Sources of Agricultural Growth and Its Determinants: A Regional Analysis of Uttar Pradesh

Sanjeev Kumar*, **Sanjay Kumar Upadhay** and Devna Joshi****

ABSTRACT

The paper examines the sources and patterns of growth in crop sector in Uttar Pradesh and identifies the drivers through panel data from 2004-05 to 2015-16. The results reveal that yield and diversification are found to be the sustainable sources of growth in crop sector in all regions except Bundelkhand. However, these sources have varied widely across the regions. The fixed effect regression model result show that irrigated area, electricity, road length, agricultural loan, agricultural market, fertilisers, tractor, literacy rate, planned expanses and normal rainfall are drivers of agricultural growth. Thus, infrastructural, institutional, technological and socio-economic factors ought to be improved through new policies.

Keywords: Crop sector, Sources of growth, Decomposition analysis, Rural infrastructure,
 Fixed effects model.

JEL: C33, Q11, Q12, R11

I

INTRODUCTION

It has been widely known that agriculture is one of the most effective instruments for achieving growth and reducing poverty especially in rural economies (Kumar *et al*., 2011). However, the promise of agriculture to reduce poverty and initiate development in any economy can be realised only if the state works in tandem in providing the core public goods, investing in physical and institutional infrastructure and regulating natural resource management apart from facilitating the private sector to pitch in profitably (World Bank, 2008). One such initiative of the Indian state was witnessed during the Green Revolution which proved quite fruitful for the Indian agricultural sector. During this phase, factors such as technological change, investment in infrastructure by way of irrigation facilities, market access, road connectivity; development of institutions particularly extension of credit services and enabling input and output price policies became the major drivers of agricultural growth throughout the country. The effects of Green Revolution also trickled down to various states. Uttar Pradesh per se benefited immensely and has been the highest producer of some food grains and non-food-grains such as vegetables, fruits, sugarcane and potato throughout the country and is commonly known as the "granary of the nation".

The agriculture growth statistics was also quite commendable. From negative growth rate of -0.9 per cent in the Third Five Year Plan (1961-66), agriculture sector grew at 5.23 per cent towards the 1980s. But after the 1990s agricultural growth in UP has been going through its own ups and downs (Government of Uttar Pradesh, 2017). It may be due to factors similar to those at the national level which might have caused decline in agricultural growth in Uttar Pradesh as well. For instance, the technologies that had driven growth may have started showing signs of fatigue (Evenson *et al*., 1999; Murgai *et al*., 2001; Sidhu, 2002; Chand *et al*., 2010) or the increased frequency of extreme climate events, such as droughts and floods, might have added to the sluggishness and instability in agriculture.

Besides plummeting yields, the aspect of crop diversification also contributed to the slowdown in agricultural growth in UP. Despite crop diversification gaining pace throughout the country during the 1990s (Birthal *et al*., 2007), the same was not true for the state of Uttar Pradesh. Being endowed with abundant natural resources; diverse agro-climatic conditions, varied soil type, abundant rainfall- which has immense scope for growing horticultural crops (Basu, 2008), the rate of crop diversification is less in the state. Hence, fostering rapid and sustainable growth in agriculture continues to be a major policy challenge for the state.

Uttar Pradesh has the highest population base throughout the country. Surging population gives rise to urbanisation and a sustained rise in per capita income. These changes ensue a significant transformation of the food basket, in quantity as well as quality (Joshi and Kumar, 2011). In order to maintain the momentum, this will cause pressures on the existing resources as the domestic production will not be as easy to meet as in the Green Revolution period. Considering the fact that the gross cropped area of UP is around 26 million hectares, there is little, if any or no scope to expand the land frontiers. Hence, intensification of the existing production systems remains the only option. This will entail competition for land, water and energy. Consequently, energy prices will rise rapidly. With the unfolding of globalisation, the sector will come under the pressure of adjustment to global market forces. Thus, addressing these challenges requires an understanding of the past sources of growth and their determinants in the context of the agricultural sector in Uttar Pradesh.

The internal sources of agricultural growth may be improvement in crop productivity, resource use efficiency, diversification, modernisation of technology, rural infrastructure and improvement of real prices received by farmers while shifting cultivators from farm to non-farm occupations and better terms of trade constitute the external sources of growth. Hence, this study is an attempt to analyse the changes in the patterns and sources of growth in the crop sector in Uttar Pradesh, which accounts for close to two-third of the total value of output by agriculture sector in the state. A better understanding of the nuances of the past sources of growth is pivotal to provide empirical support to design appropriate research and development strategies for sustainable intensification of agriculture. Specifically, the study quantifies the changes in the sources of growth in crop sector and identifies the drivers for growth
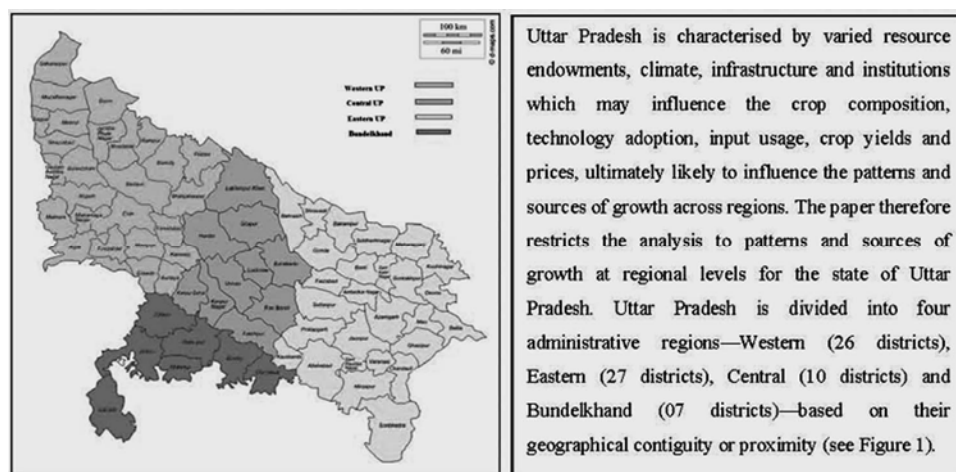
at aggregate level as well as regional level of the state. Further, it discusses the economic, institutional and policy factors underlying these changes and suggests strategies for higher, more sustainable and more inclusive agricultural growth of the state.

