1}X_{it-1}}\right)\text{Ln}\left(\frac{X_{it}}{X_{it-1}}\right)$$

Where t = year,

Q_{jt} = Output of j^{th} crop at t^{th} year,

Q_{jt-1} = Output of j^{th} crop at $(t-1)^{th}$ year,

S_{jt} = Proportional value share of j^{th} crop to total value of output at t^{th} year.

S_{jt-1} = Proportional value share of j^{th} crop to total value of output at $(t-1)^{th}$ year.

X_{it} = Quantity of i^{th} input at t^{th} year,

X_{it-1} = Quantity of i^{th} input at $(t-1)^{th}$ year.

S'_{it} = Share of i^{th} input to total cost of inputs at t^{th} year.

S'_{it-1} = Proportional of cost share of i^{th} input to total cost of inputs at $(t-1)^{th}$ year,

P_{jt-1} = Harvest price of j^{th}crop at $(t-1)^{th}$ year, P_{jt} = Harvest price of j^{th} crop at t^{th} year,

C_{it-1} = Cost of i^{th} input at $(t-1)^{th}$ year, C_{it} = Cost of i^{th} input at t^{th} year.

Total Factor Productivity Index (TFPI)

O'Donnell (2012) defines TFP as the ratio between aggregate output to aggregate input. However TFP growth is a measurement of output growth divided by a measure of input growth, which is how the productivity growth is usually defined [*e.g.* Griliches (1961); Jorgenson and Griliches (1967)].

In general, Total Factor Productivity at t^{th} year is measured by:

$$TFP_t = \frac{TOI_t}{TII_t} = \frac{\text{Aggregate Output}}{\text{Aggregate Input}}$$

Here, a *multiplicatively-complete* [O'Donnell, 2008] Tornqvist TFP indexes has been used as:

$$\text{TFPI} = \frac{\text{Tornqvist Aggregate Output Index}}{\text{Tornqvist Aggregate Input Index}}$$

For the productivity measurement over a long period of time, Output, Input & TFP indices are computed on the basis of "Chain Base Index" expressed as percentages. With chain-linking, an index is calculated for two successive periods t and (t-1) over the whole period t_0 to T, (sample from t = 0 to t = T) and the separate indexes are then multiplied together :

TOI* (t) = TOI (1). TOI (2)……TOI (t-1)

Similarly, TII* (t) = TII (1). TII (2)……TII (t-1)

Total Factor Productivity Index (TFPI):

$$TFP_t = \frac{TOI^*_t}{TII^*_t}$$

Stepwise multiple regression analysis followed the model function:

$$\ln\left(\frac{Y_t}{Y_{t-1}}\right) = \beta_0 + \beta_1 \ln\left(\frac{X_{1t}}{X_{1t-1}}\right) + \beta_2 \ln\left(\frac{X_{2t}}{X_{2t-1}}\right) + \beta_3 \ln\left(\frac{X_{3t}}{X_{3t-1}}\right) + \beta_4 \ln\left(\frac{X_{4t}}{X_{4t-1}}\right)$$

$$+\beta_5 \ln\left(\frac{X_{5t}}{X_{5t-1}}\right) + \beta_6 \ln\left(\frac{X_{6t}}{X_{6t-1}}\right) + \beta_7 \ln\left(\frac{X_{7t}}{X_{7t-1}}\right) + \beta_8 \ln\left(\frac{X_{8t}}{X_{8t-1}}\right) + \beta_9 \ln\left(\frac{X_{9t}}{X_{9t-1}}\right)$$

where, Y = total output, X_1: quantity of seeds used, X_2 : quantity of fertilizer used, X_3 : quantity of organic manure used, X_4 : quantity of irrigation charges, X_5 : total machine hour required, X_6 : plant protection cost, X_7 : bullock labour used (pair hours), X_8 : total human labour used (man hours) X_9: interest on working capital, β_0 : constant, $\beta_{1.....}\beta_9$: regression coefficients of respective variables for t^{th}over $(t-1)^{th}$ year. The step-wise regression analysis has been done here to identify the most contributory factors responsible for the TFP change over decade and to exclude the irrelevant factors from the regression model. In this regard, it has to mentioned that for convenience of analysis and interpretation, the author has included only nine variables (the paid out and operational cost components) in computing the TFP and multiple regression analysis and not the entire input level (excluding fixed factors). The entire analysis has been performed using statistical package SAS 9.3 version.

RESULTS AND DISCUSSION

The entire study has been divided into two major sections. Section-I deals with the state-wise behavioural pattern of different cost components of paddy and their break up *i.e.* Cost A1, A2, B1, B2, C1, C2, and C2 (revised) and the final Cost C3, through computation of exponential growth rates and instability over the year studied (2000-01 to 2009-10). Each and every cost components has been analysed critically and interpreted subsequently. Section-II deals with the state wise analysis of technological change in rice cultivation over the period and determination of best factor contribution for change in productivity level.

State wise growth rates and instability in different cost components and output of paddy in India

Table 1.1 illustrates the state-wise growth rates and instability of different cost components incurred as well as gross output and productivity level of paddy in India during last decades (2000-01 to 2009-10) under study.

***Cost A1*:** Cost A1 includes all actual expenses in cash and kind for the production of paddy. There has been a significant rate of change in Cost A1 for paddy as marked across all the states of India during the last decade. The highest exponential growth rate was recorded in Uttar Pradesh (7.52%) followed by Haryana (6.95%), Andhra Pradesh (6.93%) and Assam (6.33%). West Bengal has shown a marked 5.91 per cent increase in Cost A1 over the period under study. However in terms of stability in growth rates, barring Madhya Pradesh, Andhra Pradesh and Punjab, all the states has registered significant change in Cost A1 with more than 90.0 per cent stability.

***Cost A2*:** Cost A2 includes Cost A1 with the rent paid for leased in land. Barring Karnataka, Kerala and Tamil Nadu, almost all the states have registered the leased in rental data for the tenants. There are no evidences of payment of rent to the landlords in these three states as almost all the farmers bear their own land for cultivation. The growth rate in Cost A2 component surpasses Cost A1 in Andhra Pradesh (7.37%), Punjab (6.22%) and in West Bengal (6.48%) resulting existence of more and more landless labourers in those states.

***Cost B1*:** Cost B1 includes Cost A1 with interest on owned fixed capital excluding land. The highest growth rates was registered in Uttar Pradesh (7.77%) followed by Haryana (7.49%), Andhra Pradesh (6.73%) and Punjab (6.57%). These four states are enriched with farm mechanization with modern machineries, tools and implements which have exerted certain values of interest on fixed assets excluding land.

***Cost B2*:** Cost B2 includes Cost B1 with the rental value of owned land treated as the opportunity cost of the next best alternative uses of that land. High rate of growth has been recorded in Haryana (8.72%) followed by Uttar Pradesh (8.31%) and Punjab (8.23%) too. These states occupies large amount of land used for non-agricultural activities. Barring Madhya Pradesh, almost all the states bear a stable significant growth rate in Cost B2 over the year.

***Cost C1 and Cost C2*:** Both Cost C1 and C2 bear the family labour factor which has to be imputed by the researcher. In both the cases, the highest rate of change was observed in Haryana. The state covers a 20.74 per cent average share of family labour cost to the total operational cost over the year studied where the maximum share of family labour to the operational cost was found in the state of Assam (45.21%) followed by West Bengal (30.44%).

