Crop Diversification towards High-value Crops in India: A State Level Empirical Analysis

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Abstract

The paper has examined state-level trends and patterns in crop diversification in India for the period 1990-91 to 2011-12 using Simpson Index of Diversification (SID) and panel regression analysis. The study has revealed that cropping pattern at state level is transforming from foodgrains to high-value crops but the transformation is not uniform across the states/regions. The values of SID have confirmed that the agricultural economy has diversified in all the states with some fluctuations in case of food crops and non-food crops. The results of Fixed Effect Model have revealed cropping intensity, average annual rainfall and gross irrigated area to be the major determinants of crop diversification. The study has suggested that policy support in terms of enhanced cropping intensity, gross irrigated area, insurance coverage, investment in agricultural research and education, and technology development need to be extended to the farmers.

Key words: Crop diversification, Simpson index of diversification, fixed effect model, Hausman test

JEL Classification: C23, O13, R14, Q15

Introduction

Indian agriculture has undergone a radical transition from traditional to high-value agriculture during recent years. The economy has also witnessed shifting of consumption pattern from traditional cereals to a more holistic and nutritious diet of fruit and vegetables, milk, fish, meat and poultry products, and it is due to rapid growth of the economy. Hence, agricultural diversification towards high-value crops has been instituted within Indian agriculture.

Agricultural diversification has become a significant component for realizing higher output growth, higher farm income, employment generation, sustainability of natural resources and poverty alleviation. The experience from South-East Asia, Middle East and North Africa corroborates that policy makers and planners are crescent focusing on agricultural diversification to promote agricultural development (Petit and Barghouti, 1992). Several researchers have argued that agricultural diversification can be used as an instrument to raise farm income, generate employment opportunities, alleviate poverty and for conservation of natural resources (Von Braun, 1995; Pingali and Rosegrant, 1995; Ryan and Spencer, 2001; Birthal *et al.*, 2005).

Diversification of crop has immense potential as an economic driver within the agricultural sector which may prove to be of paramount consequence in meeting the challenges which ensued in the post-green revolution scenario. In view of shrinking agricultural land and operational holdings which are attributable to the expansion of urban areas and, high growth rate of population, along with changes in consumer food habits, the farmers are straining to include or substitute additional high value crops in to the cropping system (Singh, 2011).

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The performance of Indian agricultural sector in terms of income generation and diversification has followed an unsteady path and showed huge variations between different geographical locations across the country at the disaggregated level (Radhakrishna and Panda, 2006). These regional variations across the states have remained a subject of concern. To propel the agriculture sector towards further growth and development, it is imperative to identify the levels of crop diversification at the state level for making specific strategies. Agricultural diversification in India has been studied mostly at the national level, and only a few state level studies exist. Although, states are considered to be the appropriate administrative unit for regional level studies, agriculture diversification generally varies widely across the states due to different regional characteristics in terms of resource endowments, infrastructure and climate. In this backdrop, the present study has analyzed the trends and extent of crop diversification at state level along with identification of determinants of crop diversification at the state level.

Data and Methodology

The study is based on the secondary data sources, viz. *National Accounts Statistics, Agricultural Statistics at a Glance*, *Handbook of Statistics on Indian Economy* and *Land Use Statistics*, Department of Agriculture and Co-operation Network (DACNET), Government of India. To assess the extent of crop diversification, Simpson Index of crop diversification (SID) has been used. It provides a clear dispersion of commodities in a geographical region and is easy to compute and interpret. The Simpson index of crop diversification (SID) is given by Equation (1):

$$SID = 1 - \sum_{i}^{n} P_i^2 \qquad \dots(1)$$

where, P_i is the proportionate area of ith crop/crop sector in the gross cropped area

The Simpson index of diversification (SID) ranges between 0 and 1, wherein the value closer to 1 indicates high diversification and the value closer to 0, indicates no diversification.

The SID has been measured for food crops, non-food crops and the crop sector in major states of India for the period 1990-91 to 20011-12. For analytical convenience, this period was divided into two sub-

periods, viz., 1990-91 to 1999-2000 (first sub-period) and 2000-01 to 2011-12 (second sub-period). Food crops group included foodgrains, sugarcane & sugar, condiments & spices and fruits & vegetables; while the non-food crop group was comprised of oilseeds, fibres, drugs & narcotics and plantation crops. The total crop sector group included all food crops and all non-food crops. The study has covered seventeen major Indian states, viz. Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. These states contribute more than 90 per cent gross cropped area to the agriculture sector. The compound average growth rate (CAGR) of various aspects such as GDP by sectors and crop groups as well as the gross cropped area (GCA) under different crops and crop groups, at the national and state level has also been estimated by exponential model.

