Indian Journal of Agricultural Sciences **88** (11): 1704–8, November 2018/Article

Trends and determinants of crop diversification in Uttar Pradesh

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Received: 2 February 2017; Accepted: 27 June 2018

ABSTRACT

The process of crop diversification towards high-value crops in Uttar Pradesh at regional as well as district level for the period 1990-91 to 2011-12 was examined. Simpson index of diversification and panel data regression analysis were used to analyze the trends and drivers of crop diversification. The results infer that state agriculture is moving from traditional crops to high value crops. This becomes the apt choice of policy makers for boosting agricultural growth. However, this shift is not found evenly distributed across the districts/regions. The irrigation, fertilizers and mechanization were found to be the major drivers of shift in the area towards high value crops and leads to less diversification. On the other hand, access to primary markets has positive impact on diversification. This necessitates the redesign and implementation of different strategies for crop diversification in these regions. The insight emanating from results emphasize not only to arrest the rising intra-regional disparities but also policy support in terms of better marketing infrastructure, easy and cheap access to agricultural credit for the development of irrigation facilities and farm mechanization, availability of fertilizers and appropriate technologies for increasing farm income and improving farmers' livelihoods.

Key words: Crop diversification, Random effect model, Uttar Pradesh

Uttar Pradesh occupies approximately 7.3 and 12% of geographical and net cultivated area of the country, respectively and contributes 21% in food grains, 18.5% in pulses and 6% in oilseeds (GoUP 2014). Agriculture sector contributes one third of the gross state domestic product, and employs seventy percent of its workforce. The agricultural growth performance over the span of three decades from mid 1960s to mid 1990s precisely enunciates the successful implementation of new technological packages in various crops. However, post mid 1990s, the sustainability of this growth performance has been frequently questioned on account of a significant deceleration in the growth of foodgrain production, from 2.63% per annum in 1984 -1994 to 1.28% per annum during 1994-2004, owing to the fact that no significant reduction in population growth during 1990s (Birthal *et al*. 2011, Kumar *et al.* 2014). Aftermath, the performance of agricultural sector in the state has improved slightly (Birthal *et al.* 2005) mainly due to a radical transition from the traditional practice of cultivating food grain crops to high value agriculture. This was in consonance with the shift in consumption pattern from traditional cereals to a more varied and nutritious diet of high value products. This has led to the development of agricultural diversification towards high value crops. Henceforth, crop diversification has become one of important choices of policy makers for enhancing farmers' income. A number of researchers argued in the same direction (Chand 1996, Joshi *et al*. 2004, Joshi *et al*. 2006, Gulati 2007, Kumar and Gupta 2015, Von Braun 1995 and Pingali and Rosegrant 1995). This necessitates to analyze the trends and extent of crop diversification besides discerning the drivers of crop diversification at dis-aggregated levels.

MATERIALS AND METHODS

The district level secondary data (1990-91 to 2011-12) on variables, viz. area under different crops, net irrigated area, number of primary markets, number of tractors, consumption of NPK were compiled from Agricultural Statistics at a Glance (GoI 2012) and Uttar Pradesh Statistical Abstract (various issues). The area under different crops were used for measuring crop diversification index. The Simpson Index of diversification (SID) was used to assess the extent of crop diversification. The formula of SID is

$$SID = 1 - \sum_{i=1}^{n} P_i^2 \quad \text{(I)}$$

where, P_i is the proportionate area of i^{th} crop/crop sector in the gross cropped area. The value of SID ranges between 0 and 1. When the value of *SID* is closer to 1, it indicates high diversification and when closer to 0, indicates no diversification.

