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Sources of Crop Output Growth in Bihar: Implications for Policy Interventions

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Bihar has a geographical area of 9.4 million hectares and fertile agricultural land spread across the Indo-Gangetic plains. The net cultivated area in the state accounted for about 57 per cent of the total reported geographical area during 2012-14. There are four agro-climatic zones in the state, with distinct soil characteristics, rainfall and cropping patterns. They are: Zone-I (North Alluvial Plain), Zone-II (North-east Alluvial Plain), Zone-IIIA (South-east Alluvial Plain), and Zone-IIIB (South-west Alluvial Plain). Favourable agro-climatic conditions enable the farmers to grow diverse crops, and increase cropping intensity and income from cultivation.

Over 70 per cent of rural workers depend on agriculture for livelihood. Despite its importance for the economic growth of the state, the agricultural sector had for long remained neglected, needing a big policy push for unleashing its growth potential. In order to address this shortcoming, the Government of Bihar launched agriculture roadmaps with specific targets for output, distribution of inputs, and service delivery, to be achieved within a specified time frame. The different phases of agricultural roadmaps were laid out as follows: the first agriculture roadmap (2008–09 to 2011–12); the second agriculture roadmap (2012–13 to 2016–17); and the third agriculture roadmap (2017–18 to 2022–23). These roadmaps focus on the holistic development of agriculture in the state, with an emphasis on increasing productivity growth and improving farmers' income. These agriculture roadmaps have indeed improved the performance of agriculture. The average annual growth in agriculture during the pre-agriculture roadmap period (2001-02 to 2007-08) was 1.98 per cent, which increased to 2.09 per cent during the post-agriculture roadmap

Box 1: Contours of NCAER's Work on *Agricultural Diagnostics for Bihar*

The main aim of the NCAER study, which is aligned with the Bihar agriculture roadmaps laid down by the Government of Bihar (GoB), is to develop practical, evidence-based policy options for supporting sustainable growth in this sector. The purpose of the diagnostic study is to identify both the drivers of and barriers in its growth, as also other aspects such as social inclusivity, the regional dimensions of growth, and the future growth trajectory. Specifically, the key objectives of the study are to:

- Assess the drivers of agricultural productivity and growth in Bihar;
- Understand and rank the obstacles to inclusive growth; and
- Identify implementable policy action points to increase the agriculture sector's productivity and promote inclusive growth to help the sector achieve a sustained path of higher growth.

period (2008-09 to 2016-17). Within agriculture, the crop sector accounted for over 50 per cent of the total value of the output from agriculture and allied activities during 2015-16. The average growth in crop output was 3.63 per cent during the post-agriculture roadmap period as compared to a negative growth of 0.69 per cent during the pre-agriculture roadmap period.

In this context, the UK Department for International Development (DFID) in India has commissioned the National Council of Applied Economic Research (NCAER) to undertake an agricultural sector diagnostic study in the Indian state of Bihar to identify the economic, political, natural, and technological barriers that beset agricultural productivity and inclusive growth in Bihar (see Box 1).

This policy brief has been prepared as a part of this study for assessing whether input intensification or technological change is driving growth in crop output. The results would be useful for identifying the binding constraints on both input use and technological change.

Trends in Partial Productivity

Land productivity is measured as the gross value of output per hectare at 2011-12 prices. It has been found that land productivity is relatively high for horticultural crops as compared to field crops (Annex Table 1). By and large, these crops, with the exception of sweet potato and turmeric, registered higher growth in output during the periods of the agriculture roadmaps. While garlic and onion registered higher growth in output, land productivity was the highest for dry chilies, followed by sweet potato, banana, and dry ginger. For most horticultural corps, land productivity showed an increasing trend over time. There is a growing interest among farmers to expand the area under horticultural crops.

The land productivity of major field crops has also shown upward trend. The productivity of sugarcane was as high as Rs. 62,226/ha during the triennium 2015-16 with a robust average output growth of 12.12 per cent during the periods of agriculture road map. The performance of pulses particularly red gram (arhar), black gram (urad) and lentil has been very impressive. A similar encouraging trend in land productivity is evident for cereals as well. Overall, the aggregate land productivity was Rs 51,387/ha in 2015-16. The productivity improved by one-and-a-half times between 2002-03 and 2015-16. The average growth in output was appreciable at 3.63 per cent. In this context, it is important to analyse the drivers of crop output growth. This will help to identify both the growth-promoting as well as growth-inhibiting factors, and eliminating the latter would help put the agricultural sector on a higher growth trajectory.