Panel Data Regression Model

To discern the determinants of crop diversification at the state level, fixed effect model (FEM) and random effect model (REM) were used. A balanced panel data set was used which had equal number of observations for each individual (states). For best model selection between FEM and REM, Hausman specification test was used to check the suitability of the technique for data analysis.

The sample size constituted 374 observations. The regression equation specification was used to find association between SID (dependent variable) and cropping intensity, gross irrigated area and annual rainfall (independent variables).

The FEM has constant slopes but intercepts differ according to the cross-sectional (states) unit. For i classes, i–1 dummy variables are used to designate a particular state. It allows for heterogeneity or individuality among states (units) as each state is allowed to have its own intercept value. So, intercept may differ across states but intercept does not differ over time. In the random effect model (REM), the intercept is assumed to be a random outcome variable, whereas the random outcome is a function of a mean value plus a random error.

Fixed Effect Model

To take into account 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) can be given by Equation (2):

$$SID_{it} = \beta_{1i} + \beta_2\ CI_{it} + \beta_3\ RAIN_{it} + \beta_4\ GIA_{it} + u_{it} \qquad \ldots(2)$$

where, i = 1, 2, 3,...............................,17 [cross section (states)], t = 1,2,3,...............,22 [time period (years)], SID = Simpson Index of Diversification, CI =Cropping intensity, RAIN=Annual rainfall; GIA =Gross irrigated area, u =Stochastic error-term.

Random Effect Model

In the random effect (REM) model, the assumption is that individual specific coefficient β_{1i} is fixed for each time-in-variant and it is assumed that β_{1i} is a random variable with mean value of β_1 (no i subscript here) and the intercept of β_1 any cross-section unit is expressed by Equation (3):

$$\beta_{1i} = \beta_1 + \varepsilon_i \qquad \ldots(3)$$

where, ε_i is a random error-term with mean '0' and variance '$\sigma_{\varepsilon i}^2$'.

Therefore, random effect model for panel data can be written as:

$$SID_{it} = \beta_1 + \beta_2\ CI_{it} + \beta_3\ RAIN_{it} + \beta_4\ GIA_{it} + w_{it} \qquad \ldots(4)$$

where, $w_{it} = \varepsilon_i + u_{it}$.

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

Growth Performance of Agriculture: National Level

After 1990s, there has been a noticeable change in the cropping pattern of Indian agriculture, viz. diversification towards non-foodgrain crops such as oilseeds, spices, cash crops, vegetables and horticultural crops from the traditional foodgrain crops (Joshi *et al.*, 2004). During the economic reforms, it was realized that the changing pattern of crop sector was primarily due to the relative price changes among various crops and, diversification of crops.

Growth Performance of Indian Agricultural Sector and Allied Sectors

A summary of the trend of compound average growth rate (CAGR) of Indian economy across different sectors and agricultural growth rates of various crop sub-sectors is presented in Table 1. A perusal of Table 1 reveals that the growth rate was higher for non-agricultural sector than agricultural sector during the study period as well as in two sub-periods. The gross domestic product (GDP) from agricultural and allied sectors has shown a marginal decrease in growth rate during 2001 to 2012 as compared to the initial phase of economic liberalization (1991-2000), mainly due to impressive horticultural growth rates.

Table 1. CAGR of gross domestic product (GDP) in Indian economy by sector and crop groups

Sector	1990-91 to 1999-2000	2000-01 to 2011-12	1996-97 to 2004-05	1990-91 to 2011-12
GDP at factor cost	6.11	7.98	5.83	6.80
Non-agricultural GDP	6.14	7.98	5.86	6.82
Agriculture & allied GDP	3.34	3.21	1.92	2.90
Agricultural GDP	3.36	3.35	1.85	2.93
Agricultural growth rate by sub-sectors group*				
Period	Crop sector	Cereals	Fruits and vegetables	Non-horticulture crops
1990-91 to 1996-1997	3.22	2.23	5.92	2.59
1996-97 to 2004-05	0.79	0.02	3.28	0.05

Sources: Central Statistics Office (Various issues), Government of India.

