Labour Productivity of Rice Crop in India's Indo-Gangetic Plains: A Comparison Between Agriculture in Eastern and Western Regions

Nilabja Ghosh, Alka Singh, Mayanglambam Rajeshwor, and Amritanshi Preeti

Abstract Green revolution made India's development unbalanced by building up a high performing agriculture in the highly irrigated western states of Punjab and Haryana while neglecting the water-rich eastern states of Bihar and Jharkhand. Farming being the most important employment in India, the imbalance generated migration of surplus rural manpower suffering economic distress of the east to seek employment in the western states in which agriculture created demand for labour. An analysis of agricultural production in the contemporary period 2004–05 to 2019–20 indicates that over time the transition and possibly the public attention to eastern agriculture has created an equilibrating pressure on value added and labour productivity so that potential exists for a modern digitized agriculture in the east to absorb manpower especially youth to generate value added in the state while the western states need to prepare for its own transition.

Keywords Labour · Rural Employment · Migration · Productivity · Agriculture

India's agriculture, despite its dwindling share in GDP, still employs not much less than half of the workforce, a large portion of which works in small holdings as proprietors and investors and as wage-labourers in farms. Many members of such households also indulge in non-farm economic engagements and even migrate to other states as farm labour if income potential is brighter. Others move for jobs of drivers and helpers in the city (Kaushik & Campbell, 2023). In practice, they are 'pushed' to migration out of distress because of low farm generated incomes locally.

India's population by UN estimates surpassed China. PLFS data assures that over the last five years unemployment rate of rural youth in the 15–29 years age group has improved but nevertheless it hovered around 11% in 2020–21 (NSO, 2022). Moreover, it is speculated that 'Rural India (only) provides jobs in the form of disguised unemployment', which means that jobs created in agriculture do not

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necessarily add to output (NSO, 2022) even while jobs attracting the migrants tend to be poorly paid and add to problems of housing and law enforcement for the society. As per PLFS data, half of India's rural households draw major parts of their income from agriculture as cultivators and labourers while about 64% of the rural population are in the working age, one-third of them being 15–29 years old. Unlocking the potential of the youth population of the country is a major achievement that remains yet unaccomplished and the best application of productive potential concealed in the agricultural households of rural India can be a way towards this goal. While the National youth policy 2013 and 2021 address the objective, a major question that arises is, 'which sector will absorb them and how they can be trained' to participate in and contribute to the emerging economy.

Although India has been emphasizing the welfare of the farm population and intends to make agriculture remunerative, human resource utilization and management in the sector remains a challenge. As a result, not only do Indian villages remain poverty stricken, migration to other states is a regular feature of some states. Theory suggests that migration is a natural and equilibrating process to fill up the demand-supply gap by a flow of working-age people to labour-shortage states from states where earning is lower due to surplus manpower (Todaro, 1969). As labour moves from farming to non-agricultural sectors or to farm work in other states where opportunities exist, labour shortage is likely to pull up farm-wages even in the local market (Lewis, 1954). Migration, it is anticipated, will eventually raise the labour productivity in the source state and sector though some of the missing human workforce may be replaced by machines. In the dynamic process, productivity, wages, and income of agriculture across states tend to be equalized slowing down migration. Although in an efficient and diversified economic system, migration occurs as specialized with no particular bias to direction, a uni-directional flow of working-age population lacking in any particular skill reflects inequality and societal distress.

In India, literature and official data suggest that largest migration takes place from eastern to western regions and from rural to urban areas. Earnings from agriculture are a reflection of the productivity of factors of production which in turn is contingent on a number of factors like use of yield enhancing material inputs, type of crops grown, their market prices, public support, soil conditions, and level of mechanization. In a cyclical process, some of the lacking in technology and human capital can be linked to the inadequacy of past earnings as well as government failure to provide amenities while part of the shortfall can be explained by climate, water, and soil. Green revolution of 1960 and 1970s left its mark in unequal agrarian development between the east and west and in creating ecological disruptions in the successful west.

This study selects two states Bihar and Jharkhand in the east and two states Punjab and Haryana from the west and seeks to compare the technologies, costs, and returns. The direction of their movement and the share of farm work in the value added which is a measure of returns to all factors is examined in a comparative light. Pooled data from the four states smoothed for weather anomalies is modelled to measure the marginal factor productivity of labour (LFP). The paper has 5 sections consisting of this Introduction, a Background, the Method, the Results, and some Conclusions.

1 Background

The green revolution (GR) in agriculture that brought food sufficiency in India also left the country with many disparities, one of them being regional imbalance (Deane, 1965; Frankel, 1971). Given the pre-existent endowments of irrigation and economic strength consistent with the demands of the new seeds, the country, faced with food emergency, left aside the naturally water-rich eastern states and focused attention on western states fed by Ganga–Indus River projects that had already brought the water supply under control. The resulting spill-over of workforce to privileged states and cities caused forced separation in families and social distress.

Agriculture still dominates India's economic scene as a livelihood which is inseparable from economic progress. In a country where agriculture provides 60% of livelihood and only 18% of GDP, the income potential of those engaged in farm operations and their productivity is a serious issue. The Constitutional goal of regional balance had to be addressed soon after the GR lost its steam in the 1990s when poverty and woes of eastern states could no longer be politically overlooked. Meanwhile, droughts and floods, likely to be intensified by climate change, became added drivers of migration. The COVID-19 lockdown exposed the catastrophic and sudden crisis in society hit by reverse migration of home-bound farm workers who only had entitlements to national welfare schemes linked to a 'permanent address' (Naregal, 2021; TCI, 2020).

Further intriguingly, field level queries (ISSRF, 2021) in the aftermath of COVID-19 suggested that reverted migrants are not willing to move back even with reforms in universal welfare in India. A crisis which is likely to linger directed policy towards counting the migrant heads and mapping their skills to explore livelihood potential in the states of origin. Auxiliary advantages of reversion such as making economic space within the villages, urban decongestion, growth of agro-processing industries and strengthened franchise-based democracy did not go unnoticed. Agriculture with its ancillaries still remains a livelihood option so long as farm incomes and wages align with productivities that in turn improve. A digital revolution taking off in agriculture holds the potential to improve farm productivity. Prime Minister's Garib Kalyan Rojgar Abhiyaan (GKRA) and the priorities of the Ministry of Skill Development and Entrepreneurship (MSDE) were directed to the rural sector.