II

DATA BASE

To analyse the sources of agricultural growth, data on area, production, yields, farm harvest prices and wholesale price of crops from 75 districts of Uttar Pradesh was considered. Data on area, production and yield of 41 crops, namely; rice, wheat, jowar, bajra, maize, barley, millets; arhar, gram, masoor, peas; groundnut, linseed, rapeseed, til, sunflower, soyabean, cotton, sugarcane, mango, banana, papaya, litchi, guava, jackfruit, aonla, muskmelon, potato, sweet potato, onion, brinjal, cabbage, cauliflower, okra, tomato, green peas, coriander, garlic, ginger, chillies and turmeric were obtained from *Agricultural Statistics at a Glance*, DES, Ministry of Agriculture, Planning Department of Uttar Pradesh, Horticulture Board of Uttar Pradesh and UPDES. The selected crops for the present study account for more than 90 percent of both the total cropped area and the value of output of the crop sector in Uttar Pradesh (UPDES).Similarly, value of output by specific crop was generated by multiplying production with Farm Harvest Prices. Farm Harvest prices were taken out from Department of Agriculture and Co-operation Network (DACNET). These values were initially generated at current price. Later, wholesale price indexes were retrieved from the Office of Economic Advisor website in order to convert current prices into real prices (at 2011/2012 base). The time series on area, production, productivity, real prices and real value of output were later smoothened by applying Hodrick-Prescott (HP) filter by an appropriate adjustment factor. The HP filtered data series were used for analysing the patterns and sources of growth. Finally in order to identify the drivers for conducting regression analysis utilised variables related to fertiliser consumption, tractor, irrigation, roads, electrification, agriculture market, school, health centre, forest area, normal rainfall and loan for primary sector obtained from Uttar Pradesh Directorate of Economics and Statistics (UPDES).

Table 1 presents the salient features of the four administrative regions of Uttar Pradesh. The Western region (WUP) consists of 26 districts marked by fertile landscape and the highest gross cropped area and cropping intensity at 9.90 million hectares and 160.80 per cent respectively. The rural population in the region is 70.88 per cent while the urban population is 29.12 per cent. Population density is second highest after Eastern region at 978.79 persons per sq. km. The Eastern region (EUP) comprises 27 districts. This region is less fertile than the Western region. The gross cropped area is 8.55 million hectares while the cropping intensity is 155.72 per cent. 88.60 per cent of the population resides in rural areas while 11.40 per cent

Uttar Pradesh is characterised by varied resource endowments, climate, infrastructure and institutions which may influence the crop composition, technology adoption, input usage, crop yields and prices, ultimately likely to influence the patterns and sources of growth across regions. The paper therefore restricts the analysis to patterns and sources of growth at regional levels for the state of Uttar Pradesh. Uttar Pradesh is divided into four administrative regions—Western (26 districts), Eastern (27 districts), Central (10 districts) and Bundelkhand (07 districts)—based on their geographical contiguity or proximity (see Figure 1).

Source: Author's classification.

Figure 1. Administrative Regions of Uttar Pradesh.

resides in urban areas. The population density of the Eastern region is 993.04 persons per sq. km. The Central region (CUP) consists of 10 districts.77.40 per cent of the population resides in rural areas while 22.60 per cent of the population resides in urban areas. The gross cropped area is 4.74 million hectares while the cropping intensity is 153.78 per cent. The Bundelkhand region (BUP) consists of seven districts and 79.17 per cent represents rural population while 20.83 per cent represents urban population. The gross cropped area is 2.74 million hectares and the cropping intensity is 132.67 per cent.

TABLE 1. UTTAR PRADESH AT A GLANCE: DEMOGRAPHIC, SOCIO-ECONOMIC
AND LAND-USE STATISTICS

Variables	WUP	CUP	EUP	BUP	UP	INDIA
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Population in million (census 2011)	72.83	35.97	79.89	9.68	199.8	1210
Rural population (per cent) (census 2011)	70.88	77.40	88.60	79.17	77.7	68.8
Urban population (per cent) (census 2011)	29.12	22.60	11.40	20.83	22.3	31.1
Geographical area LUS (mHa)	8.04	4.53	8.64	2.96	24.10	328.7
Population density (persons per sq km)	978.79	872.51	993.04	320.43	829.00	382
Gross cropped area (mHa)	9.90	4.74	8.55	2.74	25.89	196.9
Cropping intensity (per cent)	160.80	153.78	155.72	132.67	156.15	139.86
Number of districts	26	10	27	7	70*	676

Source: ICRIER report and UPDES.
Note: Five new districts merged with existing districts.