*Based on Chand *et al.* (2007)

The growth rate of GDP at factor cost, non-agricultural GDP, agricultural and allied sectors' GDP and, agricultural GDP, declined considerably during the period 1996-97 to 2004-05. The decline in growth rate of agricultural GDP was much higher than that of non-agricultural GDP. The growth rate for crop sub-sector (cereals, fruits & vegetables, and non-horticulture crops) has decreased during 1996-97 to 2004-05 compared to the previous period. However, in the second phase of economic reforms, agricultural sector as a whole experienced a drastic reduction in the growth rates, again principally due to the decline in the growth rate of cereals. This implies that foodgrain crops are now viewed as less profitable, and the farmers are likely to shift resources away from the production of traditional crops to high-value crops.

Trends in Area under Different Crop Sub-Sectors: National Level Analysis

The trends in compound average growth rates of area under various crop sub-sectors during different periods are given in Table 2.

The total foodgrain crops experienced a negative growth rate in area, viz. -0.07 per cent per annum during the study period. A look at the non-foodgrain crops revealed that growth rate in area under oilseeds had a minor increase. On the other hand, the total fruits and vegetables had witnessed a positive and significant growth rate in area. Therefore, it can be inferred that the farmers prefer to cultivate high-value crops. Hence, the total food crops which comprise both foodgrain crops and cash crops observed a rise in area growth rate from 0.23 per cent per annum in the first sub-period to 0.35 per cent per annum in second sub-period. Compositely, the total crop sector observed a minor

increase in growth of area, from 0.39 per cent per annum in the first decade to 0.63 per cent per annum in the post-reform period, thus averaging at 0.24 per cent per annum in the whole study period. Subsequently, the non-food crop group witnessed a rise in area growth rate from 0.88 per cent per annum during the period 1990-91 to 1999-2000 to 1.45 per cent per annum in 2000-01 to 2011-12. This establishes a competitive relationship between foodgrain crops and high-value crops for acreage under crops. It may thus be concluded that the high-value crops are capturing the area of foodgrain crops.

A state-level analysis of the performance of area growth rate identifying which states fared well and which are lagging behind over the period under study is presented in the next section.

Share of Various Crop Groups in Gross Cropped Area: Regional Level Analysis

The region-wise (East & North-East Region, North-West Region, Central Region and Southern Region) shares of various crop group in gross cropped area (GCA) for the year 1990-91, 2000-01 and 20011-12 are presented in the Table 3.

It shows that the share of foodgrain crops in gross cropped area was highest in the east and north-east region (76-78 % per annum), followed by north-west region, central region and southern region. On the other side, the share of non-foodgrain crops in gross cropped area was highest in the southern region (35-37 % per annum). It was observed that the share of foodgrain crops in gross cropped area has been declining, but the share of cash crops and fruits and vegetables has been increasing in all the regions during the past 22 years.

Table 2. Growth in area under different crops and crop sub-sectors in India

Categories of crop sub-sector	1990-91 to 1999-2000	2000-01 to 2011-12	1990-91 to 2011-12
Total foodgrains	0.01	0.23	-0.07
Total fruits & vegetables	2.23*	1.03	1.99*
Total food crops	0.23	0.35	0.13
Total oilseeds	0.52	1.61*	0.37
Total non-food crops	0.88	1.45*	0.56
Total crop sector	0.39	0.63	0.24

Source: Land Use Statistics, Government of India, New Delhi
Note: * represents significant value at 5 per cent

Table 3. Region-wise shares of various crop groups in gross cropped area

(in per cent)