Table 1.1 : State-wise growth rates and instability of different cost components and output produced of paddy in India (2000-01 and 2009-10)

Items/States	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Kerala	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Uttar Pradesh	West Bengal
Cost of Cultivation (Rs/Hect):												
Cost A1(Rs/Hect)	6.93*	6.33*	6.03*	6.95*	2.13	4.13*	5.29*	6.15*	5.77*	4.82*	7.52*	5.90*
	(12.77)	(9.48)	(6.10)	(8.85)	(9.25)	(5.29)	(16.13)	(6.37)	(12.47)	(6.09)	(6.00)	(7.66)
Cost A2(Rs/Hect)	7.37*	5.96*	5.40*	6.04*	2.13	4.13*	4.67*	5.91*	6.22*	4.83*	7.22*	6.48*
	(13.57)	(9.42)	(5.63)	(10.15)	(9.25)	(5.38)	(14.16)	(6.64)	(14.69)	(6.10)	(5.89)	(8.66)
Cost B1(Rs/Hect)	6.73*	6.49*	5.84*	7.49*	2.36*	4.22*	4.43	6.28*	6.57*	4.86*	7.77*	5.65*
	(12.25)	(8.64)	(5.96)	(9.64)	(8.58)	(4.95)	(18.38)	(5.59)	(11.95)	(7.11)	(6.94)	(6.82)
Cost B2(Rs/Hect)	7.74*	6.27*	5.51*	8.72*	3.64*	5.23*	7.29*	6.96*	8.23*	4.94*	8.31*	6.82*
	(12.64)	(10.47)	(3.98)	(8.27)	(8.36)	(6.99)	(22.45)	(6.89)	(9.71)	(5.71)	(7.85)	(6.19)
Cost C1(Rs/Hect)	6.36*	5.99*	5.49*	8.06*	2.73*	4.50*	4.99*	5.76*	6.59*	5.28*	7.51*	5.56*
	(13.19)	(6.94)	(6.85)	(11.70)	(10.06)	(2.99)	(14.30)	(5.69)	(12.51)	(7.61)	(6.89)	(6.75)
Cost C2(Rs/Hect)	7.39*	5.95*	5.30*	8.15*	3.76*	5.39*	7.10*	6.44*	8.13*	5.26*	8.03*	6.50*
	(13.31)	(8.55)	(5.17)	(8.67)	(9.72)	(5.33)	(19.00)	(6.81)	(10.22)	(6.19)	(7.53)	(6.44)
Cost C2 Revised(Rs/Hect)	7.42*	5.17*	5.55*	8.15*	3.78*	5.39*	6.46*	6.73*	8.12*	5.22*	8.25*	6.21*
	(13.39)	(8.36)	(5.37)	(8.67)	(9.39)	(5.33)	(20.12)	(6.90)	(10.25)	(6.18)	(9.19)	(6.59)
Cost of Production (Rs/Qtl):												
Cost A1(Rs/Qtl)	5.57*	6.71*	6.15*	4.92*	1.79	2.48*	1.86	5.40*	4.19*	5.25*	6.27*	5.03*
	(14.05)	(13.19)	(18.33)	(14.96)	(11.36)	(6.31)	(15.25)	(9.44)	(13.99)	(7.34)	(6.74)	(6.13)
Cost A2(Rs/Qtl)	5.99*	6.37*	3.69*	3.93	1.79	2.48*	0.36	5.18*	4.51*	5.23*	6.17*	5.58*
	(14.78)	(12.42)	(9.28)	(15.93)	(11.36)	(6.31)	(15.06)	(9.63)	(14.58)	(7.46)	(8.03)	(7.49)
Cost B1(Rs/Qtl)	5.37*	6.88*	5.79*	5.46*	2.08	2.54*	1.19	5.54*	4.96*	5.44*	6.87*	4.74*
	(13.64)	(12.78)	(18.25)	(16.40)	(10.97)	(6.61)	(16.13)	(9.39)	(13.67)	(8.39)	(9.00)	(5.20)
Cost B2(Rs/Qtl)	6.36*	6.61*	5.48*	6.64*	3.26*	3.56*	3.68	6.27*	6.52*	5.42*	7.23*	5.95*
	(13.32)	(10.85)	(17.01)	(16.81)	(11.30)	(6.05)	(13.97)	(9.42)	(11.04)	(7.80)	(7.93)	(5.32)
Cost C1(Rs/Qtl)	4.99*	6.49*	5.34*	4.81*	2.46	2.79*	1.33	5.08*	5.09*	5.84*	6.60*	4.68*
	(14.31)	(12.47)	(20.31)	(17.26)	(12.80)	(5.25)	(13.80)	(9.13)	(14.52)	(8.21)	(8.74)	(5.49)
Cost C2(Rs/Qtl)	6.00*	6.39*	5.19*	6.07*	3.40*	3.68*	3.38*	5.79*	6.48*	5.74*	6.98*	5.64*
	(13.88)	(10.99)	(18.82)	(17.48)	(12.82)	(4.94)	(11.77)	(9.23)	(11.79)	(7.65)	(7.73)	(5.71)
Cost C2 Revised(Rs/Qtl)	6.03*	5.83*	5.44*	6.07*	3.42*	3.68*	2.78	6.08*	6.48*	5.70*	7.20*	5.35*
	(14.02)	(12.26)	(20.11)	(17.48)	(12.53)	(4.94)	(13.01)	(9.46)	(11.83)	(7.68)	(8.83)	(6.12)
Cost C3(Rs/Qtl)	6.03*	6.43*	5.44*	6.07*	3.42*	3.68*	1.82	6.08*	5.64*	5.70*	7.20*	5.35*
	(14.02)	(9.75)	(20.11)	(17.48)	(12.53)	(4.94)	(10.53)	(9.46)	(11.89)	(7.68)	(8.83)	(6.12)
Value of Output produced per hectare:												
Derived Yield (Qtl./Hectare)	1.57*	-0.50	0.01	2.01	1.33*	2.91*	4.30	1.65	1.49*	0.18	1.19	1.92*
	(3.66)	(12.12)	(10.93)	(8.78)	(4.85)	(7.33)	(20.63)	(6.76)	(5.17)	(6.57)	(6.98)	(3.82)
Value of Main Product (Rs./Hectare)	9.56*	5.95*	8.58*	11.63*	8.37*	9.66*	14.11*	9.71*	9.62*	6.80*	11.16*	10.69*
	(14.16)	(16.74)	(10.05)	(13.82)	(11.23)	(17.19)	(36.16)	(14.67)	(11.15)	(17.08)	(12.65)	(6.53)
Value of By- Product (Rs./Hectare)	6.26*	7.66*	9.00*	9.78*	-2.74	-0.83	7.36*	2.03	15.63*	-0.98	7.34*	3.45*
	(13.98)	(12.12)	(14.75)	(24.03)	(7.45)	(8.56)	(26.41)	(10.59)	(53.95)	(11.19)	(9.04)	(9.11)

*Note: *means significant at 5% level*

Figures in the parentheses indicates percent instability of respective parameters

Table 1.2 : State-wise growth rates and instability of various input used in paddy cultivation in India (2000-01 and 2009-10)