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The total crop sector group included all food and non-food crops. For meaningful conclusions, the period was divided into two, i.e. 1990-91 to 1999-2000 (first period) and 2000-01 to 2011-12 (second period). The districts were further classified according to four economic regions of state namely; Western, Eastern, Central and, Bundelkhand regions. The selected districts of Western region were Agra, Aligarh, Bareilly, Bijnor, Budaun, Bulandshahr, Etah, Etawah, Farrukhabad, Mainpuri, Mathura, Meerut, Muradabad, Muzaffarnagar, Pilibhit, Rampur, Saharanpur and Shahjahanpur; Central region were Barabanki, Fatehpur, Hardoi, Kanpur, Lakhimpur-Kheri, Lucknow, Rai-Bareily, Sitapur and Unnao; Eastern region were Allahabad, Azamgarh, Bahraich, Ballia, Basti, Deoria, Faizabad, Ghazipur, Gonda, Gorakhpur, Jaunpur, Mirzapur, Pratapgarh, Sultanpur and Varanasi, and Bundelkand region were Banda, Hamirpur, Jalaun and Jhansi. These 46 districts contribute more than 70% gross cropped area [Statistical Abstract (UP) 2014].

Panel data regression model: To discern the determinants of crop diversification at the district level, random effect model (REM) for panel data analysis was used so as to discern and quantify the determinants of crop diversification. A balanced panel data set is used which has equal number of observations for each individual (cross-section).

The sample size constituted 1012 observations. The regression equation specification was used to find association between Simpson index of diversification (dependent variable) and net irrigated area, number of primary market, tractor density per thousands hectare, consumption of NPK (independent variables) as well as region specific dummy variables for Bundelkhand, Eastern, Central and Western region of the state.

Random effect model: In the random effect 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:

$$\beta_{1i} = \beta_1 + \varepsilon_i \quad \text{(I)}$$

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:

$$SID_{it} = \beta_1 + \beta_2 NIA_{it} + \beta_3 PMRT_{it} + \beta_4 NOTRA_{it} + \beta_5 CNPK_{it} + D_{1_{BUN}} + D_{2_{CUP}} + D_{3_{WUP}} + w_{it} \quad \text{(II)}$$

where, i = 1,2,3,....,46 [cross section (district)], t = 1,2,3,…, 22 [time period (years)], NIA = net irrigated area, PMRT = number of primary market, NOTRA = number of tractor, CNPK = consumption of NPK and region specific dummy variables; D_1_EUP = Bundelkhand, D_2_CUP = Central Uttar Pradesh, D_3_WUP = Western Uttar Pradesh and constant β_1 = dummy for Eastern Uttar Pradesh region.

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.

RESULTS AND DISCUSSION

Regional trends of area under different crop sector

Table 1 encapsulates the regional growth trends for area under food grain crops, non-food grain crops and all crop sectors for the four regions, viz. Western UP, Eastern UP, Central UP and Bundelkhand. The growth in area under all crops, foodgrain and non-foodgrain crops is very low during the first period (1990-91 to 1999-2000) and second period (2000-01 to 2011-12) except non-food crops during the second period. The area under non-foodgrain crops increased at a growth of 1.25% per annum during second period. On the other hand, area under vegetables has increased at much faster growth of 2.02 and 2.21% per annum during first and second periods respectively. The poor growth in area under crops sector could be attributed to the fact that the area under non-agricultural uses in the state has increased at a rate of 1.38% per annum during second period, whereas the annual growth in gross cropped area was meagre and even the net sown area has decreased.

The region-wise analysis showed that the annual

Table 1 Region-wise compound annual growth (%) in area under crops in Uttar Pradesh

Particular	Time period		
	1990-91 to 1999-2000	2000-01 to 2011-12	1990-91 to 2011-12
Western region			
Foodgrain	0.60	0.14	0.30
Non-foodgrain	0.09 (2.38)	0.81 (3.59)	0.16 (2.90)
All	0.47	0.31	0.26
Central region			
Foodgrain	0.28	0.11	0.17
Non-foodgrain	1.70 (2.05)	0.85 (0.91)	1.02 (0.85)
All	0.56	0.25	0.32
Eastern region			
Foodgrain	0.23	-0.21	0.07
Non-foodgrain	-0.04 (1.40)	-0.04 (-0.54)	0.11 (-0.45)
All	0.21	-0.19	0.07
Bundelkhand			
Foodgrain	1.03	0.14	0.68
Non-foodgrain	1.60 (3.94)	11.69 (5.62)	2.99 (3.76)
All	1.08	1.18	0.95
Uttar Pradesh			
Foodgrain	0.44	0.003	0.23
Non-foodgrain	0.48 (2.02)	1.25 (2.21)	0.50 (1.72)
All	0.45	0.21	0.27