Year	Foodgrains	Total condiments and spices	Total fruits & vegetables	Total food crops	Total oilseeds	Total fibres	Drugs, narcotics & plantation crops	Total non-food crops
East & North-East Region (Assam + West Bengal + Bihar)								
1990-91	78.87	1.26	6.58	87.75	5.73	3.46	2.62	12.26
2000-01	76.87	1.14	8.54	88.86	4.84	3.17	2.12	11.04
2011-12	76.64	1.37	9.72	89.10	5.00	2.71	2.58	10.90
North-West region (Haryana + Himachal Pradesh +Uttar Pradesh)								
1990-91	77.11	0.38	3.16	82.66	6.37	3.40	0.16	17.34
2000-01	75.61	0.84	3.80	85.76	6.24	2.74	0.32	14.24
2011-12	76.35	0.89	4.76	84.94	5.93	2.63	0.37	15.06
Central Region (Gujarat + Madhya Pradesh + Maharashtra + Odisha)								
1990-91	64.78	1.15	3.95	71.09	17.13	6.52	0.51	28.91
2000-01	66.46	1.06	3.42	71.41	16.70	7.33	0.39	28.59
2011-12	66.13	1.66	6.34	71.62	16.39	8.89	0.27	28.38
Southern Region (Andhra Pradesh + Karnataka + Kerala + Tamil Nadu)								
1990-91	49.20	4.29	7.68	63.29	24.38	3.73	5.83	36.71
2000-01	40.21	4.89	9.21	64.52	21.92	4.08	6.48	35.48
2011-12	44.12	4.91	10.36	63.16	19.10	5.60	7.87	36.84
All India								
1990-91	68.89	1.25	3.60	75.93	13.54	4.67	1.02	24.07
2000-01	62.19	1.57	4.92	74.72	12.64	4.76	1.22	25.28
2011-12	63.19	1.86	4.82	72.81	14.43	6.73	1.33	27.19

Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India

The southern region (Andhra Pradesh + Karnataka+ Kerala + Tamil Nadu) has been highest producer of fruits & vegetables, with a significant share in gross cropped area. This reaffirms the fact that traditional crops have become less profitable as compared to high-value crops. Consequently, the farmers have shown their prudence to shift resources from traditional crops towards high-value crops.

Trends in Crop Diversification: State Level Analysis

This section analyses the trend in area for various crop sub-sectors and in Simpson index of crop diversification (SID) at the state as well as regional level. This in turn reveals the extent of shift in the cropping pattern and crop diversification.

Trends in Area under Different Crops and Crop Sub-sectors at State Level

Table 4 presents, the state-wise compound average growth rate of area under different crop sub-sectors such as food crops, non-food crops and total crop sub-sector across 17 major Indian states during the period 1990-91 to 2011-12.

Under total food crops sub-sector, Assam, Bihar, Gujarat, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu and West Bengal have recorded negative compound average growth rates for area under total foodgrains, whereas, the states of Andhra Pradesh, Haryana, Jammu & Kashmir, Karnataka, Punjab, Rajasthan and Uttar Pradesh have registered a positive but insignificant CAGR of area under total foodgrain crops. This indicates a shift in

Table 4. State-wise growth rate of area under different sub crop sub-sector in India, 1990-91 to 2011-12

States	Growth rate of area under food crops				Growth rate of area under non-food crops			Growth rate of area under crop sub-sector (%)		
	Total food-grains	Cash crops (sugarcane & sugar)	Total condiments and spices	Total fruits & vegetables	Total oilseeds	Total fibres	Drugs, narcotics & plantation crops	Total food crops	Total non-food crops	Total crop sub-sector
Andhra Pradesh	0.09	1.51*	-0.59	3.26*	-1.66*	3.25*	-0.62	0.35	-0.09	0.20
Assam	-0.21	-1.88*	1.83*	3.61*	-0.83	-1.92*	1.70*	0.25	0.09	0.22
Bihar	-2.00*	0.02	-3.07*	1.08	-3.34*	-0.42	-2.64*	-0.89	-1.71*	-1.19
Gujarat	-0.54	0.55	5.05*	4.49*	0.17	4.35*	-2.01*	0.10	1.12	0.65
Haryana	0.88	-1.92*	0.08	0.80	-0.44	-0.43	0.01	0.77	0.19	0.61
Himachal Pradesh	-0.48	-1.23*	5.59*	2.43*	-1.91*	-8.31*	-0.63	-0.13	-1.04	-0.16
Jammu & Kashmir	0.24	0.66	2.08*	2.14*	-0.62	-1.42*	NA	0.38	0.25	0.37
Karnataka	0.45	3.66*	2.26*	4.87*	-1.43*	-2.05*	1.94*	0.86	-1.22	0.23
Kerala	-5.04*	-5.27*	0.47	-0.77	-0.63	-3.74*	0.93	-1.71*	0.23	-0.62
Madhya Pradesh	-2.19*	1.40*	1.40*	0.98	1.89*	0.89	1.68*	-2.07*	1.34*	-1.02
Maharashtra	-0.76	2.31*	-0.58	4.59*	2.26*	1.35*	6.33*	-0.33	1.81*	0.37
Odisha	-1.19	-4.94*	-0.61	0.10	-1.59*	1.62*	-6.04*	-0.04	-1.31*	-0.19
Punjab	0.73	-1.89*	-5.08*	3.81*	-5.60*	-1.75*	10.86*	0.72	-2.00*	0.22
Rajasthan	0.64	-8.41*	2.97*	4.46*	1.67*	-1.69*	6.31*	0.74	1.33*	0.96
Tamil Nadu	-1.29*	1.10	-0.23	2.65*	-2.75*	-5.28*	0.29	-0.67	-2.16*	-1.11
Uttar Pradesh	0.16	0.06	-2.00*	1.30*	4.06*	-2.50*	3.49*	0.05	1.60*	0.17
West Bengal	-0.99	-1.80*	2.97*	1.84*	1.23*	-0.64	0.66	-0.27	0.40	-0.16
India	0.46	1.15	1.24*	0.41	1.61*	3.18*	1.62*	0.34	1.45*	0.63