Items/States	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Kerala	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Uttar Pradesh	West Bengal
Materials and input used per hectare:												
Seed (Kg.)	-0.95	0.02	-2.81	NIL	-1.44	NIL	-3.78	-0.13	NIL	NIL	NIL	-1.06
	(2.58)	(1.79)	(3.99)		(6.47)		(6.28)	(1.42)				(2.21)
Fertilizer (Kg. Nutrients)	2.87*	-2.03	0.29	-0.75	2.04	3.36*	4.96*	1.22	1.02	2.32*	4.59*	3.98*
	(4.56)	(12.72)	(9.65)	(8.06)	(8.68)	(4.95)	(19.46)	(5.94)	(8.20)	(6.34)	(8.76)	(10.85)
Manure (Qtl.)	-6.44	-0.61	24.97	NIL	-14.11	-9.32	-7.06	-0.08	3.25	-4.81	-0.98	-0.61
	(15.90)	(17.08)	(60.68)		(56.67)	(12.92)	(18.87)	(3.49)	(28.13)	(15.63)	(36.43)	(30.32)
Human Labour Family(hrs)	-5.29	-1.34	-2.92	-3.55	-2.44	-0.62	-2.34	-2.32	-3.55	-0.61	-0.45	-0.84
	(9.11)	(4.32)	(9.08)	(13.59)	(7.49)	(20.72)	(8.05)	(2.94)	(12.17)	(8.89)	(5.88)	(3.72)
Human Labour Attached(hrs)	-13.44	-6.31	-13.75	3.76	NIL	NIL	-11.47	4.65	-4.15	-1.46	-2.85	-14.29
	(16.35)	(15.96)	(63.44)	(31.33)			(91.24)	(42.74)	(10.29)	(33.79)	(64.79)	(67.79)
Human Labour-Casual(hrs)	-0.95	1.64	-0.56	3.38*	-2.00	-3.84	-2.02	1.15	1.76*	-4.19	-0.60	2.39*
	(3.70)	(15.57)	(6.10)	(8.23)	(7.64)	(5.81)	(25.35)	(4.90)	(3.32)	(7.29)	(5.33)	(4.19)
Human Labour Total (Man Hrs.)	-2.93	-0.98	-1.34	0.22	-2.19	-3.36	-2.37	-0.54	-1.14	-2.94	-0.45	0.65
	(3.59)	(2.40)	(3.55)	(10.06)	(3.64)	(7.12)	(7.78)	(1.92)	(5.43)	(6.59)	(3.58)	(2.67)
Animal Labour (Pair Hrs.)	-10.17	-2.07	-9.45	-9.96	-3.63	-30.22	-7.69	-0.60	15.24*	-11.45	-10.25	-4.49
	(14.00)	(4.51)	(14.12)	(65.10)	(13.20)	(48.30)	(11.74)	(6.01)	(44.36)	(20.58)	(29.09)	(9.84)
Rate per Unit (Rs.):												
Seed (Rs/Kg.)	11.37	3.95*	7.60*	NIL	3.97*	NIL	12.03*	4.11*	NIL	NIL	NIL	6.12*
	(46.05)	(6.64)	(11.37)		(11.71)		(20.49)	(8.15)				(9.20)
Fertilizer (Rs/Kg. Nutrients)	1.14*	5.07*	3.80*	1.82*	1.03*	-0.12	1.35*	1.56*	2.22*	1.55*	2.61*	2.54*
	(1.26)	(5.03)	(1.82)	(2.13)	(2.77)	(4.42)	(2.59)	(1.45)	(1.80)	(2.53)	(1.41)	(1.41)
Manure (Rs/Qtl.)	4.79*	4.23*	12.64*	NIL	4.42*	2.63*	8.21*	5.52*	8.65*	8.10*	3.75*	6.34*
	(12.06)	(6.35)	(46.76)		(11.37)	(7.00)	(8.00)	(4.32)	(7.35)	(12.04)	(13.66)	(7.81)
Human Labour (Rs/Man Hrs.)	10.84*	6.62*	6.76*	7.45*	6.53*	6.96*	8.66*	6.97*	10.28*	8.09*	6.92*	6.12*
	(17.27)	(8.69)	(8.80)	(7.77)	(20.17)	(7.02)	(8.65)	(7.16)	(14.81)	(10.18)	(8.89)	(8.19)
Animal Labour (Rs/Pair Hrs.)	6.99*	8.05*	8.41*	15.01*	5.78*	13.37*	8.18*	4.20*	7.15*	4.67	17.49*	2.53
	(20.11)	(5.30)	(9.84)	(38.42)	(16.98)	(43.92)	(12.92)	(8.05)	(12.51)	(16.64)	(33.33)	(19.57)

*Note : *means significant at 5% level*

Figures in the parentheses indicates percent instability of respective parameters

Table 1.3 : State-wise growth rates and instability of break-up operational cost of paddy cultivation in India (2000-01 and 2009-10) (Rs. ha^{-1})

Items/States	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Kerala	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Uttar Pradesh	West Bengal
Operational Cost (Rs ha^{-1})	6.63*	5.89*	5.84*	6.28*	2.59	4.41*	5.77*	5.63*	5.87*	5.39*	7.42*	5.70*
	(13.83)	(7.49)	(7.06)	(13.71)	(10.66)	(3.32)	(12.62)	(6.47)	(13.09)	(6.98)	(6.66)	(7.69)
Operational Cost (Rs Qtl^{-1})	4.98*	6.43*	5.83*	4.18	1.24	1.45	1.41	3.91*	4.32*	5.21*	6.15*	3.71*
	(14.35)	(12.12)	(19.98)	(20.03)	(12.98)	(6.70)	(14.52)	(8.67)	(14.65)	(7.31)	(8.98)	(7.16)
Break up of Human Labour (Rs ha^{-1})												
Family Labour(Rs ha^{-1})	4.37	5.19*	3.96	4.25	4.28	7.27*	5.96*	4.21*	6.67*	8.11*	6.68*	5.38*
	(19.21)	(5.07)	(16.51)	(21.24)	(26.52)	(15.82)	(10.66)	(7.11)	(20.28)	(13.25)	(10.50)	(8.50)
Attached Labour(Rs ha^{-1})	-4.18	-0.88	-8.53	12.48*	NIL	NIL	-2.67	10.33	5.98*	8.01	4.91	-8.99
	(28.12)	(17.62)	(64.94)	(23.35)			(82.22)	(39.98)	(16.80)	(38.62)	(87.69)	(71.45)
Casual Labour(Rs ha^{-1})	9.92*	8.54*	6.18*	10.64*	4.30*	2.77*	6.47	8.34*	12.01*	3.29*	6.02*	8.55*
	(14.21)	(25.57)	(7.57)	(17.31)	(13.68)	(4.14)	(35.15)	(12.04)	(19.09)	(6.74)	(7.09)	(8.22)
Total Human labour (Rs ha^{-1})	7.59*	5.58*	5.33*	7.69*	4.19	3.37*	6.07*	6.40*	9.03*	4.91*	6.43*	6.81*
	(15.91)	(9.40)	(9.38)	(16.77)	(17.20)	(3.34)	(16.40)	(8.11)	(17.41)	(9.16)	(8.36)	(7.98)
Hired Animal Labour(Rs ha^{-1})	1.68	-7.79	-6.11	NIL	6.46*	-20.79	12.50*	11.04*	NIL	-6.53	-13.58	9.61*
	(13.39)	(42.31)	(31.86)		(11.60)	(48.80)	(14.63)	(18.27)		(21.33)	(61.79)	(15.88)
Owned Animal Labour(Rs ha^{-1})	-5.30	5.96*	-0.61	3.14	0.40	NIL	-2.34	3.05*	23.50*	-8.20	6.66*	-4.10
	(36.75)	(4.53)	(22.27)	(52.28)	(30.77)		(15.62)	(10.72)	(49.75)	(43.77)	(31.97)	(27.18)
Total Animal Labour(Rs ha^{-1})	-3.90	5.80*	-1.84	3.24	1.94	-20.88	-0.14	3.57*	23.51*	-7.32	5.45	-2.07
	(26.97)	(4.30)	(17.00)	(51.40)	(22.11)	(51.99)	(13.38)	(9.53)	(49.68)	(20.89)	(33.49)	(23.54)
Hired Machine Labour(Rs ha^{-1})	14.75*	18.98*	10.31*	12.56*	6.96*	15.07*	23.15*	14.04*	8.48*	13.44*	8.87*	11.38*
	(16.91)	(73.57)	(17.25)	(11.69)	(15.54)	(29.13)	(23.20)	(16.32)	(11.28)	(5.73)	(20.06)	(18.82)
Owned Machine Labour(Rs ha^{-1})	-8.88	6.01*	-8.88	6.57*	25.69*	24.12	21.85	31.62*	4.42	3.87	12.14*	16.68
	(47.77)	(22.43)	(116.72)	(19.46)	(58.45)	(109.28)	(103.61)	(65.17)	(23.65)	(35.29)	(26.60)	(77.17)
Total Machine Labour(Rs ha^{-1})	14.26*	15.79*	10.06*	9.91*	8.10*	15.20*	22.87*	14.84*	6.33*	13.10*	9.29*	11.43*
	(17.08)	(61.36)	(16.35)	(8.95)	(9.68)	(28.34)	(22.49)	(14.27)	(12.47)	(6.43)	(18.81)	(19.04)
Seed (Rs ha^{-1})	10.30*	3.97*	4.57*	13.06*	2.48	3.28*	7.80*	3.98*	7.65*	3.92	8.03*	4.99*
	(46.38)	(5.77)	(13.02)	(23.27)	(17.15)	(9.23)	(12.75)	(7.00)	(10.80)	(28.69)	(5.43)	(7.86)
Fertilizer(Rs ha^{-1})	4.04*	2.93	4.11*	1.06	3.09*	3.25*	6.38*	2.80*	3.27*	3.91*	7.32*	6.62*
	(3.72)	(16.52)	(10.79)	(8.42)	(10.55)	(5.91)	(20.52)	(5.99)	(8.30)	(6.36)	(8.66)	(11.16)
Manure(Rs ha^{-1})	-1.96	3.61	41.63*	NIL	-10.31	-6.94	0.57	5.43*	12.17*	2.90	2.72	5.69
	(14.01)	(18.78)	(78.42)		(62.54)	(10.66)	(21.23)	(4.25)	(25.43)	(12.33)	(38.87)	(24.55)
Total fertilizer & manure(Rs ha^{-1})	2.95*	3.40*	5.37*	0.70	-0.09	-0.72	3.72	3.74*	3.85*	3.63*	6.97*	6.26*
	(4.14)	(11.51)	(7.98)	(8.06)	(16.54)	(3.40)	(15.87)	(3.14)	(8.36)	(3.73)	(7.30)	(9.77)
Insecticides(Rs ha^{-1})	6.52*	-12.94	NIL	5.46	-11.67	12.90*	52.20*	2.47	6.07*	10.18*	13.42*	5.98*
	(18.02)	(78.24)		(20.62)	(27.36)	(55.76)	(100.23)	(15.82)	(13.28)	(24.53)	(46.74)	(18.61)
Irrigation Charges(Rs ha^{-1})	-9.19	20.73*	23.07	3.50	-6.69	NIL	9.98	4.77	-2.33	1.26	9.64*	5.26
	(16.58)	(55.14)	(104.60)	(14.92)	(49.42)		(42.90)	(19.41)	(39.21)	(21.17)	(29.79)	(24.50)
Interest on Working Capital(Rs ha^{-1})	7.06*	6.47*	6.33*	7.02*	2.18	4.11*	5.67*	6.18*	5.74*	4.94*	7.70*	5.86*
	(12.93)	(10.41)	(6.33)	(8.70)	(9.28)	(5.38)	(15.58)	(6.51)	(12.45)	(6.39)	(6.20)	(7.89)