Figures in parentheses represent vegetables. *Sources:* Author's calculations

growth in area under foodgrain, non-food grain and all crops was found to be meagre in western, central and eastern regions of UP during both the periods except non-foodgrain crops in central region. The growth in the area under the non-foodgrain crops in central region has increased at a growth of 1.70 and 0.85% per annum during first and second periods, respectively. On the other hand, the area under non-foodgrain crops has decreased in eastern region during both the periods. Bundelkhand region witnessed a moderate growth of 1% in all the crops. It is important to note that Bundelkhand region observed an impressive growth of 11.69% in the area under non-food crops during second period. The impressive growth in Bundelkhand region during second period was on account of very high growth in the area under sesame (30.19%), mustard (9.28%) and vegetables (3.59%). It is also worth noting that the area under vegetables in all the regions showed moderate to impressive growth during both the periods except eastern region during second period.

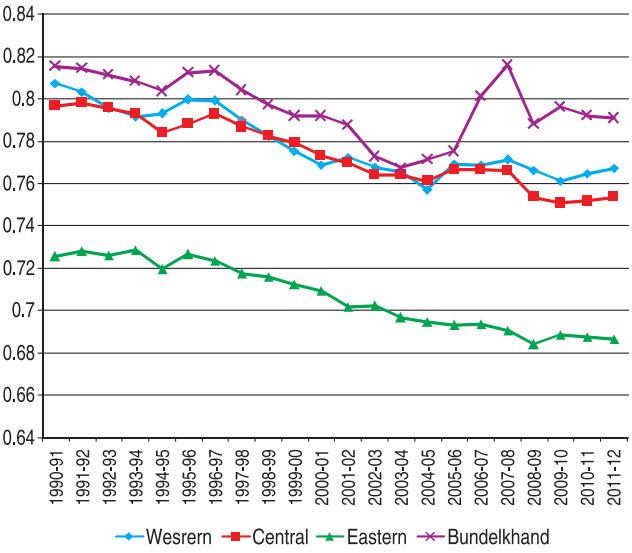

Fig 1 Regional trends of crop diversification in Uttar Pradesh

Regional trends of crop diversification

Apparently, Bundelkhand region displayed high levels of crop diversification during 1990-2012, recording an average Simpson Index of diversification (SID) value of 0.796; closely followed by Western (0.779) and Central region (0.775). Whereas, Eastern region registered lowest level of crop diversification with an average SID 0.707 (Table 2). The trend of crop diversification in all the regions showed marginal decrease between 1990-91 and 1996-97 (Fig 1). However, there was a persistence fall in crop diversification during 1996-97 to 2004-05 in all the regions. After 2005-06, crop diversification in Bundelkhand regions showed increasing trend on account of good growth in area under non-food crops especially oilseeds and vegetables during second period. Joshi *et al.* (2004) also reported that rainfed areas have benefited more as a result of agricultural diversification in favour of high value crops by substituting inferior coarse cereals.

However, Eastern region showed gradual fall in crop diversification over time due to the fact that growth in the area under food crops was stagnant and non-food crops was found to be decreasing in eastern region. The results infer that there was a decrease in crop diversification in all the regions of Uttar Pradesh especially during 1996-97 to 2004-05. Agriculture of the state was more diversified towards vegetables and oil seeds in agriculturally backward Bundelkhand and agriculturally advanced Western Uttar Pradesh.