Source: Based on author's calculations
Note: * represents significant value at 5 per cent level

the cropping pattern away from cultivation of foodgrains during the study period.

The growth rate for area under spices and condiments has been observed to be significantly positive in most of the Indian states, comprising Assam, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Madhya Pradesh, Rajasthan and West Bengal. Similarly, the compound average growth rates of area under fruits & vegetables have also been largely positive for most states, viz. Andhra Pradesh, Assam, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Maharashtra, Punjab, Rajasthan Tamil Nadu, Uttar Pradesh and West Bengal in the study period.

Under the category of non-foodgrain crops, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal were the only states to experience a significantly positive growth rate for area under total oilseeds. Likewise, the area growth rate under total fibres sector has also remained largely

negative in the majority of states, with only a few states, Andhra Pradesh, Gujarat, Maharashtra and Odisha, recording a considerably positive compound average growth rate. In contrast, the growth rate of area under drugs, narcotics and plantation crops was observed to be significantly positive in several states, viz. Assam, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and Uttar Pradesh. Interestingly, the aggregate figures reveal that the growth of area under total food crop sub-sector has been on a decline in nearly all Indian states. However, the growth rate of area in total non-food crops has been mixed, wherein Gujarat, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh have revealed a positive and significant growth rate, while Bihar, Himachal Pradesh, Karnataka, Odisha, Punjab and Tamil Nadu have exhibited a negative growth rate. But, the overall growth rate in total nonfood crops across India was found to be significantly positive. These trends indicate crop diversification from foodgrain to non-foodgrain crops. The growth rate in total crop sub-

sector has revealed a symmetrical trend across Indian states.

The state-level disaggregated analysis has shown that in almost all the states the area growth under foodgrains has markedly declined. Additionally, a widespread variation has been observed in the performance of different states in each crop sub-sector since some of the states have performed better and others have lagged behind. But, the fall in area growth of foodgrains is disturbing from the perspectives of food security and economic sustainability of these crops. It, therefore, needs to be examined whether the fall in area under foodgrains is due to reduction in total cultivated area or has been caused by the shift toward high-value crops. In order to ascertain this, we estimated Simpson Index of Crop Diversification (SID) in respect of food crops, nonfood crops and crop sub-sector, and the results are presented in Table 5.

Trends in Average SID under Different Crop Sub-Sector: State/Regional Level Analysis

The variations in crop diversification within food crops, non-food crops and overall crop sub-sector in India on regional basis with reference to specific states within those regions is presented in Table 5 across two different time periods (1990-91 to 1999-2000 and 2000-01 to 2011-2012). Within the eastern and north-eastern region, the degree of crop diversification within food crop sub-sector has been low, but there has been an increasing trend of diversification in food crops in the region with special attention to Assam, Bihar and West Bengal across the study period (1990-91 to 2011-12). On the other hand, the east and north-east region has exhibited high levels of crop diversification within the non-food crop sub-sector, wherein the SIDs of specific states of Assam, Bihar and West Bengal have increased across the study period. Hence, this region has shown low level of crop diversification within the food crops sub-sector, and a considerably high amount of crop diversification within the non-food crops sub-sector.

But, the overall crop sub-sector in the eastern region has revealed low degree of crop diversification. Moving on to the north-western region, the food crop sub-sector has displayed very low levels of crop diversification across various states such as Haryana, Himachal Pradesh, Punjab, Jammu & Kashmir and Uttar Pradesh; however, the SID of these states was observed to be rising across the study period.