While casual observation may identify the eastern states as sources of migration and western states as destination, method-based published data on the magnitude of inter-state migration with source and target is scarce. Evidence suggests that migrant population in Punjab increased from 8 to 11 lakh and further to 23 lakhs between the years 1981, 1991, and 2001 (Census of India, Website; Kumari & Singh, 2019) and only a small proportion of them opted to settle down in Punjab with families but most preferred to return one day due to poor living condition. Migrant workers in agriculture come primarily from Uttar Pradesh, Bihar, Madhya Pradesh, and Orissa where they suffer from severe unemployment and underemployment and earnings much lower than that of Punjab (Sidhu & Rangi, 1998). Occupations vary with demographics and development. Rural households of Bihar and neighbouring

states Jharkhand, Chhattisgarh, and Uttar Pradesh have fairly high proportion of agricultural households, the share of self-employed in agriculture ranging from 35 to 54% compared to 21% in Punjab and 26% in Haryana (NSO, 2022). A recent study conducted by IIPS found half of Bihar households are exposed to migration and such households tend to be landless or small holding and the migrant tends to leave his wife behind as a tie but the dominant perception is that migration brings wealth and improvement in living condition (Mishra, 2020). It appears that a major factor behind their migration is the perception that wages offered by Punjab are higher than the rates offered in their native states. On the other hand, it is observed that Punjab farmers too show preference to the migrant labourers particularly during peak season when local labourers demand higher wages.

Selected states Bihar and Jharkhand together in eastern India had been a single state called Bihar until 2000 and Punjab and Haryana in the west too were parts of a single state Punjab in a more remote past. The two states of a bifurcated single state are obviously contiguous and proximate in location though many conditions differed contributing to the reorganization in India's federal entity. Except Bihar, the states are small in size and population by Indian standards. Population density is 1307 in Bihar. Bihar and Jharkhand are highly rural in character with urban population constituting only 12% and 26% of the respective populations as compared to 31% of India. Poverty is much higher in Bihar and Jharkhand. The relative per capita GDP levels and unemployment rates also account for similar relative economic equations of the two sets of states in the east and west. The differences in development are further exposed when comparing other social attributes (Table 1).

The share of agriculture in state GDP suggests that Bihar and Jharkhand are largely agrarian although Jharkhand is more endowed with natural resources and industries between the two. Agriculture itself in Haryana and Jharkhand is more diversified than the other two but the dominance of kharif rice making up 39% and 22% of GCA of Punjab and Haryana and 68% and 43% of GCA of Jharkhand and Bihar respectively is nevertheless a commonality. Both eastern states fall in high rainfall zone with average monsoon rainfall of 1055 mm and 1017 mm but enjoys irrigation of only 14% and 72% of the GCA whereas the western states share a relatively dry zone of the country with corresponding rainfall of 467 mm and 444 mm respectively but both are highly endowed with irrigation. Punjab and Haryana, graced by the GR, are known to be agriculturally most advanced in India. In contrast the two eastern states have suffered poverty, Bihar and Jharkhand being the poorest state of India suffering from floods and carrying a legacy of caste-based land and power entitlements.

2 Data and Method

Focusing on staple crop rice, the analysis uses data only from official domain of MoA&FW. Crop yield, price and land use data including irrigation are used from DES (DES, Website) but since data on input use and costs are not reported by DES crop-wise, Cost of Cultivation (COC) data in cost studies division (DES, Website)

Table 1 Socioeconomic characters of study states in 2020–21

	Units	Data sources	Bihar	Jharkhand	Haryana	Punjab	India
Population	Million	NCP (2020)	121.3	37.9	29.1	30.1	1348.6
Rural population	%	NCP (2020)	87.96	74.34	59.67	59.26	65.88
Population density	Per km^2	NCP (2020)	1307	483	667	602	415
Literacy rate (2017–18)	%	NCP (2020)	70.9	74.3	80.4	83.7	77.7
Life expectancy	Year	NCP (2020)	69.1	69.1	69.8	72.7	69.4
Poverty rate (2011)	%	RBI (2022)	33.7	37.0	11.2	8.3	21.9
Per capita NSDP	Rs. '000 at 2011–12 prices	RBI (2022)	28.1	51.4	165.6	112.1	85.1
Agri. and allied (2019–20)	% GSVA	NABARD (2021)	22.3	17.4	18.8	28.1	16.5
CPI (March)	Index 2012 = 100	MOSPI (Website)	153.4	154.9	150.7	152.6	156.8
CPI-AL	Index 2011–12 = 100	DES (Website)	154.1	154.1	163.8	161.5	163.1
Rice area	% GCA	DES (Website)	43.4	68.0	21.7	39.3	22.5
Farm size (2015)	ha	DES (Website)	0.39	1.1	2.22	3.62	1.08

Source NSDP—net state domestic product, GSVA—gross state value added, GCA is gross cropped area, CPI is consumer price index, AL is agricultural labour

collected from official farm survey is taken to derive value added and cost shares. The sample period considered is 2004–05 to 2019–20 and smoothed out for rainfall anomalies by considering 3 year moving averages of data as variables for all years referred to as end of the triennium of (TE). The analysis is conducted with data taken at the unit area (per hectare) level. Irrigation implying use of motorized pumps and publicly engineered river projects is expressed as shares of GCA under wells and under canals DES (Website). Public infrastructure is length of road per hectare of GCA (MoRTH, Website) and number of tractors (taken from TMA, Website) per hectare of GCA is the measure of mechanization. Interest on working capital taken from COC is taken as proxy for cash availability for operation representing short-term investment. The specifications of variables derived and used in the analysis are given by following identities

Value = Price × Yield
TC = Total Cost (C2) = sum of all costs paid and real
CPI = consumer price index
CPI-AL = consumer price index Agricultural Labour
Profit = Value − TC
MC = Material cost = expenses on material inputs
VA = Value added = Value − MC
TLC = Total labour cost = cost incurred on human, animal and machine labour
TLH = Total labour hours = Hours of physical labour on farm by human, animal and machine energy
FHLC = Family human labour cost
AHLC = Attached human labour cost
CHLC = Casual human labour cost
FHLH = Family human labour hour
AHLH = Attached human labour hour
CHLH = Casual human labour hour
THLC = Total human labour cost = FHLC + AHLC + CHLC
THLH = Total human labour hours = FHLH + AHLH + CHLH
OALC = Owned animal labour cost
HALC = Hired animal labour cost
OMLC = Owned machine labour cost
HMLC = Hired machine labour cost
TALC = Total animal labour cost = OALC + HALC
TMLC = Total machine labour cost = OMLC + HMLC