Table 2 Regional trends of crop diversification in Uttar Pradesh

Year	Western region	Central region	Eastern region	Bundelkhand region
TE 1992-93	0.802	0.797	0.727	0.814
TE 2002-03	0.770	0.769	0.705	0.784
TE 2011-12	0.764	0.752	0.688	0.793
All	0.779	0.775	0.707	0.796

Sources: Author's calculations

District-wise extent of crop diversification

The extent of crop diversification across various districts falling in different regions of Uttar Pradesh during the period 1991 to 2012 is presented in Table 3. In Bundelkhand region, all four districts, viz. Jhansi Banda, Hamirpur and Jalaun witnessed higher level of crop diversification (SID > 0.75) during 1990s and 2000's. except Jhansi which figured under category of moderate crop diversification during second period.

In Western region, the districts of southern part of western region, viz Agra, Aligarh Etah, Etawah, Mainpuri and Farrukhabad had higher level of crop diversification, wherein, the value of their respective SIDs was recorded to be above 0.75 during 1990s. However, during 2000's only Etawah and Farrukhabad maintained higher levels of crop diversification and other south-western districts moved down to moderate (0.70 to 0.75) level of crop diversification. The Bareilly, Budaun, Bulandshahr, Mathura, Meerut, Moradabad, Saharanpur and Shahjahanpur witnessed moderate degree of crop diversification and Bijnor, Muzaffarnagar, Pilibhit, and Rampur witnessed lower degree of crop diversification. Futher, during 2000's Mathura, Meerut and Shahjahanpur were in lower (0.60-0.69) crop diversification category and Muzaffarnagar shifted down to very low (up to 0.59) level of crop diversification on account of higher growth in area under sugarcane in the district. Hence, as a whole Western region of UP recorded moderate to high levels of crop diversification during nineties and moderate to low during 2000's.

Central region of UP displayed either higher and moderate level of crop diversification with majority of its districts, viz. Fatehpur, Hardoi, Lakhimpur-Kheri, Lucknow, Kanpur and Sitapur recorded higher SID value and only 3 districts (Barabanki, Rae-Bareily and Unnao) recorded

Table 3 Extent of crop diversification: District-wise classification

	Very low (up to 0.59)	Low (0.60-0.69)	Moderate (0.70 to 0.75)	High (Above 0.75)
			Western region	
1990's		Bijnor, Muzaffarnagar, Pilibhit, Rampur	Bareilly, Budaun, Bulandshahr, Mathura, Meerut, Muradabad, Saharanpur, Shahjahanpur	Agra, Aligarh, Etah, Etawah, Mainpuri, Farrukhabad
2000's	Muzaffar-nagar	Bijnor, Mathura, Meerut, Pilibhit, Rampur, Shahjahanpur	Agra, Aligarh, Budaun, Bulandshahr, Bareilly, Etah, Muradabad, Mainpuri, Saharanpur	Farrukhabad, Etawah
			Central region	
1990's			Barabanki, Rae-Bareily, Unnao	Fatehpur, Hardoi, Lakhimpur-Kheri, Lucknow, Kanpur, Sitapur
2000's		Barabanki, Rae-Bareily, Unnao	Hardoi, Lakhimpur-Kheri, Lucknow	Fatehpur, Kanpur, Sitapur
			Eastern region	
1990's		Azamgarh, Basti, Deoria, Faizabad, Gorakhpur	Ballia, Ghazipur, Jaunpur, Pratapgarh, Sultanpur, Varanasi	Allahabad, Bahraich, Gonda Mirzapur
2000's		Azamgarh, Basti, Deoria, Faizabad, Ghazipur, Gorakhpur, Pratapgarh, Varanasi	Allahabad, Ballia, Jaunpur, Sultanpur	Bahraich, Gonda, Mirzapur
			Bundelkhand region	
1990's				Banda, Hamirpur, Jhansi, Jalaun
2000's			Jhansi	Banda, Hamirpur, Jalaun

Sources: Author's calculations

moderate crop diversification during first period. During recent period, the level of crop diversification has decreased in six districts of the region and three districts had shifted from higher to moderate and three from moderate to lower category of crop diversification (Table 3).