*Note : *means significant at 5% level*
Figures in the parentheses indicates percent instability of respective parameters

Table 1.4 : State-wise growth rates and instability of break-up fixed cost incurred in paddy cultivation in India (2000-01 to 2009-10)

Items/States	Andhra Pradesh	Assam	Bihar	Haryana	Karnataka	Kerala	Madhya Pradesh	Orissa	Punjab	Tamil Nadu	Uttar Pradesh	West Bengal
Fixed Costs(Rs/Hect)	8.73*	6.06*	4.17*	10.62*	6.56*	8.50*	9.38*	8.14*	10.55*	4.94*	9.06*	8.52*
	(13.20)	(11.80)	(4.50)	(10.21)	(10.50)	(13.44)	(34.31)	(9.48)	(9.47)	(7.16)	(13.34)	(4.12)
Rental Value of Owned	8.79*	6.50*	4.68*	12.23*	6.67*	8.42*	13.32*	9.05*	10.68*	5.18*	10.10*	8.41*
Land(Rs/Hect)	(12.71)	(16.21)	(6.04)	(9.03)	(10.94)	(14.69)	(35.09)	(13.38)	(10.48)	(4.63)	(12.93)	(4.93)
Rent Paid For Leased-in-	21.66	-0.93	NIL	-25.46	NIL	NIL	NIL	-8.93	8.99	6.95	-22.09	38.18*
Land(rs/Hect)	(89.82)	(24.00)		(46.08)				(38.27)	(36.93)	(46.76)	(92.22)	(60.37)
Land Revenue, Taxes, Cesses	-36.26	1.38*	0.75	NIL	-1.45	-1.40	-0.60	1.41*	NIL	4.23	-4.60	7.05*
(Rs/Hect)	(65.35)	(4.51)	(15.75)		(25.85)	(9.31)	(19.02)	(3.36)		(14.64)	(11.19)	(18.32)
Depreciation on Implements &	-2.06	5.11*	-1.73	0.26	-1.21	8.66*	0.74	5.70*	8.00*	-1.64	2.99	7.62*
Farm Building(Rs/Hect)	(10.37)	(5.61)	(16.22)	(58.06)	(13.92)	(14.93)	(30.70)	(9.13)	(26.63)	(18.85)	(11.88)	(13.19)
Interest on Fixed Capital(Rs/Hect)	2.91	7.60*	3.98*	11.71*	7.65*	16.06*	1.03	7.74*	13.22*	5.41	9.31*	2.05
	(14.60)	(11.08)	(13.22)	(22.65)	(15.17)	(34.97)	(30.54)	(12.16)	(12.25)	(23.70)	(20.15)	(17.19)
Total Cost(Rs/Hect)	7.39*	5.95*	5.30*	8.15*	3.76*	5.39*	7.10*	6.44*	8.13*	5.26*	8.03*	6.50*
	(13.31)	(8.55)	(5.17)	(8.67)	(9.72)	(5.33)	(19.00)	(6.81)	(10.22)	(6.19)	(7.53)	(6.44)

Note: *means significant at 5% level

Figures in the parentheses indicates percent instability of respective parameters

Table 1.5 : State-wise total factor productivity growth rate of paddy in India over 2000-01 to 2009-10

States	Exponential trend of total output indices (TOI)	Growth Rate (%)	Exponential trend of total input indices (TII)	Growth Rate (%)	Exponential trend of total factor productivity indices (TFPI)	Growth Rate (%)
Andhra Pradesh	$Y = 104.60e^{0.01x}$ $R^2 = 0.45$	1.25*	$Y = 98.95e^{0.0005x}$ $R^2 = 0.004$	0.05 (NS)	$Y = 105.71e^{0.01x}$ $R^2 = 0.35$	1.20 (NS)
Assam	$Y = 90.00e^{0.01x}$ $R^2 = 0.05$	1.10 (NS)	$Y = 96.75e^{-0.0009x}$ $R^2 = 0.008$	-0.09 (NS)	$Y = 93.02e^{0.01x}$ $R^2 = 0.06$	1.19 (NS)
Bihar	$Y = 105.16e^{-0.01x}$ $R^2 = 0.11$	-1.47 (NS)	$Y = 102.03e^{0.01x}$ $R^2 = 0.24$	1.13 (NS)	$Y = 103.06e^{-0.03x}$ $R^2 = 0.17$	-2.58 (NS)
Haryana	$Y = 112.73e^{0.0022x}$ $R^2 = 0.01$	0.22 (NS)	$Y = 112.50e^{0.01x}$ $R^2 = 0.27$	1.38 (NS)	$Y = 100.20e^{-0.01x}$ $R^2 = 0.07$	-1.14 (NS)
Karnataka	$Y = 108.34e^{0.01x}$ $R^2 = 0.38$	1.31 (NS)	$Y = 106.62e^{-0.02x}$ $R^2 = 0.58$	-1.81*	$Y = 101.61e^{0.03x}$ $R^2 = 0.72$	3.18*
Kerala	$Y = 89.30e^{0.03x}$ $R^2 = 0.64$	3.13*	$Y = 101.09e^{-0.01x}$ $R^2 = 0.65$	-0.58*	$Y = 88.34e^{0.04x}$ $R^2 = 0.72$	3.74*
Madhya Pradesh	$Y = 72.41e^{0.05x}$ $R^2 = 0.35$	4.82 (NS)	$Y = 89.30e^{-0.01x}$ $R^2 = 0.07$	-0.55 (NS)	$Y = 81.08e^{0.05x}$ $R^2 = 0.47$	5.40*
Orissa	$Y = 93.24e^{0.0036x}$ $R^2 = 0.02$	0.36 (NS)	$Y = 97.28e^{0.0033x}$ $R^2 = 0.26$	0.34 (NS)	$Y = 95.85e^{0.0002x}$ $R^2 = 0.008$	0.02 (NS)
Punjab	$Y = 103.89e^{0.01x}$ $R^2 = 0.08$	0.57 (NS)	$Y = 115.73e^{0.01x}$ $R^2 = 0.03$	0.56 (NS)	$Y = 89.78e^{0.0001x}$ $R^2 = 0.002$	0.01 (NS)
Tamil Nadu	$Y = 96.72e^{0.01x}$ $R^2 = 0.20$	1.03 (NS)	$Y = 95.79e^{0.01x}$ $R^2 = 0.48$	0.86*	$Y = 100.98e^{0.0015x}$ $R^2 = 0.01$	0.16 (NS)
Uttar Pradesh	$Y = 96.13e^{0.02x}$ $R^2 = 0.30$	1.52 (NS)	$Y = 102.14e^{0.02x}$ $R^2 = 0.43$	1.53*	$Y = 94.12e^{-0.0001x}$ $R^2 = 0.007$	-0.01 (NS)
West Bengal	$Y = 99.68e^{0.01x}$ $R^2 = 0.56$	0.84*	$Y = 98.28e^{0.01x}$ $R^2 = 0.59$	1.08*	$Y = 101.43e^{-0.0024x}$ $R^2 = 0.05$	-0.24 (NS)