III

METHODOLOGY

The technique of decomposition has been used in order to arrive at the results. The main variable utilised for the decomposition of data is agricultural growth. Through the growth accounting approach of Minot *et al*. (2006), agricultural growth

was decomposed by source and crop. Source refers to the variables identified, i.e., area, productivity, price and diversification while crops refer to the database of 41 crops grown in Uttar Pradesh. For instance, according to this approach, the change in gross revenue from a single crop can be decomposed into change in cropped area, change in yield, change in real price and a residual representing the interaction among area, yield and real price. One more source of growth is the diversification factor which represents reallocation of area from one to other crops. These sources of change or growth in gross revenue are influenced by a number of economic and non-economic factors.

Assuming that a farmer behaves rationally, he or she maximises profit from his or her land by choosing a production mix, inputs, and technologies subject to his resource endowments and markets. If Ai is area under crop i, Yi is its production per unit area, and Pi is the real price per unit of production, then the gross revenue R from n crops can be written as

$$R = \sum_{i=1}^{n} A_i Y_i P_i \qquad \qquad ....(1)$$

A_i can be further expressed as the share of crop i in the total cropped area, $(a_i) = A_i / \sum_i A_i$ and substituting this expression in equation (1) we get

$$R = \left(\sum_{i=1}^{n} a_i Y_i P_i \right) \sum_{i=1}^{n} A_i \qquad \qquad ....(2)$$

The total derivative of both sides of equation (2) provides the absolute contribution of changes in these components to the change in gross revenue

$$dR \cong \left(\sum_{i=1}^{n} a_i Y_i P_i \right) d\left(\sum_{i=1}^{n} A_i \right) + \left(\sum_{i=1}^{n} A_i \right) d\left(\sum_{i=1}^{n} a_i Y_i P_i \right) \qquad ....(3)$$

Equation (3) is only an approximation, as it excludes the interaction term. The second term on the right-hand side of this equation can be further decomposed from a change in sums to the sum of changes, as follows

$$dR \cong \left(\sum_{i=1}^{n} a_i Y_i P_i \right) d\left(\sum_{i=1}^{n} A_i \right) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} d(a_i Y_i P_i) \qquad ....(4)$$

Further expansion of the second term of Equation (4) results in the following expression:

$$dR \cong \begin{aligned} &\left(\sum_{i=1}^{n} a_i Y_i P_i \right) d\left(\sum_{i=1}^{n} A_i \right) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (a_i Y_i dP_i) \\ &+ \left(\sum_{i=1}^{n} A_i \right) \left(\sum_{i=1}^{n} a_i P_i dY_i \right) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (P_i Y_i da_i) \end{aligned} \qquad ....(5)$$

Equation (5) decomposes change in gross revenue due to changes in (i) total cropped area, (ii) crop yields or technology (iii) real prices and (iv) diversification or

land reallocation. The first term on the right-hand side of this equation represents the change in gross revenue due to a change in total cropped area. The second term on the right-hand side captures the change in gross revenue due to a change in the real prices of commodities. The third term measures the change in gross revenue due to a change in crop yields or technology. The fourth term represents the change in gross revenue associated with changes in crop composition. A positive fourth term indicates a diversification from lower-value to higher-value crops. Dividing both sides of equation (5) by the overall change in gross revenue (dR) gives us the proportionate share of each source in the overall change in gross revenue or agricultural growth.

Construction of Panel Data Regression Model

Panel data regression analysis has been used to quantify the association between per hectare value of output by crop sector (PHVOCS) and its determinants, i.e., gross irrigated area as per cent of gross sown area (GIA), ratio of electricity consumption by agriculture sector to total electricity consumption (ELECAG), literacy rate (LITR), total road length of per thousand hectare (RLPTH), gross sown area per tractor (GSAPTRA), zila yojna actual expense per thousand hectare (ZYAE), agricultural markets per thousand hectare (MANDI), amount of loan distribution in agriculture sector per thousand hectare (AGLTL), normal rainfall in mm (NRAIN), fertilisers consumption per hectare (FERCON). Natural log value of the variables have been taken into account for this purpose. Pooled ordinary least square regression model, Fixed Effects Model (FEM) and Random Effects Model (REM) are the important method for panel data analysis. In pooled OLS estimation, it is assumed that coefficients across time and cross-section remain the same. The major problem with this model is that it does not distinguish between the various entities or panels (districts) that we have. In other words, it denies the heterogeneity and individuality condition. For best model selection between FEM and REM, Hausman specification test is applied in order to check the suitability of the method for panel data analysis.

Fixed Effect Model (FEM)

For capturing the individuality of each state (cross-sectional unit), intercept is varied by using dummy variable for fixed effects. Fixed effect models for panel data (intercept or individual) are given by equation;

$$PHVOCS_{it} = \beta_1 + \beta_2 GIA_{it} + \beta_3 ELECAG_{it} + \beta_4 LITR_{it} + \beta_5 RLPTH_{it}$$
$$+ \beta_6 GSAPTRA_{it} + \beta_7 ZYAE_{it} + \beta_8 MANDI_{it} + \beta_9 AGLTL$$
$$+ \beta_{10} NRAIN_{it} + \beta_{11} FERCON_{it} + u_{it}$$

here, i = 1,2,3,-----70 [cross section (districts)] and t = 1,2,3------12 [time period (years)]

u_{it} stochastic error term

Random Effect Model (REM)

In the random effect model, it is assumed that the individual specific coefficient β_{1i} is fixed for each time-invariant. In the random effects model, it is assumed that β_{1i} is a random variable with a mean value of β_1 (no i subscript here) and the intercept of any cross-section unit is expressed as in following equation;

$$\beta_{1i} = \beta_1 + \varepsilon_i$$

where ε_i is a random error term with mean '0' and variance σ_{ε}^2.