C2 = total cost = THLC + TALC + TMLC + Seed cost + Fertilizer cot + Manure cost + Insecticide cost + Irrigation Charges + Crop insurance charge + Miscellaneous costs + Interest on Working Capital + Rental value of owned land + Rent paid for Leased-in Land + Land Revenue, Taxes and Cesses + Depreciation on Implements and Farm Building + Interest on Fixed Capital

MC = sum of costs of material inputs which include Fertilizer, Manure, owned Machine Labour, Seed, Insecticides, owned Animal Labour

OC = Other costs = HALC + HMLC + Irrigation Charges + Crop insurance + Miscellaneous + Interest on Working Capital + Rental value of owned land + Rent paid for Leased-in Land + Land Revenue, Taxes and Cesses + Depreciation on Implements and Farm Building + Interest on Fixed Capital

TLC = THLC + TALC + TMLC
FAC = Fixed asset cost = depreciation on fixed capital + interest on fixed capital
WCI = Working capital cost = Interest on working capital
FRT = Fertilizer Quantity (kg/ha)
TRC = No. of Tractor sale

RFP = Relative Fertilizer Price (Fertilizer price/Farm price of Rice)
RENT = Rental Value of Owned Land (Rs./ha)

Where cost of owned animal is expenses on feed, medicine, and other necessities of maintaining livestock, cost of owned machine is expense on fuel and spares. Cost of feed, fuel, spares, etc., summing up to cost incurred on owned animal and machine labour is treated as material cost.

VA = THLC + OC = returns to human, animal and machine labour, returns to land both owned and leased in, returns to fixed capital measured as depreciation and interest on fixed capital and charges paid to various agents like government, banks, money lenders, insurance agencies and individuals, all of whom invested on productive assets, public goods, and risk taking.

Real VA = VA/CPIAL = R_VA

HLP = human labour productivity = RVA/THLH

Price is in Rs./kg, yield is kg/ha, CPI is consumer price index at 2011–12 prices, CPI-AL is CPI of Agricultural labour at 2011–12 prices.

Data limitation has compelled the use of two data sources for the calculation of VA of rice. Although both sources emanate from the MOA&FW and can be treated as official, preference is for DES. The COC data is obtained from fairly large samples of farms for the purpose of evaluating a reasonable price a farmer should get from the farm business a helping government fix an MSP, but DES data, that creates the statistical database of the government, has greater coverage and statistical rigour and is validated between state and Centre and with alternative scientific methodologies. Recourse to COC data for this study is driven by compulsion due to absence of crop wise cost data from DES. In cases of over-lap of data from the root sources, a consistency check is conducted for data from DES with COC.

Yield figures are found to carry gaps between the alternative sources (DES and COC) in many cases but the differences being moderately small and not being in the same direction, bias is not indicated by one or both sources. The discrepancy can arise from sampling error and other methodological issues and approximation of wastage and by-products. Three different prices of rice namely the retail price (RP) from DES, wholesale price as average of mandis in the states (DES, Website) and producer price from COC data which presumably represents farm harvest price, are suitably standardized for rice (assuming the same physical conversion rate between paddy and rice = (2/3)) and expressed as Rs. per kg for comparison. As can be expected, the prices along the market chain differ, the COC price being lowest and retail price the highest. The WSP, taken from official domain MOA&FW and reflective of both open market and administered price through demand is used for the study.

Inputs and their prices are all taken from COC data. Movements of fertilizer price (Rs. per kg) paid by farmers as given in COC data is compared with wholesale fertilizer price index (NPK) provided by Office of Economic Advisor (OEA, Website)

show a high degree of consistency. COC gives also the break up components of wages, namely casual labour hired at going market rate as available, attached labour receiving fixed salary not linked with short-term market movements and family labour which of course demands imputation rather than observation. Total cost C2 includes all material inputs, both hired and family labour, owned and hired machinery and animals, rental value of both owned and leased land and miscellaneous charges. Cost of owned resources is imputed in COC methodology following scientific procedures. The three kinds of labour are also likely to vary in quality. For example, a large part of the family labour would be invested in supervision, monitoring, hiring, and decision-making and attached labour being more secure and trusted would also take a share of the supervision and ramify beyond farm work as desired by operator. Casual labour would be most representative of the labour remuneration as dictated by market demand and supply.

Expenses on feed or medicines for owned animal constitute material cost, but it may be noted that the same does not apply to human labour in which case costing of hired labour is done using the going wage rate just as the going rental rate is used for hired animal but for family labour costing is done with imputed wage rates rather than cost of living. The wage of attached and casual labour would include real costs like food if incurred. Wages, rent on machine hiring and land, charges on water and other facilities, and remnant profit are subsumed in the value added going to factors of production.

VA is seen as incomes to various agents mostly cultivators and labourers, owners of animals, land, and capital who mostly are the farmers themselves and public agencies for managing infrastructure of water supply. The average factor productivity of human labour HLP is measured as value added per hectare from a unit hour of human labour. To measure marginal productivity of human labour a Trans-log function is employed to model the RVA and the elasticity is worked out separately for each of the four states using not just the parameters estimated but also the associated variables (Greene, 2005) in a non-linear model with interactions. The model is estimated by pooling the moving average data of each state over the period 2006–07 to 2019–20 generating a total number of 56 observations. Fixed Effect specification is assumed to capture the differences of administrative and policy across states. All value terms are deflated by price index to overcome the inflation effect. Real value is indicated by adding a suffix '_R' to the variable. Treatment of VA_R as income of agents or returns to factors lies behind the choice of CPI_AL as the deflator reflecting the cost of living of agrarian populace.

The dependent variable is the real value added.

$$\begin{aligned}\text{Log } Y = a_0 + \sum a_i(\text{Log } X_i) + \sum a_2(\text{Log } X_i)\left(\text{Log } X_j\right) \\ + \sum a_3(\text{Log } X_i)^2 + \sum a_4(\text{Log } Z) + u_t\end{aligned}$$

where Y is dependent variable (RVA) and X_i are independent variables and the estimation is in logarithmic form. The independent variables include the following (a) fertilizer and manure (b) Labour (c) Machines and infrastructure and (d) land. Manure

quantity (COC) is assumed to be non-stochastic given by livestock population in the state, land is measured by definition as 1 hectare as per COC protocol but may differ by quality can be proxied by the rental value on land and by soil type.

