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Determinants of Crop Diversification in Bihar Agriculture–An Economic Analysis

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Abstract The nature and extent of crop diversification in the state of Bihar has been analyzed using secondary data obtained from different published sources of Govt. of Bihar from 2000–2001 to 2014–2015 i.e. a period of 15 years. Composite entropy index (CEI) and double log step-wise linear regression model was applied to assess the determinants of crop diversification in the state. The results have revealed that in almost all crops group very low diversification indices were observed. The study has suggested that despite plenty of natural resources available in the state, the economic improvement of farmers is in infancy. Pre-requisite infrastructural facilities like cheap sources of irrigation water (assured irrigation as the monsoon in the present decade had been erratic and scanty rainfall) and extension of technological know-how (quality seeds and fertilizers), may acts as catalyst in diversification of agriculture towards high-valued crops. These developmental efforts may be helpful in fetching good incomes by the cultivators.

Keywords Crop diversification, Composite entropy index (CEI), Diversification index.

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Introduction

Crop diversification has remained widely discussed issue for a long period of time and the researchers have been trying to relate diversification with developmental prospects [1]. Many studies have advocated various methods for diversification of land use and other resources for a sustainable agricultural growth and rural livelihood [2—5]. Crop diversification is one of the means to minimize the risk due to climatic change and maximize the use of land and is measured by proportion of area under various crops. The diversification in agriculture is also adopted for avoiding or minimizing the adverse effects of current system of crop specialization and monoculture for better use of resources, recycling of nutrient, regaining soil fertility. It also provides better economic viability with value added products and improvement of ecology [6—9].

Changing climatic conditions like erratic and scanty rainfall , depletion of water resources, decline in net sown area, [10—11] the existing cropping pattern is becoming less productive [12]. Cultivators are moving towards crop intensification through mixed cropping and by including high value crops (HVCs)

such as horticultural crops as well as medicinal and aromatic plants as a adaptation strategy against climatic change [13].

In general, diversification is governed by market forces, advancement in technology (access to inputs and implements), agro-climatic conditions, development of infrastructure (communication, marketing and storage facilities) and institutional factors like government's policy, protection and risk [14, 15].

The economy of Bihar is primarily dependent on agriculture. Agriculture contributed 18.1% share of GDP of the state (2016–2017) (including forestry and fishing) and provides employment to 77% of the workforce (www.krishi.bih.nic), which is much higher than the national average. Although irrigation coverage in the state is 67% with 68.11% of the crop area (paddy, wheat and maize) under high yielding varieties, average productivity in most of the crops, except maize and pulses, is much below the national average. Further net sown area in the state is shrinking and population pressure is rising day by day. Although, the state has attained self-sufficiency in food grains but the economic condition of farming community is still miserable. As the state has fertile land and huge amount of unexploited groundwater for irrigation, there is a lot of scope for acceleration in farmer's income by improving productivity and including high value crops in our cropping system.

The present paper analyzes the extent of diversification in Bihar and identifies the factors responsible for crop diversification.

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Materials and Methods

For the purpose of analyzing the crop diversification and factors influencing crop diversification in Bihar, secondary data on variables such as area under different crops, gross cropped area, gross irrigated area, net sown area, cropping intensity, percentage of urban population to total population of the state, fertilizer use, annual rainfall, population density, road density, percentage of marginal and small land holders in total holdings, percentage of area under HYVs of cereals were collected from the published sources such as Bihar Through Figures, Economic Survey of Bihar for the period during 2000–2001 to 2014–2015.

There are several methods for estimating concentration (i.e. specialization) or diversification of crops over time and space. Each method has some limitations and / or superiority over the other [10]. Keeping in mind the objective of measuring extent of crop diversification, Composite Entropy Index (CEI) was used in the present investigation. To examine the nature of crop diversification within different crop groups and within total crops taken together, CEI was worked out for crop groups like cereals, pulses, oilseeds, cash crops, vegetables, fruits and total crops as a whole. The CEI was estimated using the following formula :

$$CEI = -\left[\sum_{i=1}^{n} P_i \log_n p_i\right] \times \{1 - (\frac{1}{N})\}$$

Where, N is the total number of crops and p_i is the average proportion of i^{th} crop in total cropped area.