Therefore, random effect model for panel data can be written as by the equation;

$$PHVOCS_{it} = \beta_1 + \beta_2 GIA_{it} + \beta_3 ELECAG_{it} + \beta_4 LITR_{it} + \beta_5 RLPTH_{it} \\ + \beta_6 GSAPTRA_{it} + \beta_7 ZYAE_{it} + \beta_8 MANDI_{it} + \beta_9 AGLTL \\ + \beta_{10} NRAIN_{it} + \beta_{11} FERCON_{it} + w_{it}$$

where; $w_{it} = \varepsilon_{i} + u_{it}$

The composite error term w_{it} has two components; ε_i represent the cross-section or individual-specific error component and u_{it} represent combined time series and cross-section error component.

Hausman specification test (1978) is used to select appropriate model between fixed effects model (FEM) and random effects model (REM) and it is given by equation;

$$H = (\hat{\beta}_{RE} - \hat{\beta}_{FE})' [Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})]^{-1} (\hat{\beta}_{RE} - \hat{\beta}_{FE})$$

IV

SOURCES OF GROWTH AT THE STATE LEVEL

The patterns and sources of agricultural growth by crop sector in Uttar Pradesh from 2004-05 to 2015-16 and its two sub-periods, i.e., 2004-05 to 2009-10 and 2010-11 to 2015-16 respectively has been estimated in Table 2. In the table, it is found that the share of cereals in gross cropped area has increased marginally though its share in value of output decreased drastically over a period of time. Also, the share of cereals in overall growth was impressive at 20.03 per cent. For coarse cereals and pulses, their share in gross cropped area as well as value of output has decreased considerably during the study period. Also, the share of foodgrain in gross cropped area and value of output has decreased though the growth was significant during the study period. Regarding oilseeds and sugarcane, their share in gross cropped area and value of output accelerated but growth of only sugarcane was highly remarkable.

The share of vegetables and fruits in the gross cropped area increased considerably but in the case of value of output of vegetables in particular, it increased but for fruits, it declined. In the case of spices, gross cropped area remained stagnant while its value of output declined with a negative growth rate over the study period. Hence, from the overall analysis, it is observed that cereals; particularly wheat and rice being the dominant crops accounted for close to two-thirds of the gross cropped area and contributed about half the value of output by crops sector while oilseeds and sugarcane occupied about 13 per cent of gross cropped area representing about one-third of the gross value of the output of crops during the study period. On the other hand, vegetables, fruits and spices are the next most important crop groups in the state. These crops accounted for around 5.0 per cent of the gross cropped area and nearly one-fifth in value of output of crops during the study period. Thus, growth of crop sector reveals a very clear pattern of the growing importance of high-value crops during the study period in Uttar Pradesh.

TABLE 2. CONTRIBUTION OF VARIOUS CROPS TO AGRICULTURAL GROWTH IN UTTAR PRADESH

Crop groups	Share in gross cropped area			Share in real value of output			CAGR in real value of output			Share in overall growth
	2004-05 to 2009-10	2010-11 to 2015-16	2004-05 to 2015-16	2004-05 to 2009-10	2010-11 to 2015-16	2004-05 to 2015-16	2004-05 to 2009-10	2010-11 to 2015-16	2004-05 to 2015-16	2004-05 to 2015-16
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Cereals	64.94	65.87	65.41	44.00	40.51	42.09	0.28	0.68	1.67	20.03
Coarse cereals	9.14	8.39	8.76	3.40	3.09	3.23	-1.30	- 0.88	1.63	1.49
Pulses	8.29	7.16	7.72	5.42	5.00	5.19	-4.36	- 2.30	0.65	0.95
Foodgrain	82.36	81.43	81.89	52.82	48.61	50.51	-0.38	0.26	1.54	22.05
Oilseeds	4.15	4.51	4.33	2.32	2.50	2.42	3.08	1.63	3.98	2.74
Sugarcane	8.93	8.98	8.95	26.25	30.07	28.35	0.33	1.34	6.94	55.94
Vegetables	2.98	3.43	3.21	8.56	9.14	8.88	3.26	4.50	4.30	10.86
Fruits	1.34	1.41	1.38	9.39	9.04	9.20	0.19	3.52	2.98	7.80
Spices	0.24	0.24	0.24	0.66	0.64	0.65	-0.35	-0.04	3.65	0.67
Total	100.00	100.00	100.00	100.00	100.00	100.00	-0.06	0.60	3.52	100.00

Source: Estimated by authors.

Further, the growth of value of output by crop sector in Uttar Pradesh has been decomposed into change in cropped area, yield, real prices and diversification. The contributions of these sources of growth in value of output by crops sector from 2004-05 to 2015-16 and its two sub-periods, i.e., 2004-05 to 2009-10 and 2010-11 to 2015-16 respectively are presented in Figure 2. In the figure, it is found that the area expansion accelerated during the sub-periods and grew at an average of 8.76 per cent from 2004-05 to 2015-16 in the state. However, the growth in yields and real prices has been pulled down during the sub-periods and the overall period. On the other hand, diversification of crops increased substantially during the sub-periods and grew at an average rate of 10.12 per cent during the study period. The declining share of yields was well compensated by a phenomenal rise in the diversification of the