Eastern region experienced lowest level of crop diversification, wherein the majority of districts witnessed low (Azamgarh, Basti, Deoria, Faizabad and Gorakhpur) and moderate (Ballia, Ghazipur, Jaunpur, Pratapgarh, Sultanpur and Varanasi) level of crop diversification during nineties. During the second period, the situation of crop diversification worsened in most of these districts and only three districts; Bahraich, Gonda and Mirzapur experienced higher degree of crop diversification. Henceforth, Eastern region largely experienced sparse amounts of crop diversification within the study period.

Drivers of crop diversification at district level

To identify the drivers (determinants) of crop diversification at the district level, random effect model was applied to evaluate the drivers of SID at the districts level for the period 1990-91 to 2011-12.

The random effects model (REM) results are presented in Table 4. The REM indicates that the values of within, between and overall R-square are 0.4297, 0.0254 and 0.0216 respectively, which implies that the regression model on the within explains 42.97% per annum of the total variations in crop diversification index. The magnitude of F-value indicates that the given model is a good fit. The results of REM attest that net irrigated area, number of tractor per thousand hectare of land and consumption of NPK have a statistically significant and negative impact on crop diversification index. The negative impact of these variables could be explained by the fact that the irrigation and fertilizers had complementary relationship and therefore, the farmers with better access to irrigation and

Table 4 Panel data regression result by random effect model

Variables	Dependent variable: SID	
	Coefficient	P-value
Net irrigated area	-0.0001*	0.0000
Number of primary market	0.002*	0.0003
Number of tractor	-0.0002*	0.0000
NPK consumption	-0.0004*	0.0002
Constant	0.759*	0.0140
Central region (Dummy)	0.768	0.0211
Bundelkhand region (Dummy)	0.793	0.0212
Western region (Dummy)	0.766	0.0180
Wald chi Square	713.07	0.0000
R2: Within	0.43	
R2: Between	0.026	
R2: Overall	0.06	
No. of observations	1012	

Sources: Author's calculations

tractor shifted their area under most profitable crops from less profitable crops. This resulted in higher growth under non-food high value crops like sugarcane, potato, other vegetables and lower diversification. However, the impact of number of primary market on crop diversification was found to be positive and statistically significant indicating easy access to markets to sell the agricultural products leads to more diversification. The impact of dummy variables for Bundelkhand on Simpson index of crop diversification was found slightly statistically significant. On the other hand, other region specific dummy variables, viz. Central region and Western region have not statistical significant impact on crop diversification index.

In this context, most of the parameters under consideration, viz. net irrigated area, number of primary market, number of tractor and consumption of NPK have been found to influence the nature and extent of crop diversification in the state at the disaggregated level (district level).

Conclusions and policy implications

The study establishes the fact that with emerging trends of area and Simpson index of diversification, Uttar Pradesh is moving from traditional crop sector, i.e. food-grain crops to high value agriculture. However, this shift is not found evenly distributed across the districts/region. The extent of crop diversification displayed high degree of crop diversification in Bundelkhand region followed by Western and Central regions of Uttar Pradesh. Meanwhile, Eastern region registered low degree of crop diversification. The crop diversification showed decreasing trend in all the regions especially during 1996-97 to 2004-05. In the recent times, Bundelkhand region witnessed diversification towards high value crops, i.e. vegetables and low water requiring oilseed crops like sesame in *kharif* season and mustard in *rabi* season.Western region also witnessed high growth in high value vegetables crops in recent time. Within all the regions sharp intra-regional disparities in crop diversification were found at the district level as well as regional level. The irrigation, fertilizers and mechanization are the major drivers of shift in the area towards high value crops and leads to less diversification. On the other hand, access to primary markets gives an opportunity to realize good prices of their products and hence leads to more diversification. This necessitates the redesign and implementation of different strategies for crop diversification in these regions. The study paved the pathways for policy support in terms of better marketing infrastructure, easy and cheap access to agricultural credit for the development of irrigation facilities and farm mechanization, availability of fertilizers, crop insurance, and appropriate technologies need to be extended to the farming community for increasing their income for improved livelihoods.

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