*Note: *means Significant at 5% level, NS: Non-Significant at 5% level*

Table 1.6 : Multiple step-wise linear regressions between change in output over change in various inputs used in paddy cultivation across major states of India during 2000-01 to 2009-10

States	Regression equation	Parameters	Remarks
Andhra Pradesh	$Y = (-)\ 0.007 + 3.786\ X_6$*	X_6: plant protection chemicals	Plant protection chemicals has a positive impact on output and become the key factor contributor for change in TFP over time.
Assam	$Y = 0.061\ (-)\ 47.111\ X_5$* $Y = 0.016\ (-)\ 1.556\ X_5$*	X_5: irrigation charges	Irrigation charges has a negative impact over output, features as the sole factor contributor for change in TFP over time.
Bihar	$Y = (-)\ 0.001\ (-)\ 2.085\ X_5$**+ $2.936\ X_4$**	X_5: irrigation charges X_4: machine labour use	Irrigation followed by machine labour use become the prime contributor over output where irrigation has an inverse effect on output and farm mechanization has a positive impact on overall productivity change.
Haryana	$Y = (-)\ 0.019 + 7.232\ X_1\ (-)\ 1.088\ X_2\ (-)\ 16.642\ X_3 + 2.352\ X_4\ (-)\ 0.615\ X_5\ (-)\ 1.260\ X_6 + 16.700\ X_7 + 0.592\ X_8 + 20.885\ X_9$	X_1: seed use X_2: fertilizer use X_3: organic manure use X_4: machine labour use X_5: irrigation charges X_6: plant protection chemicals X_7: bullock labour use X_8: human labour use X_9: interest on working capital	The equation includes all the variables where seed use, mechanization, bullock labour use, human labour contribution and interest on working capital have positive impact on output change whereas fertilizer and manure use, irrigation and plant protection chemicals have detrimental effect on the change in productivity over the period.
Karnataka	$Y = (-)\ 0.002 + 2.594\ X_2$*$Y = 0.003 + 2.829\ X_2$** $+ 0.883\ X_3$*	X_2: fertilizer use X_3: organic manure use	Fertilizer and manure use are the most contributable factors for change in output over time where both the inputs have positive impact on productivity.
Kerala	$Y = (-)\ 0.411 + 47.288\ X_1 + 238.485\ X_2 + 25.667\ X_3\ (-)\ 19.030\ X_4\ (-)\ 81.682\ X_6 + 27.076\ X_7\ (-) 17.848\ X_8$	X_1: seed use X_2: fertilizer use X_3: organic manure use X_4: machine labour use X_6: plant protection chemicals X_7: bullock labour use X_8: human labour use	The regression equation includes all the variables excepting irrigation charges and interest on working capital which have no impact on output change. Seed, fertilizer and organic manure use have positive impact on the overall productivity of crop but farm mechanization, use of insecticides and human labour use have the negative impact on output change.
Madhya Pradesh	$Y = 0.051\ (-)\ 8.591\ X_5$*$Y = 0.100\ (-)\ 8.523\ X_5$** $+ 4.496\ X_8$*$Y = 0.055\ (-)\ 8.016\ X_5$** $+ 3.521\ X_8$* $+ 34.410\ X_9$*	X_5: irrigation chargesX_8: human labour use X_9: interest on working capital	Irrigation charges has a negative impact on productivity change whereas human labour use and interest on working capital have been identified as prime factor contributor with positive impact on output change.
Orissa	$Y = 0.019 + 5.247\ X_8$**	X_8: human labour use	Human labour contribution features maximum for overall productivity change during entire period of time.
Punjab	$Y = (-)\ 0.377 + 36.400\ X_1\ (-)\ 19.933\ X_2\ (-)\ 36.267\ X_3 + 9.300\ X_4\ (-)\ 5.600\ X_5\ (-)\ 18.267\ X_6 + 89.000\ X_7\ (-)\ 11.267\ X_8 + 163.167\ X_9$	X_1: seed use X_2: fertilizer use X_3: organic manure use X_4: machine labour use X_5: irrigation charges X_6: plant protection chemicals X_7: bullock labouruse X_8: human labour use X_9: interest on working capital	All the variables included in the regression equation where fertilizer and manure use, irrigation charges, plant protection chemicals and human labour factors showing negative impact on productivity change whereas farm mechanization has shown positive relation with the change in output over time.
Tamil Nadu	$Y = (-)\ 0.084 + 3.992\ X_4$*	X_4: machine labour use	Farm mechanization is the key factor contributor responsible for overall productivity change over the period of time.
Uttar Pradesh	$Y = 0.027\ (-)\ 1.649\ X_5$*$Y = 0.004\ (-)\ 1.899\ X_5$** $+ 5.180\ X_2$*$Y = (-)\ 0.001\ (-)\ 1.183\ X_5$** $+ 6.241\ X_2$** $+ 7.609\ X_3$**	X_5: irrigation chargesX_2: fertilizer use X_3: organic manure use	Irrigation charges with its negative impact on productivity change became the key factor contributor followed by use of inorganic fertilizer and manure use in paddy cultivation have shown positive impact over change in output.
West Bengal	$Y = 0.022\ (-)\ 1.196\ X_2 + 6.748\ X_3 + 4.786\ X_4\ (-)\ 5.872\ X_5\ (-)\ 18.879\ X_6\ (-)\ 4.013\ X_7 + 3.694\ X_8$	X_2: fertilizer use X_3: organic manure use X_4: machine labour use X_5: irrigation charges X_6: plant protection chemicals X_7: bullock labour use X_8: human labour use	Barring seed use and interest on working capital, all the variables has been showing impact on productivity change where fertilizer use, irrigation charges, plant protection measures and bullock labour use have negative impact but organic manure showing positive effect indicating promotion for organic agriculture. Farm mechanization has also been a positive impact on output change over the period. Human labour use has a positive impact on the overall productivity change for paddy.