The non-food crops sub-sector has recorded varying degrees of crop diversification across the north-western states, wherein some states (Haryana, Himachal Pradesh and Punjab) have recorded high level of crop diversification, while others (Jammu & Kashmir and Uttar Pradesh) have recorded low or very low degree of crop diversification. Hence, the average level of crop diversification within non-food crop sub-sector in this region has been found to be low. Correspondingly, the north-western region has registered low levels of crop diversification within the overall crop sub-sector during the study period.

The central region of India has exhibited very low level of crop diversification within the food crop sub-sector during the study period. Meanwhile, non-food crop sub-sector for the central region has recorded moderate degrees of crop diversification, owing to huge transversal fluctuations in the SID for different states within this region, wherein the level of crop diversification was seen to be either increasing during the study period or else remained constant. Subsequently, the aggregate crop sub-sector has registered a moderate degree of crop diversification within the central region of India. The states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu have experienced varying degrees of crop diversification within food crop sub-sector, thus recording a moderate average value for SID in the food crop sub-sector for the study period. However, the trend of SID for the food crop sub-sector over the study period was observed to be increasing for the southern region.

On the other hand, the non-food crop sub-sector within the southern region has registered a moderate level of crop diversification across majority of the southern states, which in turn remained more or less constant down the study period. Henceforth, the aggregate crop sector in the southern region has displayed a moderate degree of crop diversification for the study period. In nutshell, India has overseen its food crop sub-sector having little or no crop diversification during the study period, while the non-food crop sub-sector has registered a moderate degree of crop diversification at the country level. Conclusively, the total crop sector in India has experienced moderate levels of crop diversification for the entire study period. However, a critical observation of our study was that crop diversification has been

Table 5. State/ region-wise average Simpson Index of Diversification of food crops, non-food crops and total crop sub-sector in India

Region	State	Food crops			Non-food crops			Crop sub-sector
		1990-91 To 1999-2000	2000-01 To 2011-12	1990-91 To 2011-12	1990-91 To 1999-2000	2000-01 To 2011-12	1990-91 To 2011-12	1990-91 To 2011-12
East & North-East	Assam	0.24	0.30	0.28	0.61	0.60	0.61	0.30
	Bihar	0.12	0.14	0.13	0.53	0.54	0.53	0.15
	West Bengal	0.26	0.33	0.29	0.59	0.62	0.61	0.26
	Average	**0.21**	**0.26**	**0.23**	**0.58**	**0.59**	**0.58**	**0.23**
North-West	Haryana	0.10	0.09	0.09	0.50	0.50	0.50	0.41
	Himachal Pradesh	0.17	0.22	0.20	0.26	0.27	0.27	0.17
	Jammu & Kashmir	0.13	0.15	0.14	0.02	0.01	0.02	0.19
	Punjab	0.08	0.10	0.09	0.30	0.25	0.27	0.30
	Uttar Pradesh	0.23	0.25	0.24	0.18	0.32	0.26	0.16
	Average	**0.14**	**0.16**	**0.15**	**0.25**	**0.27**	**0.26**	**0.24**
Central	Gujarat	0.22	0.32	0.28	0.48	0.51	0.50	0.49
	Madhya Pradesh	0.08	0.11	0.10	0.17	0.17	0.17	0.43
	Maharashtra	0.17	0.24	0.21	0.50	0.50	0.50	0.44
	Odisha	0.24	0.26	0.25	0.14	0.15	0.15	0.18
	Average	**0.18**	**0.23**	**0.21**	**0.32**	**0.33**	**0.33**	**0.39**
Southern	Andhra Pradesh	0.29	0.34	0.32	0.42	0.48	0.45	0.45
	Karnataka	0.21	0.28	0.25	0.38	0.38	0.38	0.42
	KERALA	0.66	0.64	0.65	0.48	0.49	0.49	0.49
	Tamil Nadu	0.33	0.41	0.37	0.36	0.34	0.34	0.41
	Average	**0.37**	**0.42**	**0.40**	**0.41**	**0.42**	**0.42**	**0.44**
	All India	**0.19**	**0.23**	**0.21**	**0.44**	**0.46**	**0.45**	**0.38**

Source: Based on authors' calculations

increasing over the years in both food and non-food crop sub-sectors of the country.