Labour (COC) is also taken as given and dependent on exogenously given demographics and wage rates which are also administered. Machines and infrastructure are also exogenous but, in this case, proxied by number of tractors (TMA, Website) per hectare and also wells proxied by the extent of well irrigated area per hectare of gross cropped area. Infrastructure, similarly, is measured as length of roads per hector of GCA. Capital also includes short-term or working capital (COC) which helps in buying inputs and storing and selling gains. Fertilizer (COC) is taken to be a function of exogenous variables price of fertilizer relative to product price expectedly with a negative effect and availability of working capital expectedly having a positive effect. Among all possible specifications, only that with variables having significant coefficients is selected for presentation.

3 Results

This section analyses the descriptive statistics and the decompositions inherent in the data on various aspects and the outcome of econometric production function estimation with value added. Labour is the core interest but coverage has a larger dimension.

3.1 Variation of Production and Prices

As can be expected, the value of rice produced per hectare is much higher in both western states than in the east (Table 2) but contrarily, Fig. 1a also shows its faster rise in the eastern states compared to the saturation seen in the west. CPI, the deflator at the all-India level, indicates a sluggish cost of living and low inflation. Value rose much faster than CPI until 2017 when its rise fell even below the CPI in Punjab and Haryana. The cost of living of farmers as proxied by CPI-AL rose in all cases but with wide differentials (Fig. 1b). Considerably high rates of rise of CPI-AL in the western states where production value was stabilizing points to the crisis being faced by agriculture in Punjab and Haryana where high levels of productivity have been attained through GR. Yet, cost of cultivation (Table 2) is also highest in Haryana and Punjab while low-cost agriculture characterized the two eastern states.

Table 2 Total cost (C2) of cultivation per hectare and its share of material cost, labour cost, and other cost

Year (TE)	Bihar				Jharkhand				Haryana				Punjab			
	C2	MC	THLC	OC	C2	MC	THLC	OC	C2	MC	THLC	OC	C2	MC	THLC	OC
Unit	Rs. '000	%			Rs. '000	%			Rs. '000	%			Rs. '000	%		
2004–05	13.8	18.0	38.0	44.0	13.4	25.0	41.0	33.0	30.6	20.0	27.0	54.0	30.0	22.0	16.0	62.0
2005–06	14.5	18.0	37.0	46.0	13.2	23.0	42.0	34.0	31.0	20.0	25.0	54.0	30.2	21.0	16.0	63.0
2006–07	15.0	17.0	37.0	47.0	14.1	21.0	43.0	36.0	31.5	20.0	25.0	55.0	30.7	20.0	16.0	64.0
2007–08	15.2	16.0	36.0	47.0	14. 8	22.0	42.0	37.0	32. 8	19.0	25.0	56.0	31.7	19.0	16.0	65.0
2008–09	16.2	17.0	38.0	45.0	16.4	23.0	39.0	38.0	37.1	17.0	25.0	58.0	36.8	19.0	17.0	64.0
2009–10	17.7	16.0	39.0	45.0	16.9	23.0	38.0	39.0	43.4	14.0	27.0	58.0	43.6	18.0	18.0	64.0
2010–11	19.6	16.0	41.0	43.0	18.7	22.0	40.0	38.0	48.1	13.0	29.0	58.0	49.1	17.0	20.0	63.0
2011–12	22.8	14.0	43.0	42.0	21.0	21.0	43.0	36.0	52.3	13.0	31.0	56.0	51.9	17.0	21.0	62.0
2012–13	26.5	15.0	46.0	39.0	24.9	20.0	44.0	36.0	55.1	14.0	30.0	56.0	56.6	17.0	21.0	62.0
2013–14	30.6	14.0	46.0	40.0	27.3	19.0	44.0	37.0	60.8	14.0	30.0	56.0	62.3	17.0	21.0	62.0
2014–15	34.7	14.0	43.0	43.0	31.9	19.0	40.0	41.0	68.4	14.0	29.0	57.0	68.8	17.0	20.0	63.0
2015–16	38.7	13.0	39.0	48.0	34.7	19.0	39.0	43.0	76.1	13.0	29.0	58.0	72.1	17.0	21.0	63.0
2016–17	42.1	12.0	38.0	50.0	37.6	18.0	37.0	44.0	81.3	12.0	29.0	59.0	74.6	16.0	21.0	63.0
2017–18	44.6	12.0	39.0	50.0	45.6	19.0	37.0	44.0	82.9	12.0	28.0	60.0	77.4	16.0	21.0	63.0
2018–19	47.5	12.0	40.0	49.0	51.2	21.0	38.0	42.0	83.0	14.0	26.0	60.0	80.7	17.0	21.0	63.0
2019–20	50.2	12.0	41.0	47.0	55.7	21.0	38.0	41.0	86.2	15.0	24.0	61.0	85.3	17.0	20.0	63.0

(continued)

Table 2 (continued)

Year (TE)	Bihar				Jharkhand				Haryana				Punjab			
	C2	MC	THLC	OC	C2	MC	THLC	OC	C2	MC	THLC	OC	C2	MC	THLC	OC
Unit	Rs. '000	%			Rs. '000	%			Rs. '000	%			Rs. '000	%		
Average	27.2	14.8	40.1	45.3	28.2	21.0	40.3	38.7	57.9	15.3	27.4	57.3	55.1	17.9	19.1	63.1
CV (%)	47.8	14.7	7.7	7.3	50.2	9.2	6.1	8.9	35.8	19.2	8.1	3.7	35.9	9.9	11.4	1.4

Note MC—material costs, THLC—total labour costs includes family, casual and attached human labour, OC—other cost includes irrigation, miscellaneous, interest on working capital, fixed costs (rental value of owned land, rent paid for leased-in-land, land revenue, taxes, cesses, depreciation on implements and farm building, interest on fixed capital), machine labour hired and animal labour hired. CV is coefficient of variation
Source Computed

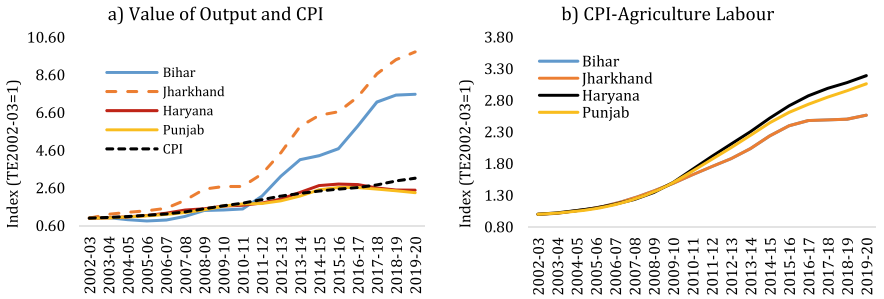

Fig. 1 Value of output and cost of living

3.2 Labour Share

Labour share in total cost (C2) is much higher in the eastern states at 40% but a mildly increasing tendency of labour share is discernible in all cases till 2012 after which it stabilized or even shrank as apparent in Haryana (Table 2). The material cost share differentials varying from 12 to 21% do not suggest superiority of inputs used in the west. The largest share in C2, which is higher in western states (about 60%), is occupied by the OC category comprising fixed cost and a few components of operational cost.