production towards fruits, vegetables, sugarcane and all other crops. It is observed that the growth of yields increased significantly due to the better availability of water, improved agricultural inputs, soil fertility and better climatic conditions. The change in real farm prices may have been influenced by agricultural price policy, demand and supply imbalances of production and commodity substitution. Moreover, diversification might have been influenced by changes in the relative prices of agricultural commodities, costs of production and the level of development of infrastructure. Hence, it is quite clear that the sources which influenced the gross revenue of agriculture have extensive variations during the study period in Uttar Pradesh.
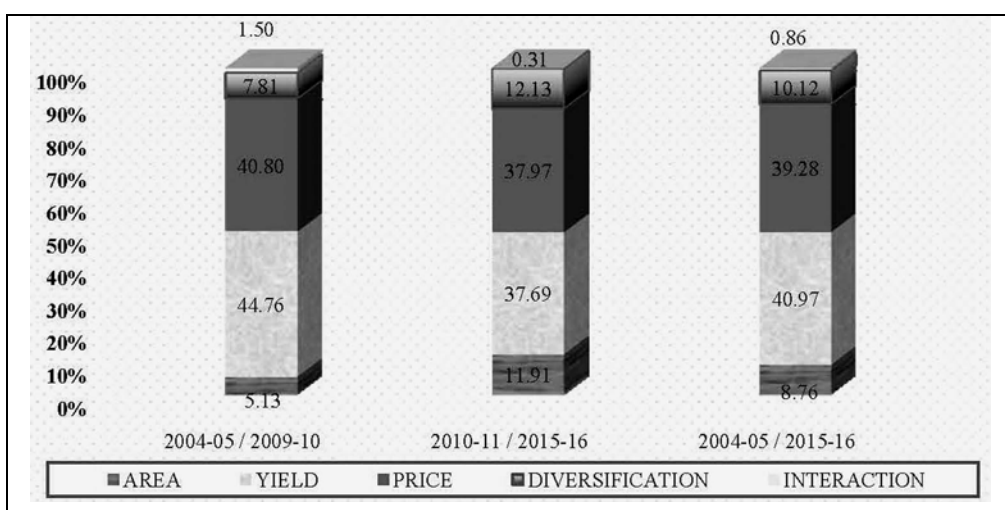
Source: Authors' calculation.
Figure 2. Sources of Growth in Crop Sector in Uttar Pradesh.

V

SOURCES OF GROWTH AT REGIONAL LEVEL

The sources of growth by crops sector at regional level of Uttar Pradesh during two sub-periods, i.e., 2004-05 to 2009-10 and 2010-11 to 2015-16 respectively are presented in Table 3. It is found that the contribution of area in the value of output in agriculture was highest in Bundelkhand (28.57 per cent), Western region (4.89 per cent), followed by Eastern region (0. 42 per cent) and decreased drastically in the Central region (-2.12 per cent) during 2004-05/ 2009-10. An increasing trend is observed in the share of value of output in area across all the regions from 2010-11 to 2015-16. But this is not true in case of yields as the value shares of yields declined among all the regions over the period of study. In particular, the value shares of yields were highest in Eastern region in Uttar Pradesh which may be due to

increasing land developmental opportunities, fertile soil and better availability of water. However, the effect of real prices was a mixed bag and revealed fluctuations which may be due to changes in the terms of trade to crop sector. The contribution of real prices particularly declined in the Western and Central regions whereas it increased significantly in the Eastern and Bundelkhand regions during the period of study. The growth of diversification also improved across all the regions except in the Western region. It improved by more than fifty per cent in Bundelkhand region in the study period. This may be due to the significant shift in the cropping pattern from traditional crops to cash crops as this region is highly drought prone and hence less water availability and climatic variability have serious repercussions for agricultural development in the state.
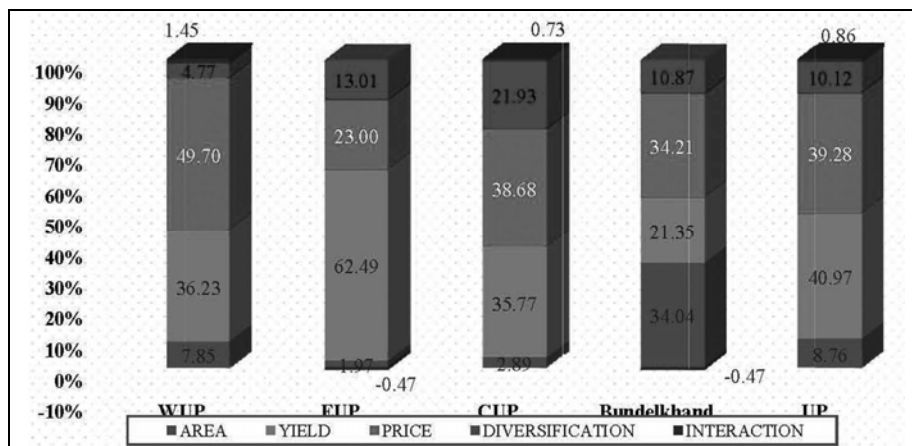
TABLE 3. SOURCES OF GROWTH IN CROP SECTOR AT REGIONAL LEVEL OF UTTAR PRADESH

Regions (1)	Periods (2)	Area (3)	Yield (4)	Price (5)	Diversification (6)	Interaction (7)	Total (8)
WUP	2004-05 to 2009-10	4.89	36.61	52.63	5.03	0.84	100
	2010-11 to 2015-16	10.53	35.90	47.03	4.53	2.01	100
EUP	2004-05 to 2009-10	0.42	69.46	21.76	9.19	-0.83	100
	2010-11 to 2015-16	3.52	55.56	24.22	16.81	-0.11	100
CUP	2004-05 to 2009-10	-2.12	35.93	44.30	17.48	4.41	100
	2010-11 to 2015-16	6.50	35.65	34.63	25.14	-1.92	100
Bundelkhand	2004-05 to 2009-10	28.57	32.77	30.63	5.55	2.48	100
	2010-11 to 2015-16	37.71	13.68	36.62	14.45	-2.46	100

Source: Estimated by authors.