Extent of Crop Diversification

Figure 1 classifies different Indian states under three categories defining the extent of crop diversification in different crop sub-sectors, viz. food crops, non-food crops and total crops sub-sectors, wherein the extent of crop diversification has been further classified into three classes namely; Lower SID (Range: 0.00-0.20), Moderate SID (Range: 0.21-0.40) and Higher SID (Range: 0.41-1.00).

Under the food crops category, Madhya Pradesh, Punjab, Haryana, Rajasthan, Jharkhand, Bihar and

Jammu & Kashmir did not experience crop diversification at a significant scale and hence recorded a lower SID. The states of Himachal Pradesh, Maharashtra, Uttar Pradesh, Karnataka, Odisha, West Bengal, Andhra Pradesh and Tamil Nadu registered a moderate degree of crop diversification and hence were under the category of moderate SID. Kerala was the only state which recorded a higher degree of crop diversification among food crops, hence higher SID. Under non-food crops category, Jammu & Kashmir, Odisha and Madhya Pradesh observed lower levels of crop diversification (lower SID). Rajasthan, Uttar Pradesh, Himachal Pradesh, Punjab, Tamil Nadu and Karnataka depicted moderate levels of crop diversification (moderate SID) and Andhra Pradesh,
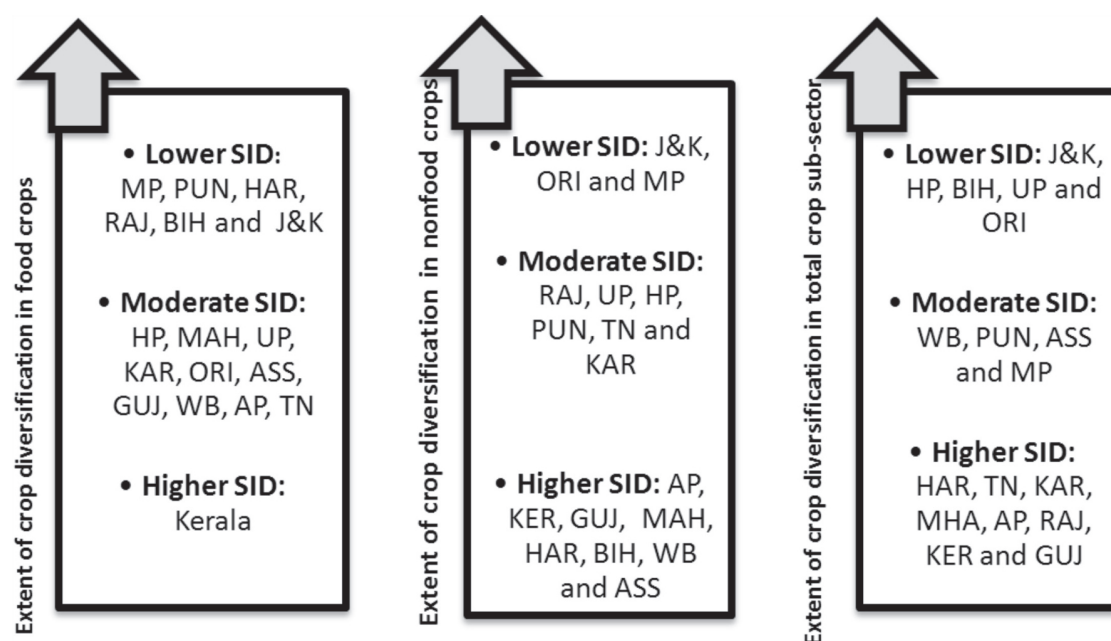
Figure 1. Extent of crop diversification across 17 major states of India

[*Note:* AP = Andhra Pradesh, ASS = Assam, GUJ = Gujarat, BIH = Bihar, HAR = Haryana, HP = Himachal Pradesh, J&K = Jammu & Kashmir, KAR = Karnataka, KER = Kerala, MP = Madhya Pradesh, MAH = Maharashtra, ORI = Odisha, PUN = Punjab, RAJ = Rajasthan, TN = Tamil Nadu, UP = Uttar Pradesh and WB = West Bengal]

Kerala, Gujarat, Maharashtra, Haryana, Bihar, West Bengal and Assam registered high levels of crop diversification (higher SID).