Contrasting the largely unremarkable change in share of human labour in total cost, diminution of animal labour share reaching zero in some cases, and gain in machine labour share in cost in Bihar and Jharkhand is observed (Fig. 2). Its share is least in Punjab where machine has the largest share. Human labour is far from homogenous. Shares of family labour hours saw stronger increases in the eastern states while the attached labour lost share continuously reducing to 0 in Jharkhand, 2% in Bihar and Haryana but remaining substantial at 11% in Punjab. Casual labour shares have been unstable in Bihar and Jharkhand but despite some swings show a rising trend in the western states. Except in Jharkhand where farming relies mostly on family hands, casual labour occupies more than half the labour hours for farm work (Table 3).

It is known that casual farm labour makes up some of the poorest sections of the Indian population. The fleeing of workforce often turns out as casual wage labour somewhere. Although the eastern states are found to have more labour-intensive agriculture, it may not be surprising to find in Fig. 3 that it is the western states that have in tandem shown growth in the share of casual workers in labour cost since the base year barring a fall in 2016–17, but since 2012 both the eastern states reduced their corresponding shares. However, in Jharkhand the share has been high relative to base year while in Bihar it is stagnant at a lower level.

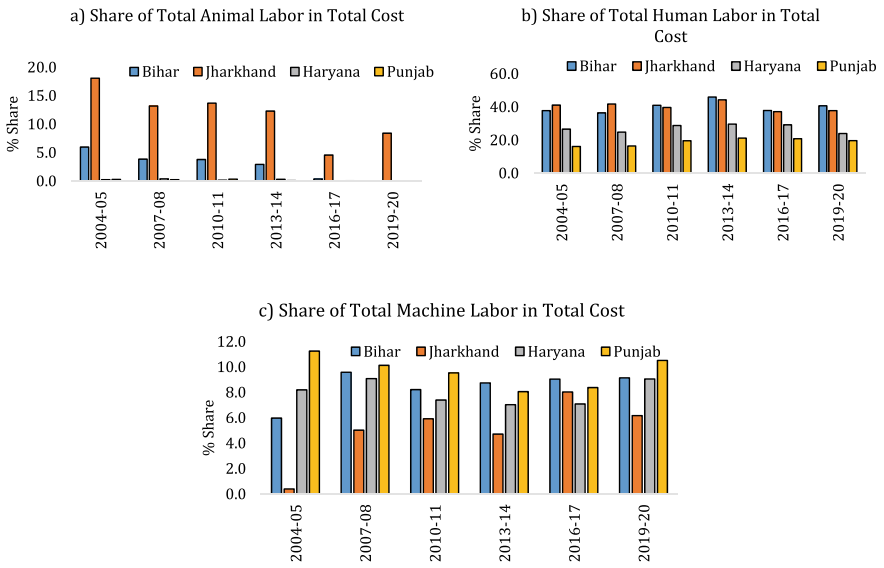

Fig. 2 Labour share (%) in total cost

3.3 Value Added and Profitability of Cultivation

Table 4 gives nominal estimates of average profit and value added. Both eastern states started with loss making rice cultivation which over time increasingly became profitable. In contrast the western states did not reveal such a gain. The profit was negative in the years 2018–19 in Haryana. The VA in all cases increased in nominal terms and rice growing in Punjab fetches higher profit than other states. A decomposition of the VA in Table 5 shows a meagre share of 28% for labour in VA in Bihar which has fallen continuously from 75% in 2004–05 while profit (farming income) has gained share which speaks of policy success in making agriculture profitable. Decomposition of VA shows heterogeneity among states. Profit takes the largest share of 38% in Bihar where human labour has a poor share of 28%. On the other hand, in Jharkhand, also in the east, labour has a higher share 33% comparable to profit. In both Punjab and Haryana labour and farm profit have low shares in VA reaching a negative value in Haryana but the highest share is taken by land rental. Contribution of machine power too is moderately low and that of animal power or even less and zero in cases. Government charges on farm services are fairly high in contribution to VA in Haryana but low on others.

Table 3 Break up of human labour hour (% of total hour)

Year (TE)	Family	Attached	Casual	Family	Attached	Casual	Family	Attached	Casual	Family	Attached	Casual
	Bihar			Jharkhand			Haryana			Punjab		
2006–07	34.0	0.4	65.6	53.0	2.3	44.7	41.4	9.2	49.4	37.2	15.7	47.1
2007–08	31.4	0.3	68.3	46.4	3.1	50.4	41.8	9.4	48.8	34.8	15.4	49.8
2008–09	32.9	0.2	66.9	41.8	1.9	56.3	40.7	9.0	50.3	33.7	15.6	50.7
2009–10	34.1	0.2	65.7	39.2	0.9	59.9	40.2	7.9	52.0	34.3	14.5	51.3
2010–11	38.2	0.2	61.6	39.0	0.0	61.0	37.2	7.3	55.4	32.8	13.2	54.0
2011–12	42.5	0.2	57.3	42.7	0.0	57.3	38.9	7.3	53.8	35.1	10.1	54.7
2012–13	43.1	0.2	56.7	45.3	0.0	54.7	40.2	6.4	53.4	36.0	9.9	54.2
2013–14	43.2	0.2	56.6	43.8	0.0	56.2	40.8	5.7	53.5	38.3	9.3	52.4
2014–15	41.3	0.2	58.5	42.9	0.0	57.1	42.4	3.9	53.7	38.8	10.3	50.9
2015–16	42.7	0.2	57.1	45.5	0.0	54.5	43.9	3.4	52.7	39.6	10.7	49.7
2016–17	42.7	0.3	57.0	52.7	0.0	47.3	48.3	1.7	50.0	40.8	11.8	47.4
2017–18	42.3	0.2	57.5	54.3	0.0	45.7	48.8	1.9	49.3	40.8	11.6	47.6
2018–19	43.5	0.1	56.4	55.5	0.0	44.5	47.3	2.0	50.7	39.5	11.7	48.8
2019–20	42.6	0.0	57.4	55.1	0.0	44.9	42.4	2.1	55.5	37.7	11.0	51.3
Average	39.6	0.2	60.2	46.9	0.6	52.5	42.5	5.5	52.0	37.1	12.2	50.7
CV (%)	11.4	44.3	7.4	12.7	180.4	11.4	8.2	53.3	4.4	7.2	18.5	4.9