The sources of growth in the crop sector at regional level in Uttar Pradesh from 2004-05 to 2015-16 are presented in Figure 3. It can be seen that the share of area by crops sector was the highest in Bundelkhand at 34.04 per cent while it was lowest for yields when compared with the rest of regions during the study period. On the other hand, there is a contrasting observation witnessed in the Eastern region. Despite having very low share in terms of area, the share of yield has increased significantly. This may be due to yield-augmenting technologies, better soil and water conservation and management practices besides favourable climatic conditions. For Central region, growth in area accounted for 2.89 per cent and contributed 35.77 per cent towards yield by crop sector. Price is the other dominant source of growth contributing about 50 per cent towards agricultural growth in the Western region. Herein, area accounts for 7.85 per cent and productivity 36.23 per cent, respectively with least diversification opportunities. Hence, in a nutshell, it is observed that the contribution of various sources to agricultural growth by crop sector across the various administrative regions have widespread fluctuations. Growth in yields by crops sector was remarkable in the Eastern region which may be due to better water availability, favourable weather conditions, fertile soil, availability of credit facilities and improved technology. The effect of price was found to be highly significant in the Western region which may be due to better market price for farm produce, demand

and supply balances and rise in the minimum support prices (MSPs) during the study period in Uttar Pradesh.

Source: estimated by authors calculation.

Figure 3. Sources of Growth in Crop Sector at Regional Level of Uttar Pradesh.

The contributions of various crops in agricultural growth at the regional level in Uttar Pradesh from 2004-05 to 2015-16 are presented in Table 4. Wheat and rice are the dominant cereal crops of the state. Consequently, the share in the gross cropped area of cereals was the highest among other crops, particularly in the Eastern region. On the other hand, growth of area of coarse cereals and pulses was very low in all the regions and about half of the area under coarse cereals and pulses was found in the Bundelkhand region over the study period. The contribution of area under oilseeds was highest, i.e., 12.62 per cent in Bundelkhand region while the share of gross cropped area of sugarcane accounted for 14.84 per cent in Western region and lowest, i.e., 0.35 per cent in Bundelkhand region during the study period. Vegetables, fruits and spices are the main horticultural crops in the state. The total value shares of area under these crops contributed about 6.0 per cent in Western region, followed by 3.0 per cent in Eastern region and 4.0 per cent in Central as well as Bundelkhand regions.

With regard to the share of cereals in real value of output, it was also the highest, i.e., 58.21 per cent in Eastern region during the study period. The share of pulses and coarse cereals in real value of output was the best in Bundelkhand region in case of pulses while in case of coarse cereals, the Western region accounted for as high as about 4 per cent of value share and contributed least, i.e., 0.88 per cent value shares for pulses. The share of total foodgrain in the value of output was the highest, i.e., 71.64 per cent in Bundelkhand region during the study period. The Western region accounted for the highest gross cropped area as well as real value of output for

TABLE 4. CONTRIBUTION OF VARIOUS CROPS TO AGRICULTURAL GROWTH AT
REGIONAL LEVEL IN UTTAR PRADESH

Regions (1)	Cereals (2)	Coarse cereals (3)	Pulses (4)	Foodgrain (5)	Oilseeds (6)	Sugarcane (7)	Vegetables (8)	Fruits (9)	Spices (10)	Total (11)
Share in gross cropped area										
WUP	59.69	13.25	1.51	74.45	4.16	14.84	4.53	1.59	0.43	100
EUP	78.42	5.69	6.28	90.40	1.54	4.71	2.04	1.24	0.07	100
CUP	67.73	6.29	5.86	79.87	5.55	10.03	2.34	1.92	0.29	100
Bundelkhand	36.24	7.52	39.11	82.87	12.62	0.35	4.02	0.08	0.05	100
U.P.	65.41	8.76	7.72	81.89	4.33	8.95	3.21	1.38	0.24	100
Share in real value of output										
WUP	34.78	4.41	0.88	40.07	2.61	38.15	9.54	8.52	1.11	100
EUP	58.21	2.14	5.48	65.82	1.05	17.19	6.82	8.98	0.14	100
CUP	41.70	1.92	4.06	47.68	2.72	28.94	5.99	14.28	0.39	100
Bundelkhand	29.81	3.17	38.66	71.64	5.91	1.10	20.68	0.52	0.14	100
U.P.	42.09	3.23	5.19	50.51	2.42	28.35	8.88	9.20	0.65	100
Annual compound growth in real value of output										
WUP	0.62	2.76	- 2.70	0.80	2.46	6.21	3.84	4.83	4.40	3.57
EUP	2.58	- 0.67	0.19	2.26	2.45	7.60	3.33	3.70	- 1.02	3.37
CUP	1.53	- 1.39	- 4.01	0.93	4.62	7.58	1.71	0.32	1.11	2.79
Bundelkhand	4.39	1.68	3.31	3.53	9.35	10.27	9.12	5.75	6.00	5.21
U.P	1.67	1.63	0.65	1.54	3.98	6.94	4.30	2.98	3.65	3.52
Share in overall growth										
WUP	6.01	3.40	- 0.66	8.98	1.80	66.40	10.26	11.52	1.37	100
EUP	44.44	- 0.42	0.31	44.16	0.76	38.74	6.73	9.86	- 0.04	100
CUP	22.83	- 0.96	-5.83	15.83	4.51	74.56	3.67	1.65	0.15	100
Bundelkhand	25.09	1.02	24.56	48.46	10.61	2.17	36.18	0.58	0.16	100
U.P.	20.03	1.49	0.95	22.05	2.74	55.94	10.86	7.80	0.67	100

Source: Estimated by authors.

sugarcane due to indulgence in better farm practices, availability of irrigation facilities, agricultural assets and financial services. For horticultural crops, the area under vegetables, fruits and spices together accounted for 6.55 per cent in Western, followed by 3.35 per cent in Eastern, 4.55 per cent in Central and 4.15 per cent in Bundelkhand region. The share in value of output of these crops in Western, Eastern, Central and Bundelkhand regions was 19.17 per cent, 15.94 per cent, 20.66 per cent and 21.34 per cent respectively during the study period.