Higher value of CEI refers to the higher level of diversification and the lower value of CEI indicates the higher level of concentration or specialization.

Cereals group included rice, wheat maize, barley, ragi, jowar, bajra and other small millets crops. The pulses group included arhar, gram, lentil, pea, khesari and other pulses crops. Oilseeds group included rapeseeds and mustard, linseed, sunflower and other oilseeds. The cash crops included sugarcane, condiments and spices, jute, mesta, sanhemp and other fibers. Vegetables and fruits crop group contained potato, sweet potato, onion other vegetables, mango,

Table 1. Nature and extent of crop diversification in Bihar during 2000–2001 to 2015–2016. * Selected crops only.

Year	Cereals	Pulses	Oilseeds*	Cash* crops	Vege-tables* & fruits	Total crops
2000-01	0.405	0.728	0.526	0.540	0.656	0.503
2001-02	0.405	0.734	0.505	0.483	0.762	0.520
2002-03	0.405	0.718	0.555	0.541	0.661	0.504
2003-04	0.404	0.728	0.523	0.497	0.634	0.499
2004-05	0.413	0.723	0.555	0.498	0.647	0.511
2005-06	0.416	0.710	0.575	0.501	0.649	0.504
2006-07	0.410	0.721	0.576	0.505	0.645	0.500
2007-08	0.410	0.703	0.567	0.519	0.641	0.495
2008-09	0.402	0.712	0.558	0.503	0.639	0.488
2009-10	0.412	0.698	0.589	0.507	0.629	0.496
2010-11	0.422	0.699	0.592	0.452	0.612	0.524
2011-12	0.412	0.699	0.548	0.448	0.573	0.485
2012-13	0.412	0.702	0.546	0.424	0.620	0.500
2013-14	0.417	0.699	0.551	0.411	0.612	0.503
2014-15	0.413	0.689	0.500	0.414	0.603	0.498

banana and other fruits crops group. The total crops grown in the state were constituted into different groups such as cereals, pulses, oilseeds, cash crops, vegetables and fruits crops.

To identify the important factors influencing diversification step-wise multiple regression (double log model) analysis was carried our using time series data from 2000–2001 to 2014–2015. The composite entropy index (Y) was specified as a function of the following independent variables.

$$Y = a + b_1X_1 + b_2X_2 \ldots\ldots + b_nX_n + U$$

The explanatory variables were as under : X_1 = Annual rainfall (mm), X_2 = Percentage of urban population to total population, X_3 = Road length per lakh hectare of geographical area (Km), X_4 = NPK consumption (kg/ha), X_5 = Percentage of gross irrigated area (GIA) to gross cropped area (GCA), X_6 = Cropping intensity (CI), X_7 = Population density per square Km, X_8=Percentage of marginal and small landholder in total land holdings, X_9=Percentage of HYV area of paddy, wheat and maize in total cereal's area, X_{10} = Average holdings size (ha), U = Error-term.

Results and Discussion

The year wise crop diversification indices for different crops in Bihar for the period of sixteen years i.e. 2000-2001 to 2014-2015 are presented in Table 1. The calculated composite entropy index (CEI) for cereals was observed to be almost constant during the period under consideration. This indicates that the farmers are more interested in cultivating paddy, wheat and maise as these are the staple food crops for the state despite low income they are forced to grow these crops for food security point of view. The pulses crop showed decrease in CEI from 2000-2001 (0.728) to 0.689 in 2014-2015. The reason for declining trend of CEI values for pulses group may be attributed low profit from pulses and crop losses due to pest and animal attack.

No specific pattern of diversification was observed in case of oilseeds. The indices for oilseed groups were estimated to be 0.500 and 0.526 for 2014-2015 and 2000-2001, respectively. CEI for cash crops was found to be the lowest (0.411) in 2013-2014 and highest (0.541) in 2002-2003, followed by 0.540 in 2000-2001. The diversification indices for cash crops group was revealed in the recent year comparatively slower or in lower side although the government has revised the payment policy with regard to sugar mills in the state and thus the farmers used to receive their payment directly in their accounts without any botheration.

In case of vegetable and fruit crops the composite entropy index (CEI) exhibited fluctuating trend

Table 2. Step-wise regression function for determinants of crop diversification. Figures in parentheses are standard errors. *Denote significance at 1% probability level.