*Note: *means significant at $p_{0.05}$ level **means significant at $p_{0.01}$ level (-) means negative value*

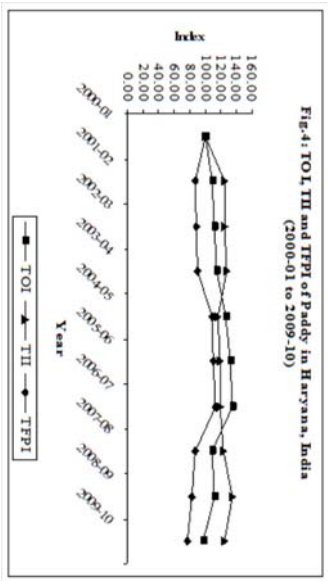
Table 1.7 : Correlation matrix between changes in output to changes in various inputs used in paddy cultivation across major states of India during 2000-01 to 2009-10

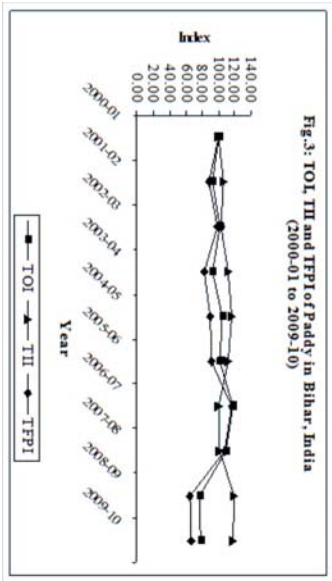
States	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Andhra Pradesh	1.000	-	0.442	0.052	(-) 0.317	0.275	0.681*	0.457	0.676*	0.079
Assam	1.000	-	0.133	(-) 0.188	0.135	(-) 0.698*	-	0.449	0.623	-
Bihar	1.000	(-) 0.025	0.368	(-) 0.164	0.128	(-) 0.765*	-	(-) 0.294	(-) 0.326	-
Haryana	1.000	0.432	(-) 0.094	(-) 0.026	(-) 0.156	0.029	(-) 0.442	0.468	0.391	0.296
Karnataka	1.000	(-) 0.201	0.728*	0.364	0.040	(-) 0.689*	0.282	0.196	(-) 0.082	-
Kerala	1.000	0.212	0.430	(-) 0.369	0.464	-	0.356	(-) 0.502	(-) 0.351	-
Madhya Pradesh	1.000	(-) 0.662	0.664*	(-) 0.098	0.184	(-) 0.746*	0.455	0.098	0.510	0.562
Orissa	1.000	-	0.029	(-) 0.003	(-) 0.033	(-) 0.606	-	0.297	0.785**	-
Punjab	1.000	0.022	0.117	0.094	0.434	(-) 0.068	(-) 0.046	(-) 0.070	(-) 0.135	(-) 0.105
Tamil Nadu	1.000	0.454	0.482	0.232	0.693*	0.282	-0.033	0.283	0.085	-
Uttar Pradesh	1.000	(-) 0.227	0.300	0.708*	(-) 0.241	(-) 0.722*	0.089	(-) 0.120	(-) 0.199	-
West Bengal	1.000	-	0.000	0.234	(-) 0.094	(-) 0.025	0.126	0.029	0.382	-

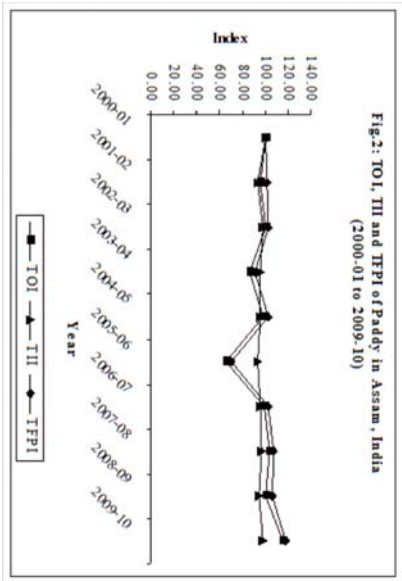
Note: X_1: seed use X_2: fertilizer use X_3: organic manure use X_4: machine labour use X_5: irrigation charges X_6: plant protection chemicals X_7: bullock labour use X_8: human labour use X_9: interest on working capital

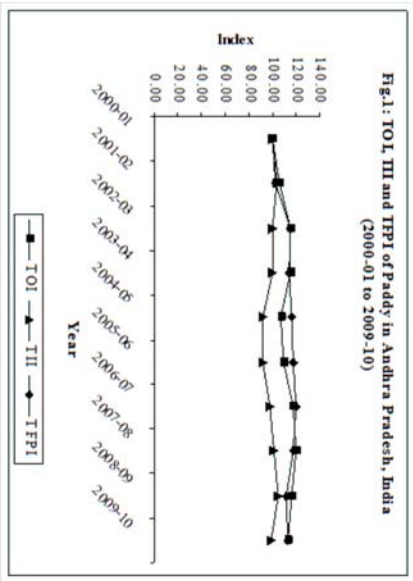
**means significant at $p_{0.05}$ level*

***means significant at $p_{0.01}$ level(-) means negative value*









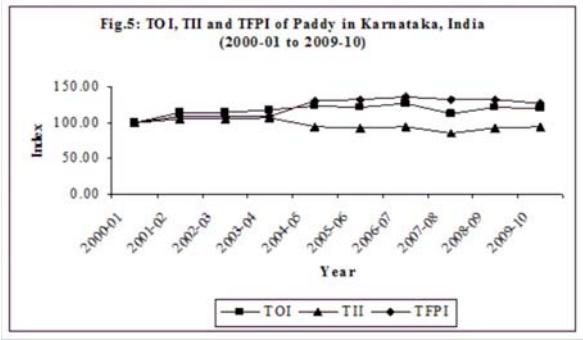


Fig.5: TOI, TII and TFPI of Paddy in Karnataka, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

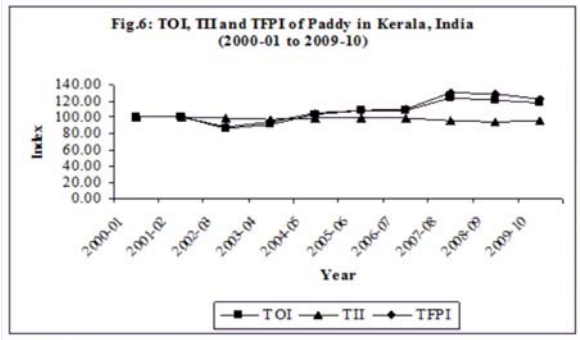


Fig.6: TOI, TII and TFPI of Paddy in Kerala, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

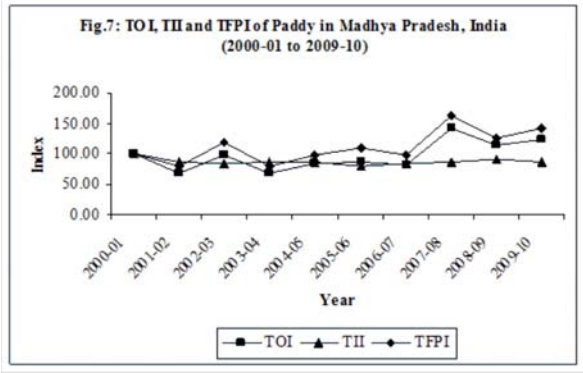


Fig.7: TOI, TII and TFPI of Paddy in Madhya Pradesh, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

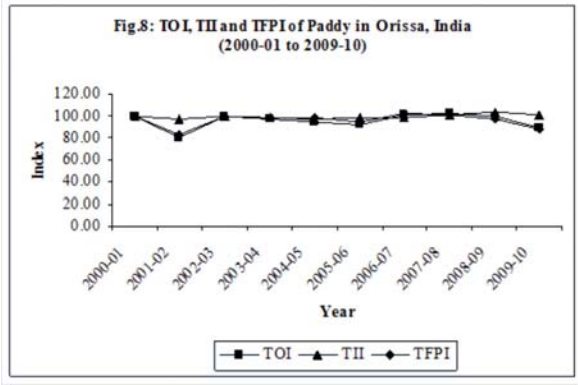


Fig.8: TOI, TII and TFPI of Paddy in Orissa, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

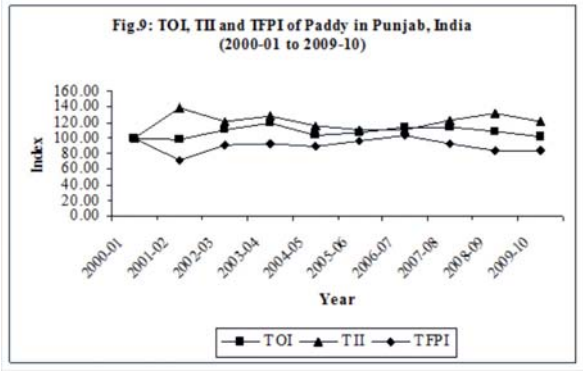


Fig.9: TOI, TII and TFPI of Paddy in Punjab, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