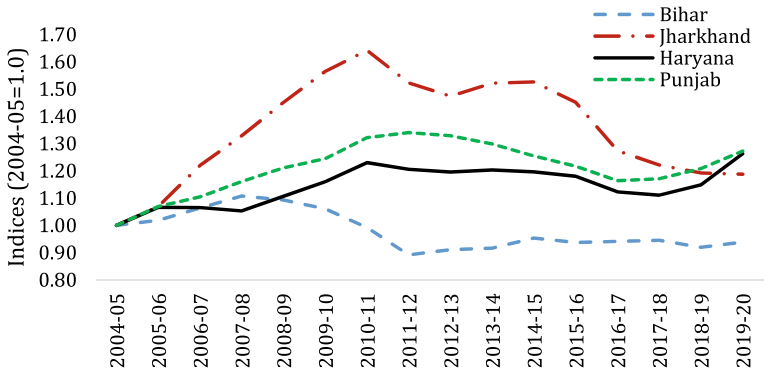

Fig. 3 Indices of share for casual labour in THLC

Table 4 Value of output, value added (VA), and profit (Rs. 000/ha) of study states

Year (TE)	Bihar			Jharkhand			Haryana			Punjab		
	Value	VA	Profit	Value	VA	Profit	Value	VA	Profit	Value	VA	Profit
2004–05	9.45	6.94	– 4.36	10.22	6.81	– 3.20	35.43	29.43	4.79	46.95	40.29	16.93
2005–06	8.74	6.21	– 5.72	10.80	7.71	– 2.45	37.63	31.28	6.61	49.44	43.06	19.21
2006–07	9.22	6.71	– 5.80	11.85	8.85	– 2.21	41.71	35.29	10.25	52.62	46.49	21.90
2007–08	11.26	8.81	– 3.94	15.14	11.96	0.36	47.33	41.14	14.54	57.51	51.47	25.79
2008–09	14.44	11.75	– 1.78	19.75	15.97	3.31	49.46	43.20	12.32	63.53	56.70	26.71
2009–10	14.70	11.86	– 3.03	20.86	16.91	3.91	54.27	48.02	10.82	72.09	64.27	28.51
2010–11	15.24	12.16	– 4.40	20.84	16.75	2.17	55.58	49.26	7.51	77.10	68.60	28.03
2011–12	22.25	18.98	– 0.60	26.00	21.57	4.95	59.44	52.71	7.17	77.97	69.27	26.06
2012–13	33.12	29.21	6.64	34.81	29.79	9.91	66.50	58.89	11.38	84.33	74.85	27.72
2013–14	42.12	37.76	11.51	45.62	40.43	18.31	78.09	69.41	17.26	95.30	84.71	32.99
2014–15	44.24	39.40	9.54	50.24	44.25	18.29	90.12	80.83	21.72	110.21	98.64	41.42
2015–16	48.06	43.14	9.35	51.68	45.17	17.02	92.65	83.13	16.53	115.59	103.61	43.51
2016–17	60.34	55.12	18.24	57.72	50.80	20.09	91.69	82.15	10.43	115.35	103.26	40.69
2017–18	73.42	68.19	28.79	67.28	58.44	21.68	85.76	75.58	2.85	111.62	99.32	34.26
2018–19	77.23	71.55	29.74	73.12	62.57	21.96	82.22	70.81	– 1.45	107.70	94.19	26.96
2019–20	77.67	71.66	27.44	76.35	64.40	20.64	81.98	68.94	– 4.22	103.24	88.39	17.91
Average	35.09	31.22	6.98	37.02	31.40	9.67	65.62	57.50	9.28	83.78	74.20	28.66
CV (%)	74	79	185	63	66	101	31	32	73	30	30	28

Table 5 **a** Decomposition of nominal value added (%). **b** Decomposition of value added (%)

Year (TE)	Profit	Labour			Charges	Rent	Fixed capital	Profit	Labour			Charges	Rent	Fixed capital
		Human	Animal	Machine					Human	Animal	Machine			
(a)														
	Bihar							*Jharkhand*						
2004–05	− 63.0	75.3	2.6	11.6	7.6	53.5	12.5	− 47.0	81.1	5.0	0.8	3.4	37.9	18.8
2005–06	− 92.3	85.3	2.6	17.5	12.3	59.3	15.1	− 31.7	72.7	4.4	3.7	3.1	30.4	17.5
2006–07	− 86.4	81.9	2.8	19.0	13.1	55.6	14.1	− 24.9	67.9	3.6	6.7	3.0	26.4	17.2
2007–08	− 44.7	62.8	1.9	16.3	8.7	43.6	11.3	3.0	51.6	2.0	6.2	2.3	21.0	14.0
2008–09	− 15.1	52.9	1.5	11.5	4.2	36.3	8.7	20.7	40.0	1.0	5.1	1.8	19.8	11.5
2009–10	− 25.5	58.3	1.0	12.6	6.2	37.9	9.6	23.1	38.0	0.7	5.4	1.8	19.7	11.2
2010–11	− 36.2	66.2	1.1	13.2	9.0	37.5	9.1	13.0	44.2	0.5	6.6	2.1	21.8	11.8
2011–12	− 3.2	52.3	0.9	10.3	6.2	26.7	6.8	23.0	41.5	2.7	4.1	1.8	19.0	8.1
2012–13	22.7	42.0	0.6	7.6	3.8	18.6	4.7	33.3	36.7	3.0	2.8	1.7	16.6	6.0
2013–14	30.5	37.3	0.5	7.0	4.3	16.3	4.1	45.3	29.9	2.2	3.2	1.3	13.7	4.4
2014–15	24.2	37.6	0.3	7.7	5.6	19.7	4.9	41.3	29.2	0.9	4.5	1.3	17.8	5.0
2015–16	21.7	35.3	0.2	8.0	7.5	21.7	5.5	37.7	29.6	0.1	5.8	1.3	20.3	5.2
2016–17	33.1	28.9	0.0	6.8	6.3	19.8	5.1	39.5	27.5	0.1	5.8	1.2	20.8	5.0
2017–18	42.2	25.2	0.0	5.8	6.2	16.7	3.8	37.1	28.9	0.0	5.2	1.6	22.1	5.1
2018–19	41.6	26.2	0.0	5.9	6.7	16.4	3.3	35.1	30.9	0.0	5.2	1.6	22.2	4.9
2019–20	38.3	28.5	0.0	6.3	7.4	16.8	2.8	32.1	32.7	0.1	5.3	1.7	23.6	4.6
Average	− 7.0	49.8	1.0	10.4	7.2	31.0	7.6	17.5	42.7	1.6	4.8	1.9	22.1	9.4
CV (%)	− 658.6	40.5	99.9	41.2	36.3	49.5	52.6	161.7	39.9	101.6	32.5	35.1	25.8	55.4
(b)														