Factors	Cereals	Pulses	Oilseeds	Cash crops	Vegetables & fruits	Total crops
Constant	– 0.201*	0.540*	0.240	1.796*	1.378*	0.028
	(0.043)	(0.107)	(0.280)	(0.390)	(0.380)	(0.114)
X_1 = Annual rainfall (mm)	– 0.062*					
	(0.014)	–	–	–	–	–
X_2 = Percentage of urban population to total population	–	– 0.663*	–	–	– 1.514*	–
	(0.103)				(0.366)	
X_3 = Road length per lakh hectare of geographical area (Km)	–	–	–	–	–	–
X_4 = NPK consumption (kg/ha)	–	–	0.183*	–	–	–
			(0.046)			
X_5 = Percentage of gross irrigated area (GIA) to gross cropped area (GCA)	–	–	– 0.499*	–1.179*	–	–
			(0.181)	(0.217)		
X_6 = Cropping intensity (CI)	–	–	–	–	–	–
X_7 = Population density per square Km	–	–	–	–	–	–
X_8 = Percentage of marginal and small landholder in total land holdings	–	–	–	–	–	–
X_9 = Percentage of HYV area of paddy, wheat and maize in total cereal's area	–	–	–	–	–	– 0.185 (0.065)*
X_{10} = Average holding size (ha)	–	–	–	–	–	–
R^2	0.766	0.871	0.621	0.833	0.754	0.621
F–value	18.83*	41.04*	8.032*	29.40*	17.13*	8.169*

throughout the study period vegetables and fruits are considered as remunerative crops which prompts farmers to diversity their farms towards vegetable and fruit crops. However, some bottle necks like perishable nature and lack of storage facilities arises in cultivation of vegetables and fruits which slow down the process diversification.

Overall diversification index was recorded highest (0.524) during 2010-2011 and then it declined marginally. Marginal decline in diversification at later period of the investigation period may probably be due to costlier irrigation and as a result of global warming and erratic and scanty rainfall (monsoon) in the recent past.

The most important factors influencing crop diversification were evaluated by applying step-wise regression model and the results so obtained are presented in Table 2. A significant and negative effect of rainfall (X_1) was noticed on diversification in case of cereal crops. Per unit change in the factors would lead to decrease in diversification. In case of pulses the coefficients of variables such as percentage of urban population (X_2), population density (X_8) was found negative and significant. In oilseed crops, NPK consumption (X_4) showed positive and significant effect on diversification while percentage of gross Irrigated Area (GIA) to Gross Cropped Area (GCA) (X_5) recorded negative and significant effect. When the determinant of diversification was assessed in case of cash crops, percentage of GIA to GCA (X_5) played a positive and significant role on diversification showing that per unit increase in this factor would lead to increase in area under cash crops, while assessing the effect of different factors on diversification of vegetable and fruits crops. It was observed

that the regression coefficients of factor percentage of urban population to total population density (X_2) was estimated to negative and significant which revealed disfavored / diminution effect on diversification of vegetable and fruits crops. For total crops, the regression coefficient of variable percentage of HYV area of paddy, wheat and maize in total cereal's area (X_9) was calculated negative and significant, resulting decrease in diversification with per unit increase in the factor.

Conclusion

From the foregoing discussion, it is observed that the composite entropy index was used to study the nature and extent of crop diversification and further the observation of the fact was that on the whole, the very less diversification was recorded for all crops in the state during the period under investigation. In the study, the most important factors which affecting the diversification towards crops were identified and these are rainfall, percentage of urban population, percentage of GIA to GCA, and NPK consumption.

On the basis of the result of the study, it may be the policy implication that the creation of basic infrastructural facilities like assured supply of irrigation water on cheaper rate, market availability, technology extension, storage facilities, establishment of processing units may be considered as the pre-requisite facilities for agricultural development and crop diversification for further raising the farmer's income by value-addition of their produce. The purpose of the very study may be realized by harnessing the rich natural resources like abundant groundwater, fertile soils, varied climatic condition as well as cheap labor forces. Hence, a compact policy intervention to raise the economic and social status of farmers with new technological expansion is need of the time as the whole economy of the state depends on agriculture and allied sectors.

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