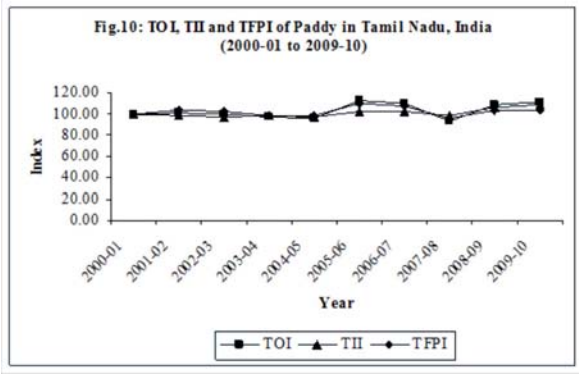


Fig.10: TOI, TII and TFPI of Paddy in Tamil Nadu, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

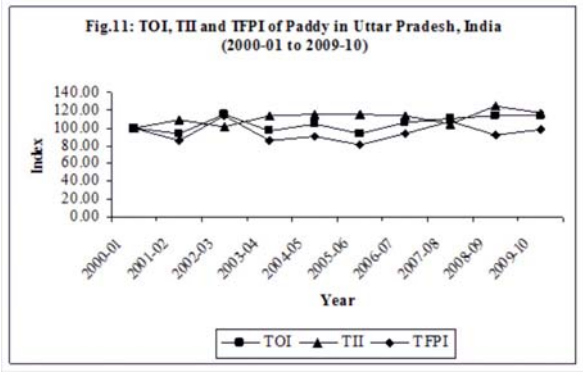


Fig.11: TOI, TII and TFPI of Paddy in Uttar Pradesh, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

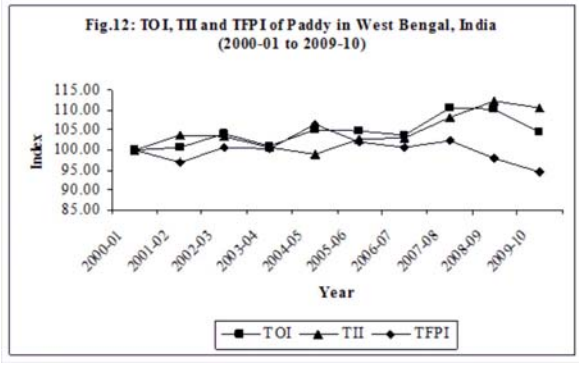


Fig.12: TOI, TII and TFPI of Paddy in West Bengal, India
(2000-01 to 2009-10)
Index
Year
TOI
TII
TFPI

***Cost C2 Revised*:** Cost C2 Revised includes additional value of human labour based on higher wage rate or prevailing market rate (whichever is higher). Haryana, Punjab and Uttar Pradesh have occupied the highest level of growth rates (8.15%, 8.12% and 8.25%) followed by a handsome rate of change in Andhra Pradesh (7.42%).

***Cost of Production for Paddy*:** Cost per unit of output has been increased in a mammoth rate over the last decade (2000-01 to 2009-10), where highest rate of change in Cost A1 was observed in the state of Assam (6.71%) followed by Uttar Pradesh (6.27%) and Bihar (6.15%). Assam and Uttar Pradesh regained its position for change in Cost A2 component while Bihar shows lesser tendency of paying rent for leased land to the landlords only showing a 3.69 per cent increase of Cost A2 over the year studied. The picture was more or less same for Cost B1 where the maximum growth rate of change in fixed capital assets excluding land was observed in Assam (6.88%) followed by Uttar Pradesh (6.87%). But the change in Cost B2 (including rental value of owned land) were dominated by Haryana and Punjab as these states occupies large amount of land used for non-agricultural purposes, that's why the opportunity cost of land came into act. The marked rate of change in Cost C1, C2 and C2 Revised also occupied by Haryana, Punjab and Uttar Pradesh and Assam subsequently as these states are the well contributor of family labour to the cultivation aspect of paddy. Cost C3 includes the managerial cost added to Cost C2 Revised, where no managerial cost has been incurred in the state of Uttar Pradesh, Andhra Pradesh, Bihar, Haryana, Karnataka, Kerala, Orissa, Tamil Nadu and West Bengal. Assam has registered the highest rate of change, jumped up from 5.83 to 6.43 per cent in Cost C2 Revised to Cost C3 *i.e.* the final cost.

***Output Growth*:** The highest significant growth rate in derived yield of paddy over the decade was registered 2.91 per cent in Kerala with over 90.0 per cent stability followed by 1.92 per cent in West Bengal and 1.57 per cent in Andhra Pradesh with more than 95.0 per cent stability. These states are rich in paddy cultivation where rice based cropping system prevails here. Gross output from one hectare paddy cultivation has been changed significantly in a mammoth rate in all the states of India over the last decade under study. The highest rate of change was registered in Madhya Pradesh (14.11%) with 64.0 per cent stability followed by Haryana (11.63%), Uttar Pradesh (11.16%) and West Bengal (10.69%). Rate of change of return from straw over the period has been registered highest in Punjab (15.63%), followed by Haryana (9.78%) and Bihar (9.00%).

State wise growth rates and instability in various input use and break-up cost of paddy in India

Table 1.2 and 1.3 measures the state-wise growth rates and instability of various input use as well as break up cost of different input used per hectare of paddy cultivation. Regarding seed use, the states of Haryana, Kerala, Punjab, Tamil Nadu and Uttar Pradesh have their usual practice of seedlings raising instead of seed sowing and transplanting as common agronomic practices. For that reason, the seed use data were not available for those states. It was seen critically from the results that almost all the states have registered declining trend in seed use over the decade with stability over 95.0 per cent. That ensures the introduction of HYV seed instead of local one that yields more with lesser quantity use. Inorganic fertilizer use has been increased to a certain extent in almost all the states of India where highest change was observed in Madhya Pradesh (4.96%) followed by Uttar Pradesh (4.59%) and West Bengal (3.98%). Organic manure use in paddy cultivation has been decreased over the decade except Punjab at 80-85.0 per cent stability level. Human labour has been reduced and converted into hired machine labour at the onset of farm mechanization in India. The overall picture of human labour has been drastically changed over the decade. Family labour use has been reduced much across the states with negative trend over the year. Subsequently, the use of hired casual labour has been increased in Haryana (3.38%), West Bengal (2.39%) and Punjab (1.76%). Since the introduction of farm machineries incorporated in paddy cultivation across the states of India, the use of bullock labour has been declined to a greater extent barring Punjab (15.24%) where animal labour has been used to a negligibly small extent. Among all inputs, the rate of Human labour shows its consistency over the year with a stable rate. The highest growth of wage rate for the hired labour was observed in Andhra Pradesh (10.84%), followed by Punjab (10.28%) with more than 80.0 per cent stability. Bullock labour rate has been found to be maximum in Haryana (15.01%) followed by Kerala (13.37%). Operational cost per hectare for paddy cultivation has been increased significantly to a greater extent over the year across all the states of India, where highest growth rate was observed in Uttar Pradesh (7.42%) followed by Andhra Pradesh (6.63%) and Haryana (6.28%). Operational cost per quintal has also been increased with a significant rate where Assam got the highest change (6.43%) followed by Uttar Pradesh (6.15%), Bihar (5.83%) and Tamil Nadu (5.21%). Cost of labour both hired and owned has been significantly increased a lot where Tamil Nadu stood the first position in family labour growth (8.11%) followed by Kerala (7.27%), Uttar Pradesh