Sources of Output Growth

The sources of crop output growth have been analysed by using a decomposition approach (Minot et al., 2006).[1] According to this approach, the change in gross revenue can be decomposed into the: (a) change in crop area, (b) change in yield, (c) change in real prices, and (d) diversification or re-allocation of land for different crops. The analysis covers 31 crops, which account for about 98 per cent of the total cropped area in the state.

Table 1: Sources of Crop Output Growth

Particulars	2001-02 to 2007-08	2008-09 to 2016-17	2001-02 to 2016-17
Area Effect	-6.9	-7.8	-7.5
Diversification Effect	8.1	36.8	26.9
Yield Effect	-54.4	210.8	119.3
Price Effect	176.1	-77.2	10.2
Interaction Effect	-23.0	-62.6	-48.9
Total	100.0	100.0	100.0

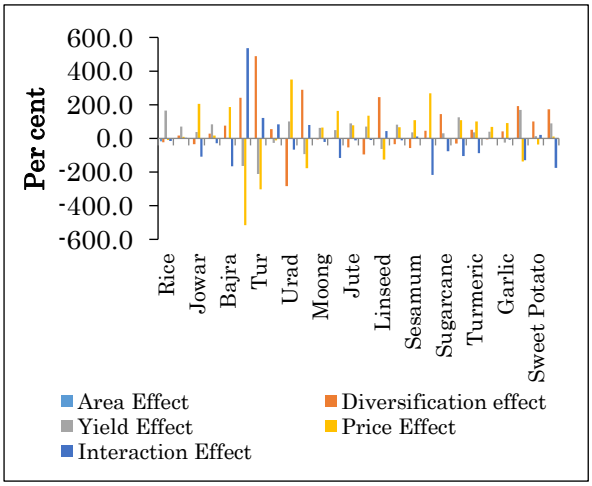
Source: Authors' estimates.

[1] Minot, N., M. Epprecht, T.T. Tram Anh and L.Q. Trung (2006). "Income Diversification and Poverty in Northern Uplands of Vietnam", *Research Report 145*, Washington D.C.; International Food Policy Research Institute.

During the period 2001-02 to 2007-08, the contribution of price was significantly higher along with diversification (Table 1). These effects could not help much in boosting output growth during this period. However, the output growth of about 3.6 per cent during the period 2008-09 to 2016-17 was bolstered with a splendid contribution of the yield effect. The contribution of the diversification effect also improved and positively influenced the output growth. Improvement in the diversification effect reflects the re-allocation of the area cultivated by farmers from low-productive to high-productive crops such as horticultural crops. The price effect and area expansion were negative during the most recent period.

During the overall study period, the yield effect was dominant along with positive diversification and price effects. The contribution of the price effect to output growth, at 10.2 per cent, was lower than that of the yield effect. An improvement in yield is a sustainable source of output growth in the long term. The negative interaction effect is largely due to a fall in the contribution of the area effect to output growth. Diversion of productive agricultural land for non-agricultural uses and increase in fallow land contribute to a fall in the cultivated land area.

Figure 1: Sources of Output Growth by Crops



Source: Authors' estimates.

There was considerable variation in the sources of output growth for individual crops (Figure 1). The area effect was negative and was relatively large for rice. This implies that the actual area under cultivation of rice had been kept fallow or had been diverted for growing other crops. This is, in fact, evident from the value of the diversification effect, which shows a re-allocation of the area among cereals, particularly to maize and wheat. The positive value of the diversification effect shows a gain in area under a particular crop, while the negative value indicates the loss of its area to other crops.

There was a large shift in area from crops such as *urad*, jute, mesta, and banana towards barley, *ragi*, *tur*, horse gram, linseed, sugarcane, potato, sweet potato, and onion. This implies that coarse cereals, pulses, and commercial crops are gaining importance among the farmers due to an increase in demand for these crops from food processing industries. Besides these crops, the contribution of diversification effect was positive for wheat, maize, and gram.

Drivers of Crop Output Growth

An analysis of the sources of output growth revealed that most of the growth in crop output was the result of improvements in yield, which can be brought about through the introduction of new technology in the form of improved seeds, increased use of inputs, and adoption of better crop management technology. Since crop output growth registered an appreciable growth rate, it would be pertinent to analyse whether this growth is being driven by input intensification or technological innovation. It is also important to examine the sustainability of this higher growth in the long run. This section provides further insights into the factors influencing the growth in crop outputs.