The CAGR of cereals showed a positive growth rate but showed mixed trends for coarse cereals and pulses across almost all the other regions during the study period. The growth of commercial crops like oilseeds and sugarcane and horticultural crops such as vegetables and fruits grew at a positive rate in the state. It is thus observed that all the regions are transforming their cropping patterns from traditional crops to high value systems in the state. The share of sugarcane in overall growth was around two-thirds while cereals, coarse cereals, pulses, oilseeds, vegetables, fruits and spices accounted for one-third in Western region over the study period. In case of Eastern region, the share in overall growth of cereals was highest at 44.44 per cent, followed by -0.42 per cent for coarse cereals and 0.31 per cent of pulses. Oilseeds and sugarcane accounted for 0.76 per cent and 38.74 per cent respectively. This region is considered as the food basket of the state.

It is also considered better due to availability of water, technological transformation and farming opportunities. The share in overall growth of vegetables and fruits together accounted for about 16.59 per cent while spices revealed a negative growth rate at -0.04 per cent in the Eastern region. The share in the overall growth was the highest, i.e., 74.56 per cent for sugarcane, followed by 22.83 per cent of cereals, 4.51 per cent of oilseeds and became negative for both coarse cereals and pulses in the Central region. Horticultural crops, vegetables, fruits and spices together accounted only around 5.0 per cent during the study period in Central region. Considering Bundelkhand region, cereals, coarse cereals and pulses together accounted for half of the share in the overall growth whereas oilseeds and sugarcane contributed for 10.61 per cent and 2.17 per cent respectively. Similarly, the share in the overall growth of vegetables, fruits and spices together was about 37 per cent in Bundelkhand region. The contribution of various crops in agricultural growth has wide spread variations across all the regions in Uttar Pradesh during the study period. There are several policy and non-policy drivers responsible for such variations of growth of various crops sector and their contributions to the agricultural growth in the state.

IV

PANEL DATA REGRESSION RESULTS

The panel data regression results of value of output by crop sector and its determinants for the period 2004-05 to 2015-16 are presented in Table 5 which is calculated by using STATA. The Chi square value of Hausman test has revealed that these two models are not different enough to reject the null hypothesis. Hence, fixed effects model (FEM) is applied to evaluate the drivers of value of output by crop sector. The regression result shows that the values of within, between and overall R-square are 0.4755, 0.1726, 0.2136 respectively, which implies that the regression model on the whole explains 21.36 per cent per annum of the total variations in per hectare value of output in crop sector.

The FEM further reveals that all the drivers of agricultural growth, which has been taken in present study, had a significant impact on value of output by agriculture sector. The parameter relating to the rural infrastructure viz., gross irrigated area, electricity consumption by agriculture sector, road length of per 1000 hectare, zila yojna actual expense per 1000 hectare and agricultural markets had a positive and significant impact on agricultural growth (value of output). On the inputs side, i.e., fertiliser consumption, availability of tractor and agricultural loan are found also to be the main sources of agricultural growth. Moreover, literacy rate and normal rainfall had a positive and significant impact on per hectare value of output by crop sector in Uttar Pradesh. The findings of the regression result indicate that rural infrastructure variables along with agricultural input variables need to be incorporated for formulating the holistic agricultural policy to enhance the agricultural growth of the state.

TABLE 5. PANEL DATA REGRESSION RESULT OF VALUE OF OUTPUT AND ITS DRIVERS

Fixed-effects (within) regression		Number of observations = 840		
Dependent variable: per hectare value of output by crop sector (PHVOCS)				
Group variable (i): District		Number of groups = 70		
	within = 0.4755	Observation per group = 12		
R- Squared	between = 0.1726	F(10,760) = 68.91		
	overall = 0.2136	Prob > F = 0.0000		
Independent Variables	Coefficient	Standard Error	Test Statistics (Z)	Significance Level P>|z
(1)	(2)	(3)	(4)	(5)
GIA	0.23672	0.07011	3.380	0.001
ELECAG	0.04222	0.01418	2.980	0.003
RLPTH	0.08692	0.04247	2.050	0.041
MANDI	0.02812	0.02142	1.310	0.189
AGLTL	0.01530	0.00729	2.100	0.036
FERCON	0.03538	0.01745	2.030	0.043
GSAPTRA	0.04186	0.02157	1.940	0.053
LITR	0.88516	0.10969	8.070	0.000
ZYAE	0.02702	0.00783	3.450	0.001
NRAIN	0.04053	0.01739	2.330	0.020
Constant	4.38798	0.53512	8.200	0.000
Sigma_u = 0.37139083		*Sigma_e = 0.12373894*		*Rho = 0.900084*
F test that all u_i=0:		*F(69, 760) = 58.48*		*Prob > F = 0.0000*
Hausman Test Statistics				
Test: Ho: difference in coefficients not systematic				
chi2(10) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 63.06			Prob>chi2 = 0.0000	
Fixed Effect Model is appropriate for panel data analysis				

Source: Author's calculation.