In the third category of total crops sub-sector, Himachal Pradesh, Bihar, Uttar Pradesh, Jammu & Kashmir and Odisha displayed very little crop diversification (lower SID). Punjab, West Bengal, Madhya Pradesh and Assam experienced moderate degree of crop diversification (moderate SID) and Haryana, Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh, Rajasthan, Kerala and Gujarat registered high level of crop diversification (higher SID).

Determinants of Crop Diversification at State Level

To identify determinants of crop diversification at the state level, fixed effect and random effect models (REM) were used and for best model selection, Hausman specification test was used. The results of Hausman specification test by using STATA are presented in Table 6.

The Hausman test has revealed that the p-value < 0.05 manifests that these two models are different enough to reject the null hypothesis. Hence, fixed effects model (FEM) was applied to estimate the

Table 6. Hausman specification test results

Variable	Dependant variable: Simpson index of crop diversification (SID)			
	Fixed (b)	Random (B)	Difference (b-B)	Std. error
Cropping intensity (CI)	0.0007772	0.0006648	0.0001124	0.0000481
Annual rainfall (RAIN)	7.57e-06	7.69e-06	-1.18e-07	0.00000
Gross irrigated area (GIA)	5.10e-07	-2.20e-09	5.08e-07	4.17e-07
b = consistent under Ho and Ha; obtained from panel data regression (xtreg)				
B=inconsistent under Ha, efficient under Ho; obtained panel data regression (xtreg)				
Test: Ho: difference in coefficients not systematic				
Chi square value	48.38		Prob.>Chi Square	0.0000

Table 7. Panel data regression results by using fixed effect model

Variable	Dependant variable: Simpson index of crop diversification (SID)			
	Coefficient	Std. error	t- Statistic	Prob.
Cropping intensity (CI)	0.0007772	0.0002537	3.06	0.002
Annual rainfall (RAIN)	7.57e-06	3.90e-06	1.94	0.053
Gross irrigated area (GIA)	5.10e-07	1.89e-06	0.97	0.487
Constant	0.208119	0.0315282	6.60	0.000
R-squared	within	0.0524	F(3,354)	6.52
	between	0.2552	Prob. >F	0.0003
	overall	0.2293	No. of observations	374

parameters of SID at the disaggregated level for the period 1990-91 to 2011-12. The values of within, between and overall R-square were 0.0524, 0.2552 and 0.2292, respectively, which implied that the regression model on the whole could explain 22.92 per cent of the total variations in crop diversification index. The magnitude of F-value indicated that the given model was a good fit.

The results attest that cropping intensity and annual rainfall have a statistically positive and significant impact on crop diversification throughout the study period. These results are consistent with the findings of Joshi et al. (2004).

The impact of gross irrigated area on Simpson index of crop diversification was not statistically significant but positive. In a state having irrigation facilities, farmers tend to cultivate more cash crops than traditional crops (wheat and rice). In this context, most of the parameters under consideration, viz. cropping intensity, annual rainfall and gross irrigated area have been found to influence the nature and extent of crop diversification in India at the disaggregated level during the study period.

Conclusions

The paper has examined trends in crop diversification towards high-value crops at the state level along with identification of major factors determining crop diversification. The study has observed that the areas under high-value crops have recorded significant growth (1.99 %) during the past two decades. Consequently, the share of high-value

crops in the total value of agricultural output has remarkably increased.

The trends in area growth and value of SID (Simpson Index of Diversification) have shown that Indian agriculture is transforming from traditional subsistence agriculture to high-value agriculture. However, this transformation is not evenly distributed across states/regions as well as across different crop sub-sectors, viz. food crops, non-food crops and total crops sub-sector. The extent of crop diversification in the total crops sub-sector has displayed very little SID in Himachal Pradesh, Bihar, Uttar Pradesh, Jammu & Kashmir and Odisha; moderate crop diversification in the states of Punjab, West Bengal, Madhya Pradesh and Assam; and high crop diversification in Haryana, Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh, Rajasthan, Kerala and Gujarat. The results of FEM have revealed that cropping intensity and annual rainfall have a significant positive impact on crop diversification at the state level. The results have testified that gross irrigated area also has a positive influence on crop diversification.

Policy Implications

Presently, diversification in agriculture is leading to agribusiness, and the focus on vertical integration between farmer and retailer is increasingly becoming common (Pingali, 2010) and therefore public and private investments, especially in the areas of R&D, extension services delivery and technology development need to be enhanced. It is imperative to take steps towards reinforcement of link across production, processing, marketing and crop management.

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