The resource decomposition method proposed by Fugie (2012) enables us to identify the intensity of use of resources and the role of technology in promoting output growth[2]. Under this method, output growth is estimated as the sum of the area growth and yield growth. Thereafter, yield growth is decomposed to the growth in Total Factor Productivity (TFP) and growth in inputs. For performing the resource decomposition analysis, detailed information about inputs and output is required. The cost of cultivation

[2] Fuglie, K. (2012). "Productivity Growth and Technology Capital in the Global Agricultural Economy", in K. Fuglie, S.L. Wang, and V.E. Ball (Eds.), Productivity Growth in Agriculture: An International Perspective. Oxfordshire, UK:Eco CAB International., Oxfordshire, U.K.

survey provides this information only for six major crops, including paddy, wheat, maize, gram, lentil, and potato. This has thus been used in this assessment. These crops account for 87 per cent of the total cropped area in the state.

Before discussing the results of resource decomposition analysis, it is useful to present here the trend in weighted indices of output, inputs, and TFP. The aggregate output index showed a gradual rising trend from 2000-01 to 2006-06 (Figure 2). It suddenly increased in the subsequent years and then declined in 2009-10. There was an apparent structural break in the output series during 2009-10, which was caused by widespread drought in different regions of Bihar.[3] However, an encouraging trend was the upward surge in the output index subsequently. The upward movement in the output index from 2010-11 onwards occurred during the period of the second agriculture roadmap.

The aggregate input index declined steadily during the study period. This indicates that input use in the cultivation of the crops was low, and also seen to be declining over time. Further, this also implies that output growth is largely driven by technological change, while the contribution of input intensification is limited. The aggregate TFP index, which is a measure of technological change, moved in tandem with the aggregate output index. It was encouraging to note that the overall rise in TFP led to an increase in the output index.

The relative contribution of various material inputs, labour, TFP, and natural resources such as land and irrigation water is given in Figure 3**.** Taking all the six crops into consideration, the aggregate TFP growth was only 1.71 per cent during the period 2000-01 to 2015-16. Output growth was about 1.0 per cent, which was mainly contributed by TFP growth. Input growth was negative. At the aggregate level, only fertilisers and manure, machinery, area, and irrigation registered positive average growth rates. Irrigation was the single largest input for growth, contributing about 38 per cent of the output growth, followed by mechanisation, at 23 per cent.

Figure 2: Trends in Output, Input and TFP Index

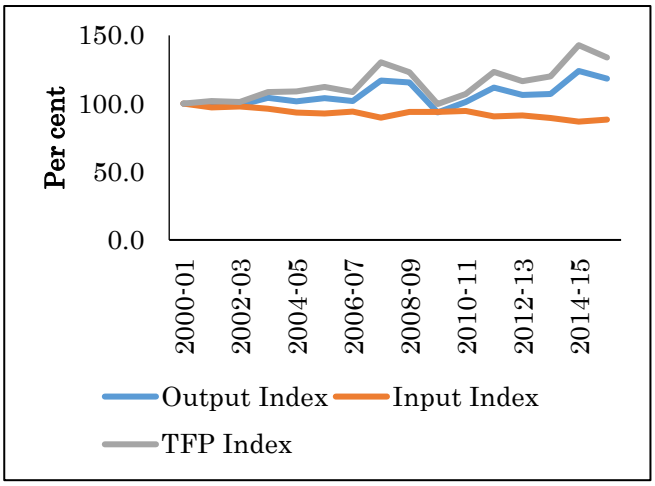
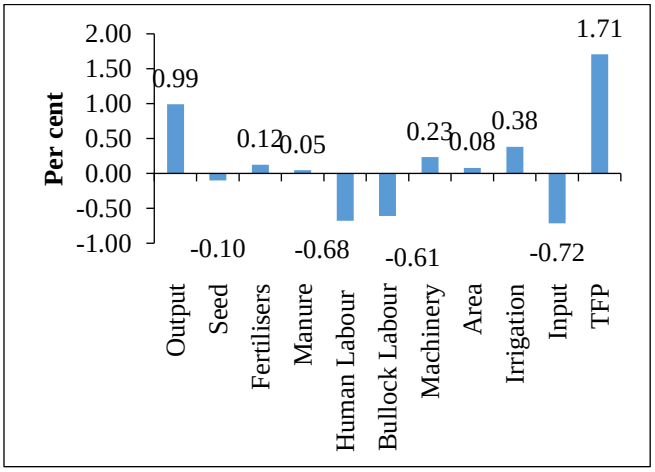


Figure 3: Relative Contribution of Input Growth and TFP Growth: 2000-01 to 2015-16



Source: Authors' estimates.