(6.68%) and Punjab (6.67%). Casual labour growth has been found to be robust in Punjab too (12.01%) followed by Haryana (10.64%), West Bengal (8.55%), Assam (8.54%) and Orissa (8.34%) with over 75.0 per cent stability. Attached labour cost has been reduced significantly except Haryana (12.48%) as it is found to be more cost bearing nowadays. Farmers and growers used to apply seasonal hired labour at the time of need and requirement for maintaining cultivation operation smoothly. It is both cost effective and remunerative too for the landlords. Bullock labour has nowadays been implemented in some selected pockets of India where Madhya Pradesh registered the highest growth rate of cost of hired bullock (12.50%) followed by Orissa (11.04%) and West Bengal (9.61%). Owned bullock cost has been changed to a mammoth extent in Punjab (23.50%). Use of machineries like tractors and power tillers instead of bullock has been observed to a greater extent in the last decade and being the common practice for cultivation across all the states of India. The hired machine cost has been raised to 23.15 per cent in Madhya Pradesh followed by Assam (18.98%), Kerala (15.07%), Orissa (14.04%) and Tamil Nadu (13.44%). Cost of seed has been increased to a greater extent in almost all the states where Haryana (13.06%), Andhra Pradesh (10.30%), Uttar Pradesh (8.03%), Madhya Pradesh (7.80%) as these states have their usual practice of seedling raising instead of seed sowing and transplanting. The cost of inorganic fertilizer has been increasing over time as the decade progresses where fertilizer cost has been featured highest in Uttar Pradesh (7.32%) followed by West Bengal (6.62%) and Madhya Pradesh (6.38%). Growth of organic manure cost has been found to be insignificant amongst all states except Bihar registered a gigantic 41.63 per cent growth over the decade. Use of insecticides and pesticides has been raised over the time where the cost of plant protection chemicals has been raised to over 10.0 per cent with fluctuations and unstable rate. Rice has still been cultivated as rainfed crop in rainy season as cost of irrigation does not affect much to the overall operational cost barring Assam (20.73%) and Uttar Pradesh (9.64%). Interest on working capital has been inclined to a mammoth rate over all the states where highest rate was registered in Uttar Pradesh (7.70%) followed by Andhra Pradesh (7.06%) and Haryana (7.02%).

State wise growth rates and instability in various fixed cost break up of paddy in India

Table 1.4 highlighted the growth rates of various fixed costs incurred in paddy cultivation across all the states of India. The table clearly depicts that there has been a significant rise in the fixed cost of paddy across all the states where Haryana and Punjab exhibits a fantastic rise in the fixed costs over the decade (10.62% and 10.55% respectively) followed by Madhya Pradesh (9.38%), Uttar Pradesh (9.06%) and Andhra Pradesh (8.73%) with over 85.0 per cent stability. This is due to the excessive rise in the value of land over the regions in India during last decade. The opportunity cost of land has been increased up to 13.32 per cent in Madhya Pradesh followed by a marked increase in Haryana (12.23%), Punjab (10.68%) and Uttar Pradesh (10.10%). Dominancy in the leased-in land has been marked in West Bengal where a significant 38.18 per cent increase in rent paid for leased-in land has been recorded over the decade. This is because of the 85.0 per cent dominancy of marginal and small farming community in this state with an average size of holding of 0.77 hectare for all size classes and 0.49 hectare for the marginal farmers (Anonymous 2014). Interest on fixed capital over the decade crosses 10.0 percent mark in Kerala (16.06%), Punjab (13.22%) and Haryana (11.71%). Overall the total cost of paddy cultivation per hectare has been increased with a steady growth rate over the decade in all the states of India. Haryana, Punjab and Uttar Pradesh, the three dominating states of India in regards to agricultural growth and development over the years have registered an 8.15 per cent, 8.13 per cent and 8.03 per cent increase in total cost of cultivation of paddy cultivated per hectare of land.

State-wise decadal change in Total Factor Productivity (TFP) for paddy over 2000-01 to 2009-10

Table 1.5 highlights the state-wise total output growth, total input growth and total factor productivity growth rates for paddy over the period 2000-01 to 2009-10 that has also been illustrated in figures (Fig.1 to Fig.12). The growth rate in total factor productivity (TFP) exhibits the ratio between relative changes in output growth to that of input growth, measures the extent of technological change in paddy cultivation across major paddy growing states of India over last decade. The table features that the technological change in paddy cultivation has been occurred significantly in the state of Madhya Pradesh (5.40%) followed by Kerala (3.74%) and Karnataka (3.18%) where the output changes in faster mode than the input use. Assam and Andhra Pradesh features an unsteady rate of change in TFP (1.19% and 1.20%) where in other states, the technological advancement in paddy cultivation has been choked. This is due to the over use of inorganic fertilizer, plant protection chemicals that would hamper the inherent fertility status of the soil. The extent of overuse in input use can be visualized in the state of Bihar and Haryana where a negative rate of change in TFP (-2.58 and -1.14%) has been observed. West Bengal, Tamil Nadu, Orissa, Punjab and Uttar Pradesh exhibits stagnancy in total factor productivity change in the context of paddy cultivation over the period.

Correlation and Multiple Regression analysis for identification of factor contribution of rice in the states of India

Table 1.6 and 1.7 exhibits the correlation matrices as well as multiple linear regressions between changes in output over change in all factors of production for paddy across the major states of India. Use of plant protection chemicals has a strong positive relationship (0.681) with the change in output over time in Andhra Pradesh and become the key factor contributor for overall change in productivity. Human labour use has been another contributable factor here next to the plant protection measures. Irrigation has been the key factor identified in the state of Assam with a negative impact on productivity (-0.698) because the state belongs to a heavy rainfall region that has reduced the overall productivity of rice. The picture is more or less same for Bihar where a strong negative correlation between changes in output to that of change in irrigation has been observed. All the factors are equally contributable in Haryana state where use of seed, machineries, bullock labour, human labour and interest on working capital have shown positive impact on change in output over time whereas inorganic fertilizer and manure use, irrigation and plant protection chemicals have registered negative impact on productivity change. Fertilizer (correlation coefficient 0.728) and manure use has been identified the most promising factor contributed for overall change in the productivity of paddy in Karnataka for the last decade that has already been reported by Kannan (2011). Irrigation factor has been found negligible contribution over productivity change in Kerala. Rest of the factors is contributed equally in productivity change over decade. Irrigation too has a negative impact (correlation coefficient -0.746) on productivity change in Madhya Pradesh as most of the region has adopted cultivation of paddy in rainfed situation. Human labour use has an effect to overall productivity change of paddy in the state. Use of human labour has been the key parameters in Orissa too while farm mechanization has been the sole factor contributor identified in Tamil Nadu for overall change in output. Punjab has shown inclusion of all the factors which have equal impact on change in productivity of paddy over the period. The same feature was observed for the state of West Bengal where the use of inorganic fertilizer, irrigation charges, plant protection chemicals and bullock labour use have negative impact on productivity as has been observed by Chatterjee *et. al*., 2013, whereas the machine labour use and organic manure have shown positive regression coefficient with output change owing to farm mechanization in the light of organic agriculture in the state. Almost same result was observed in Uttar Pradesh where inclusion of inorganic fertilizer and organic manure as second and third factor has promoted a combination of organic and inorganic package of practices for paddy cultivation in the state over the decade (2000-01 to 2009-10).

CONCLUSION

Although there has been stagnancy in the overall productivity of crop sector in India due to excessive use of inorganic fertilizer, insecticides and pesticides resulting saturation in the soil strata, still the promotion of organic and inorganic mix package of practice for paddy in different states of India in the current decade become a key feature in this study. With the rise in operational cost of various factors of production used in paddy cultivation with rise in the hiring rate of tractors and power tillers, farm mechanization has been the prime contributor in different states of India. Despite of a sharp increase in the human labour wage rate over the year, the contribution of human labour still dominates the overall farming system in most of the states as indispensible factor for cultivation. Irrigation factor has been the major contributors for paddy cultivation with a negative impact on productivity change as most of the region has cultivated rainfed rice where the cultivators depend upon the rainfall only. The contribution of fixed factor in the production of paddy has been gone up as the opportunity cost of land (rental value of owned land) has been increased. Marked technological change in rice cultivation has been observed in the state of Madhya Pradesh (5.40%), Kerala (3.74%) and Karnataka (3.18%) where a combination of organic and inorganic package of practices in rainfed paddy cultivation is highly visualized.

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