(continued)

Table 5 (continued)

Year (TE)	Profit	Labour			Charges	Rent	Fixed capital	Profit	Labour			Charges	Rent	Fixed capital
		Human	Animal	Machine					Human	Animal	Machine			
	Haryana							*Punjab*						
2004–05	16.3	27.7	0.0	3.9	13.0	32.6	6.6	42.0	12.0	0.0	3.2	9.7	29.0	4.0
2005–06	21.1	25.0	0.0	4.2	11.2	32.4	6.0	44.6	11.1	0.0	3.4	7.8	28.8	4.3
2006–07	29.0	21.9	0.0	4.3	10.0	29.8	5.1	47.1	10.7	0.0	3.4	6.7	27.9	4.3
2007–08	35.3	19.8	0.0	3.9	8.2	28.5	4.3	50.1	10.1	0.0	3.5	4.9	27.1	4.3
2008–09	28.5	21.9	0.0	4.4	8.2	32.1	5.0	47.1	11.2	0.0	3.6	3.9	29.7	4.7
2009–10	22.5	24.6	0.0	4.4	7.8	34.5	6.2	44.4	12.4	0.0	3.6	3.5	31.4	4.8
2010–11	15.2	28.1	0.0	4.8	8.2	37.4	6.3	40.9	14.0	0.0	3.7	3.3	33.1	5.0

Note Charges include miscellaneous expenses, interest on WC, crop insurance, payment to contractor, irrigation, land revenue, taxes and cess. Rental value includes both rental value of owned land and rent paid for leased in land

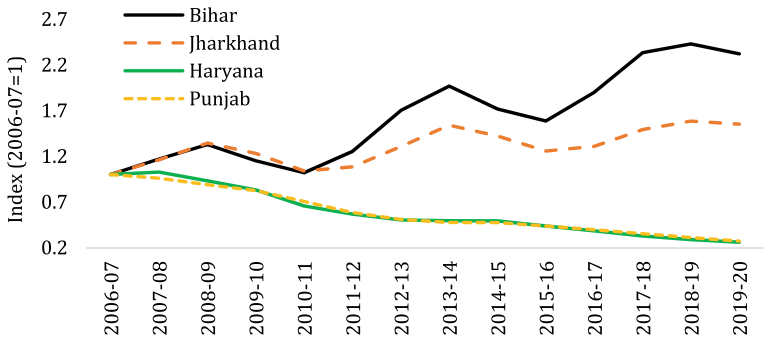

Fig. 4 Average human labour productivity (labour data is available from TE 2006-07)

Human labour productivity

Plots of the R_VA per labour hour (Fig. 4) converted to index numbers with base TE 2006-07 shows how labour productivity of the agriculturally backward eastern states seem to have continuously grown and those in west fallen. This means that value added has grown far faster or slower than physical labour. Estimation of the regression equation explaining the R_VA of rice in Table 6 did not show significance of squared variables but a number of interaction variables emerged showing the complex inter-relation of factors and inputs in generating the value added both through both the production side and the cost side. Both FE and RE model are presented (Tables 6a and b). Though with four units of cross-section states, FE sounds more reasonable, a Hausman test (Table 6) suggests arguably a preference for the RE model.

In the reduced form equations estimated (Table 6), the results are not too different, relative price of fertilizer shows the expected negative effect further exacerbated by physical use of manure and well irrigation as compliments of fertilizer. Interest on working capital has a positive interaction with price. Taking account of the fertilizer equation (Box 1), the productivity of fertilizer is positive also seen in its elasticity. Both tractor use and land rent interact with labour to determine R_VA but the interactions are negative (substitutive) and positive (synergical) respectively but while labour itself without interaction variables failed to reveal any significant effect, its productivity differs across the states.

Appendix Table A.1 gives the sample averages of variables used. As can be expected RVA and land rent are much higher in western states Punjab and Haryana than eastern states Bihar and Jharkhand but although western states are privileged with lower relative fertilizer price and greater irrigation, eastern states absorb more both of labour and tractor hours, consume more manure and pay less interest on working capital. To compare the productivities, mean state values of explanatory variables (Table 7) are considered along with the estimated coefficients of equations (Table 6) and the auxiliary equation for fertilizer (Box 1). Elasticity of fertilizer (Fig. 5) is highest at 1.7 in Bihar followed by 0.35 in Jharkhand, 0.30 in Punjab, and lowest at 0 in Haryana. Similarly, the saturation or even unsustainability of using

Table 6 Panel regression on relative value added (R_VA)