An analysis of the relative contributions of inputs and TFP to output growth during different periods shows that the contribution of TFP stands out clearly (Figure 4). At the same time, the contribution of fertilisers and manure, expansion in the area under cultivation, and irrigation also improved during the period of the second agriculture roadmap. However, the effect of these inputs still remains low, and hence their relative contributions to yield growth were also low as compared to that of TFP growth.

The contribution of various inputs and technological change to output growth varied across crops. Output growth was relatively high for gram and potato, at 1.89 per cent and 1.60 per cent, respectively

[3] Government of Bihar (2011) Economic Survey.

(Figure 5). Both TFP growth and input growth are responsible for the output growth in gram, while TFP growth alone has contributed significantly to output growth in potato. TFP growth was highly robust at 2.69 per cent. Similarly, for paddy and wheat, TFP growth was appreciable at 1.85 per cent and 1.72 per cent, respectively. However, low TFP growth for lentil points to the great scope for increasing output growth by introducing new technologies in its cultivation. For most crops, input growth was negative.

As is evident from the previous analysis, the contribution of area growth to output growth was positive for maize, wheat, and potato. However, the higher negative growth in human labour and animal labour outweighed positive growth in material inputs, leading to overall negative growth in the input of these crops. Interestingly, the contribution of fertilisers and manure, and machinery was positive for almost all the crops. This implies that the increased use of fertilisers and mechanisation would emerge as the future sources of agricultural growth in Bihar. At the same time, it is important to examine the constraints in the efficient use of quality seeds and other inputs. Overall, it emerges that technological change has been the major driver of crop output growth. On the other hand, input intensification is low and even has worsened for some crops. Although TFP growth was slightly impressive, low input intensification is a matter of concern as it affects the growth in yield.

Figure 4: Contribution of Inputs Growth and TFP Growth by Different Periods

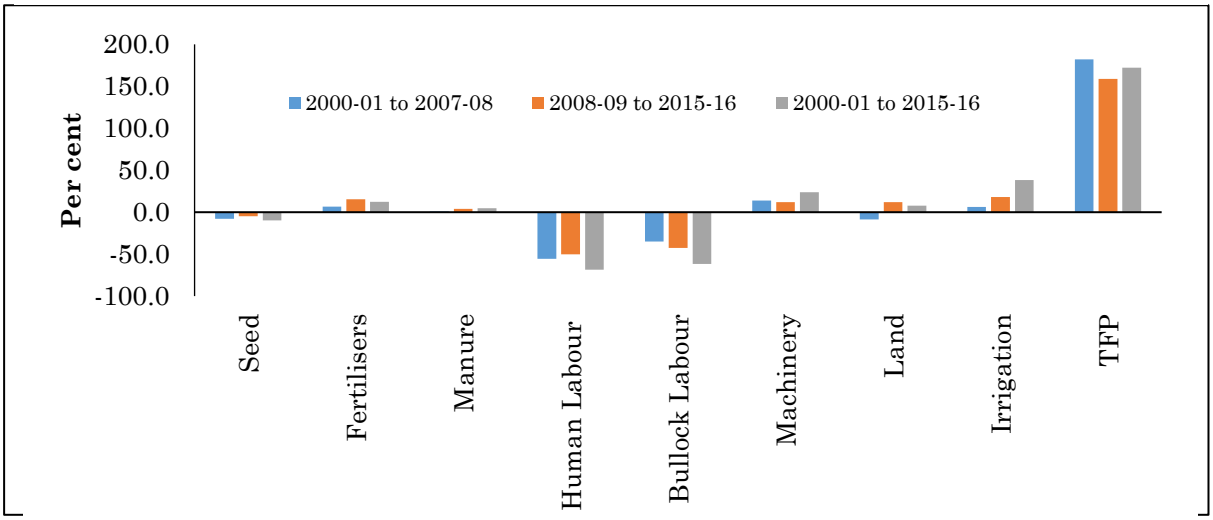
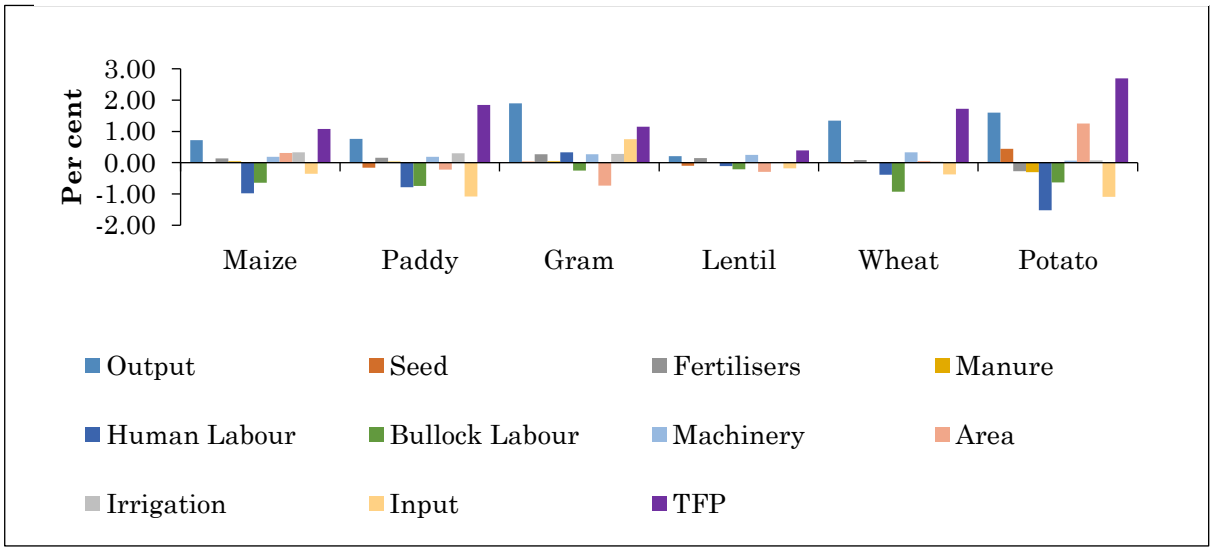