VII

CONCLUSION AND POLICY IMPLICATIONS

Uttar Pradesh is commonly known as the "granary of the nation". But, since the 1990s, agricultural performance in Uttar Pradesh has been a mixed bag. The disparities have surfaced more particularly at the regional level whereby the performance of WUP has been better in comparison to the other regions. It can be thereby asserted that the differences in the patterns and sources of agricultural growth across regions of state, owe primarily to the differences in policy environments and resource endowments.

The analysis of sources of growth in UP at regional level reveals four important implications. *First,* the prospects for growth via area expansion are limited due to land constraints except in Bundelkhand region. However, area fluctuations within regions are observed. As competition for land is likely to surge due to the increasing demand for land for residential and industrial purposes, the only possibility for enhancing the contribution of area expansion to growth is through intensifying the cultivation of existing cropped land through extending irrigation facilities. *Second,* real prices play an important role in stimulating agricultural growth. Agricultural growth decomposing to output prices is the highest in the WUP while it was the lowest in the Eastern region. It is noticed that the administered price–led growth may

distort cropping patterns, degrade natural resources and widen interpersonal and regional disparities as the benefits of price increases accrue in proportion to the marketable surplus which obviously is less for poor farmers (Joshi *et al*., 2006). Thus it is necessary to enhance competition in the market place and improve market and transportation infrastructure to reduce marketing and transaction costs.

Third, fluctuating yields in the crop sector remain a matter of concern. It might be due to a variety of various factors. In the context of Uttar Pradesh, it is witnessed that the agricultural growth has the highest stake in yields in the EUP followed by WUP, CUP and Bundelkhand in that order. In order to increase yield, there is need to improve the rural infrastructure by sustaining the level of public investment in agriculture. Also, investment in agricultural research and extension is far from adequate which can cater to this need. *Fourth,* diversification towards high-value commodities is a sustainable source of growth and provides a cushion to agricultural growth. At the regional level, it is witnessed that diversification has been high in CUP while lowest in the WUP.For diversification, it has been witnessed that there has been some progress in dismantling policy and institutional barriers to the high-value agriculture and food industry in the last few years. But, harnessing its potential for inclusive growth can translate into attaining the objectives of Doubling Farmers' Income and ensuring food security.

Moreover, with respect to the drivers propelling agricultural growth in Uttar Pradesh, the panel data regression analysis reveals that rural infrastructure variables, viz., irrigated area, electricity consumption, road length, amount of loan distribution, fertilisers consumption, gross sown area per tractor, literacy rate, Zila yojna actual expense and normal rainfall were found the significant drivers of agriculture growth by crop sector in Uttar Pradesh. The regression findings suggest that there is need to improve infrastructural, institutional, technological and socio-economic factors through new programmes and policies, which directly or indirectly affect the agricultural growth.

REFERENCES

Basu, R.L. (2008), Diversification of Agriculture in Eastern India and the Poor , in Thakur and Padmadeo (Eds.), (2008), *Growth and Diversification of Agriculture*, Deep & Deep Publications, New Delhi.

Birthal, P.S., P.K. Joshi, D. Roy and A. Thorat (2007), *Diversification in Indian Agriculture Towards High-Value Crops: The Role of 194/Crop Diversification and Food Security in India Smallholders*, Discussion Paper No.727, International Food Policy Research Institute, Washington, D.C., U.S.A.

Chand, R., P. Kumar and S. Kumar (2010), *Total Factor Productivity and Contribution of Research Investment to Agricultural Growth in India,* Policy Paper 25, National Centre for Agricultural Economics and Policy Research, New Delhi.

Evenson, R.E., C.E. Pray, and M.W. Rosegrant (1999), *Agricultural Research and Productivity Growth in India,* Research Report 109, International Food Policy Research Institute, Washington, D.C., U.S.A..

Government of Uttar Pradesh (2017), *UP Statistical Abstract (2017)*, Economics and Statistics Division, State Planning Institute Planning Department.

Hausman, Jerry A. (1978), "Specification Tests in Econometrics", *Econometrica,* Vol.46, No.6, pp.1251-127.

Joshi P.K.; P.S. Birthal and N. Minot (2006), *Sources of Agricultural Growth in India: Role of Diversification towards High-value Crops, Markets, Trade and Institutions*, Discussion Paper No. 85, International Food Policy Research Institute, Washington, D.C., U.S.A.

Joshi, P.K. and P. Kumar (2011), *Food Demand and Supply Projections for India*, International Food Policy Research Institute (Asia Office), New Delhi (mimeo.).

Joshi, P.K; A. Gulati; P.S. Birthal and L. Tewari (2004), "Agriculture Diversification in South Asia: Patterns, Determinants and Policy Implications", *Economic and Political Weekly*, Vol.39, No.24, 12 June, pp. 2457-2467.

Kumar, A., P. Kumar, and A.N. Sharma (2011), "Rural Poverty and Agricultural Growth in India: Implications for the Twelfth Five Year Plan", *Indian Journal of Agricultural Economics*, Vol.66, No.3, July-September, pp.2690-2708.

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, International Food Policy Research Institute, Washington, D.C., U.S.A.

Sidhu, H.S. (2002), "Crisis in Agrarian Economy in Punjab: Some Urgent Steps", *Economic and Political Weekly,* Vol.37, No.30, 27 July, pp. 3132–3138.

Verma, S., Ashok Gulati and Siraj Hussain (2017), *Doubling Agricultural Growth in Uttar Pradesh: Sources and Drivers of Agricultural Growth and Policy Lessons*, ICRIER Working Paper 335, Indian Council for Research on International Economic Relations, New Delhi.

World Bank (2008), *World Development Report 2008: Agriculture for Development,* Washington, D.C., *U.S.A.* https://openknowledge.worldbank.org/handle/10986/5990