Variables	Random effect		Fixed effect	
	Model 1	Model 2	Model 1	Model 2
RFP	− 11.47***	− 0.694*	− 10.83***	− 1.305***
	(1.328)	(0.379)	(1.643)	(0.480)
RFP × MNR	− 0.0803**	–	− 0.0985**	–
	(0.0323)		(0.0380)	
WEL × RFP	− 1.317***	0.195	− 1.269***	− 0.395*
	(0.178)	(0.138)	(0.197)	(0.231)
RENT_R	− 2.049***	− 0.428*	− 1.167	0.00919
	(0.549)	(0.227)	(1.045)	(0.256)
RENT_R × THLH	0.434***	–	0.300*	–
	(0.0889)		(0.169)	
WCI_R	− 0.878*	1.491***	− 0.790	2.033***
	(0.449)	(0.335)	(0.540)	(0.343)
WCI_R × RFP	4.963***	–	4.646***	–
	(0.633)		(0.837)	
TRC/GCA × THLH	− 0.618**	0.922***	− 0.435	0.817***
	(0.261)	(0.336)	(0.347)	(0.298)
TRC/GCA	3.866**	− 5.889***	2.624	− 5.238***
	(1.650)	(2.111)	(2.247)	(1.884)
WELCNL/GGA	1.218***	-0.181**	1.217***	0.748
	(0.279)	(0.0803)	(0.333)	(0.475)
CHLH × DUM_HY	− 0.122***	–	0.181	–
	(0.0370)		(0.638)	
CHLH × DUM_PJ	0.0143	–	0.553	–
	(0.0465)		(0.605)	
CHLH × DUM_JH	0.280***	–	0.407	–
	(0.0800)		(0.259)	
THLH	–	− 1.753***	–	− 1.102**
		(0.400)		(0.431)
Constant	6.157***	16.81***	4.594**	10.64***
	(0.929)	(2.443)	(1.975)	(3.096)
Observations	56	56	56	56
R-squared	0.944	0.806	0.946	0.856
Number of states	4	4	4	4

Note Standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

other common inputs is shown by the finding that working capital is not proving productive in Haryana and Punjab but helps only in the eastern states. Intriguingly, labour is found highly productive in all the study states, with elasticities exceeding unity in all except Haryana where it is close to unity. Labour productivity too is relatively higher in the eastern states.

Table 7 Hausman test (FE vs. RE)

	Coefficients		(b − B) Difference	Sqrt (diag(V_b − V_B)) S.E.
	(b)	(B)		
	Fixed	Random		
RFP	− 10.83	− 11.47	0.64	0.90
RFP × MNR	− 0.10	− 0.08	− 0.02	0.02
WEL × RFP	− 1.27	− 1.32	0.05	0.07
RENT_R	− 1.17	− 2.05	0.88	0.86
RENT_R × THLH	0.30	0.43	− 0.13	0.14
WCI_R	− 0.79	− 0.88	0.09	0.28
WCI_R × RFP	4.65	4.96	− 0.32	0.52
TRC/GCA × THLH	− 0.43	− 0.62	0.18	0.22
TRC/GCA	2.62	3.87	− 1.24	1.44
WELCNL/GGA	1.22	1.22	0.00	0.17
CHLH × DUM_HY	0.18	− 0.12	0.30	0.62
CHLH × DUM_PJ	0.55	0.01	0.54	0.59
CHLH × DUM_JH	0.41	0.28	0.13	0.24

Test Ho: difference in coefficients not systematic. $chi^2(3) = (b - B)'[(V\_b - V\_B)^{(-1)}](b - B) = 1.10$, Prob > $chi^2 = 0.7759$. We choose random effect model because Prob > chi^2 is > 0.05

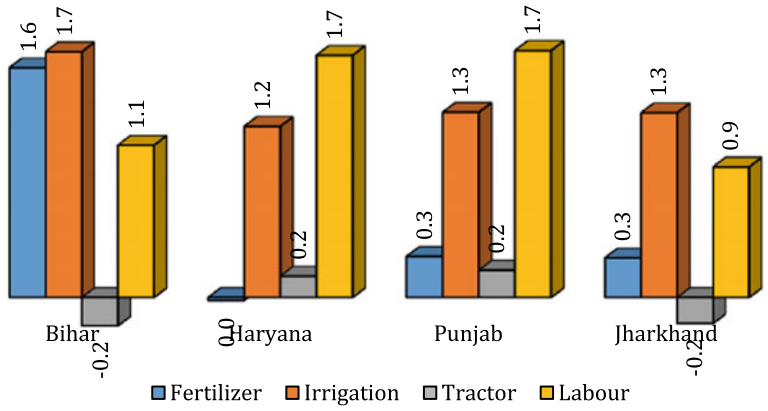

Fig. 5 Elasticities of real value added to inputs based on model 1 and box 1 equation

4 Conclusion

Despite the problems of migration, regional imbalance and rural unemployment, conclusions of the study bring relief that labour has gained share in value added of rice cultivation in the source states of migration while being in demand also in destination states. While material inputs are losing productive value and sustainability in the western high production states of India, the marginal productivity of labour remains positive and high in all states though higher in the eastern states contesting any claim of disguised unemployment. Over time, casual labour has gained share in the west while family labour remains important in the east. Farm income shows better performance in the east but is becoming poor and even negative in west. Material inputs like fertilizer remain important for agricultural production but their use levels are hardly yielding any added benefit unlike land and labour.

As the results vindicate the implications of Lewis model, there is scope in Bihar and Jharkhand to develop agriculture and absorb manpower for a productive agriculture while Punjab and Haryana too need much more attention towards renovation of their economies. Agriculture the traditional reserve of workforce itself may be making space for employment opportunity and in the times ahead offers potential to build a modern and highly productive farm sector that releases more land space for other uses without compromising production. As the information technology infiltrates rural India, a highly digitized practice of agriculture is possible with proper training for sharing and gaining knowledge, timely acquisition of weather alerts and demand conditions, financial transactions, and production planning.

Box 1

$$\underset{}{\text{FRT\_E}} = \underset{}{5.73} - \underset{(-9.08 * **)}{1.21} \times (\text{FRT}_{\text{Price}}/\text{Rice}_{\text{WSP}}) + \underset{(7.12 * **)}{0.32} \times \text{WEL/GCE}$$

Appendix

See Table A.1.

Table A.1 Mean values for variables used in panel regression

Variable	Interpretation and units	Mean			
		Bihar	Haryana	Punjab	Jharkhand
RVA	Relative value added (Rs./ha)	31,600	66,900	86,300	32,800
RFP	Relative fertilizer price (ratio)	1.77	1.16	1.06	1.77
RENT_R	Relative rent from owned land (Rs./ha)	7,070	22,988	24,043	6,605
WCI_R	Relative interest on working capital (Rs./ha)	483	875	765	435
TRC/GCA	Tractors deflated by gross cropped area units/'000 ha	3.70	3.47	2.84	4.18
WELCNL/GCA	Sum of well and canal net irrigated area by GCA (ratio)	0.39	0.47	0.52	0.05
MAN	Manure quantity (kg/ha)	16.5	8.8	253.5	44.0
WEL/GCA	Well deflated by GCA (ratio)	0.27	0.28	0.38	0.05
THLH	Total human labour hours (h/ha)	727	555	382	706

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