Figure 5: Relative Contribution Inputs Growth and TFP Growth by Crops: 2000-01 to 2015-16



Source: Authors' estimates.

Concluding Remarks

- Among the sources of output growth, improvements in yield has largely contributed to crop output growth during the period 2001-02 to 2016-17.
- The effect of crop diversification on crop output growth is positive.
- The output growth led by improvement in TFP is sustainable in the long run.
- Low input intensification is a matter of concern as it seems to have affected the level of crop yield. Thus, increased use of inputs may further accelerate yield growth.
- There is still scope to improve TFP growth for most crops. An increase in public spending on agricultural research and extension will help in developing area-specific crop technology and in disseminating it effectively among farmers. Similarly, investment in rural infrastructure such as roads, markets, and financing facilities will help promote the adoption of better cultivation practices among farmers.
- It is crucial to conduct periodic training for the extension functionaries. Simultaneously, it is also imperative to offer farmers practical advice on the use of different inputs in terms of dosage, combination of the inputs, and the time of application. The Government could supply major inputs such as seeds, fertilisers, pesticides, and machinery to farmers through rural cooperative societies. The easy and timely availability of quality inputs will enhance both the quantity and efficiency of the inputs used in cultivation.

Annex Table 1: Growth in Crop Output and Average Productivity

Crop	Growth Rate (%)		Average Productivity (Rs/ha)		
	2000-01 to 2007-08	2008-09 to 2015-16	TE 2002-03	TE 2007-08	TE 2015-16
Paddy	-1.14	5.09	18917	18738	28845
Wheat	3.03	0.54	21712	25042	27780
Jowar	14.40	-9.78	5154	6623	11190
Bajra	30.31	3.68	5285	4590	16892
Barley	-2.80	1.63	10467	11438	17269
Maize	3.15	9.67	20040	22543	37925
Ragi	-9.49	6.15	5989	5648	26251
Gram	-3.77	-1.49	30850	28380	29012
Arhar	-2.33	-1.64	35692	37839	61350
Urad	-2.34	2.49	18673	19573	51120
Moong	-5.18	8.56	19240	14679	28422
Lentil	-3.36	2.17	23637	20916	45629
Khesari	-3.61	-3.57	8571	10723	21953
Linseed	-2.98	-4.85	20975	22160	29553
Rapeseed and Mustard	1.64	6.59	23030	28244	42240
Sugarcane	-5.98	12.12	67171	46052	62226
Jute	5.19	6.32	18647	27144	56707
Mesta	1.69	17.60	16913	23637	56279
Dry Chilies	-5.84	2.98	64516	62692	113205
Dry Ginger	15.03	8.63	35581	53755	76755
Turmeric	8.26	-0.38	40362	58049	71579
Coriander	5.92	3.85	17385	24047	37837
Garlic	2.21	13.06	34030	32096	59532
Potato	4.67	4.93	49578	59720	34586
Sweet Potato	4.97	-18.90	104505	142807	95412
Banana	-6.11	3.35	209949	149166	83153
Onion	11.53	11.68	54167	88663	51379
Overall	-0.69	3.63	51387	57405	86268

Source: Computed from DES, Ministry of Agriculture and Farmers Welfare, and National Accounts Statistics (various years).