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Research Article

An Analysis of Crop Diversification in India

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Abstract

Crop diversification refers to a shift from the regional dominance of one crop to the regional production of several crops. In India, the degree of diversification exhibits large disparities among different regions. In this context, this study is aimed at computing the growth rate in area, production, and productivity of selected crop groups in India and analyzing crop diversification at the national level by computing the crop diversification index (SID) for all the states. The data used for the estimation of the state-wise food crop diversification index were collected from the land-use statistics, Directorate of Economics and Statistics, Ministry of Agriculture and Farmer's Welfare, Government of India. We estimated the crop diversification index using the triennium average of food crops area ending for the year 2018-19, The Simpson index of diversity (SID) values as well as growth rate indicated that there is high crop diversification in the southern and western regions of India whereas, Northern and eastern regions showed low diversification due to the system of monocropping and crop specialization prevailing in the same region.

Keywords: Crop Diversification; Simpson Index of Diversity (SID); Growth Rate

Introduction

India is the world's seventh largest country covering an area of 328 million hectares (mha). Nearly half of this land (156.4 mha) is arable and only 42.6 percent of the total geographical area (about 140 mha) is cultivated as of 2015-16 [14]. The major challenge in Indian agriculture is feeding its largest population, especially in the wake of the emerging challenges of climate change and the degradation of natural resources such as air, water, land and loss of biodiversity resulting in slow down of the growth rate of productivity [29]. Given shrinking agricultural land and operational holdings which are attributable to the expansion of urban areas and, the high growth rate of population, along with changes in consumer food habits, the farmers are straining to include or substitute additional high-value crops into the cropping system [3,10]. Crop diversification refers to a shift from the regional dominance of one crop to the regional production of several crops. In India, the degree of diversification exhibits large disparities among different regions. Changing climatic conditions pose a serious threat to agriculture by increasing the risk of crop failures. Models that link yields of the four largest commodity crops to weather indicate that global maize and wheat production declined by 3.8 per cent and 5.5 per cent, respectively, relative to a counterfactual without climate trends [20]. With greater climate variability, shifting temperature and precipitation patterns, and other global change components, farmers are increasingly being subjected to crop failures, which not only affect their livelihoods but also negatively impact the food production for the country [4,31]. Diversification has been advocated as a useful strategy for mitigating the effects of unpredictable variations, reducing income variability, and increasing the farm enterprise's ability to withstand adverse climate conditions [9]. Crops such as fruits, vegetables, flowers, spices and condiments, medicinal and aromatic plants, and plantation crops which generate higher net income per unit land area compared to other crops are considered high-value crops. The feasibility of using crop diversification towards high-value crops like fruits and vegetables in small holdings as a management strategy is well documented [6,18]. Crop diversification refers to a shift from the regional dominance of one crop to the regional production of several crops. In India, the degree of diversification exhibits large disparities among different regions. Diversification of crops enhances the cropping intensity

and productivity growth. It enhances farmers' income security and risk-bearing ability and also helps reduce the vulnerability of small farmers toward climate change [7,8,28]. Crop diversification (horizontal and vertical) has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement. The crop diversification in South Asia was influenced by per capita gross domestic product (G.D.P.), minimum temperature, pesticide consumption, food crop yield index [32]. Looking at the importance of the above-mentioned issues, this topic was selected to study crop diversification in India.

Methodology

The data in this paper came from a nationally representative survey of farm households conducted by the National Sample Survey Organization (NSSO) of the Government of India (India, MSPI) [26]. The growth rate in area, production, and productivity of selected crop groups in India is calculated by using data from agriculture statistics at a glance in 2021 from the directorate of statistics and economics. The estimated growth rate is tested for significance using 't' statistics. The data used for the estimation of the state-wise crop diversification index were collected from the land-use statistics 2018-19, Directorate of Economics and Statistics, Ministry of Agriculture and Farmer's Welfare, Government of India. State-wise diversification indices were estimated for the 28 major states considering the area under food crops. We estimated the crop diversification index using the triennium average of food crops area ending for the year 2018-19. Simpson index of crop diversification (SID) was used to assess the degree of crop diversification. The index was estimated using the following formula where pi is the proportion of the i^{th} crop/crop sector in the gross cropped area. The diversification index ranged between 0 and 1, with higher values indicating a high degree of crop diversification.

Results and Discussion

Particulars	Area			Production			Productivity		
	Period I	Period II	Overall	Period I	Period II	Overall	Period I	Period II	Overall
Food grains	-0.20	0.26**	0.11**	1.09**	2.27***	1.81***	2.00***	1.29***	1.69***
Pulses	-0.22	1.92***	0.88***	0.07	4.14***	2.18***	0.29	2.17***	1.29***
Oilseeds	-0.79*	-0.45**	0.15	0.25	1.21**	1.89***	1.05	1.68***	1.75***
Nutri-Cereals	-1.27***	-1.67***	-1.24***	0.63	1.89***	1.70***	1.92***	3.62***	2.98***
Fruit crops	2.94***	1.15**	3.24***	3.05***	4.13***	4.42***	0.07	2.95***	1.13***
Vegetable crops	2.09***	2.78***	2.96***	3.95***	3.92***	4.48***	1.59***	1.03***	1.39***

Table 1: Growth rate in area, production and productivity of selected crop groups in India.

Note: Period I - 1991-92 to 2004-05, Period II - 2005-06 to 2019-20, Overall - 1991-92 to 2019-20.

Table 1 shows the results of compilation using data from Agriculture statistics at a glance in 2021. The cultivation of food grains witnessed a significant positive shift in productivity from Period I to Period II, the overall productivity increased by 2.00 times from Period I to Period II. Investment in productivity, the research system, technology transfer, extension, and infrastructure, and the development and spread of modern crop varieties and total factor productivity in the Indian crop sector Sources for the growth of total factor productivity in Indian agriculture [11]. Notably, the production growth outpaced the area change, resulting in improved productivity with a remarkable increase in production (1.09 to 2.27). This can be attributed to advancements in agricultural technologies and practices [17]. Pulses exhibited a substantial surge in both area and production during Period II. The RKVY (Rashtriya Krishi Vikas Yojana) programme along with NFSM and several state and centrally-sponsored programmes are the probable reason for the increased production of Pulses. The productivity, however, showed low-paced growth. This could be attributed to the efforts of government initiatives, as [33] suggested, aimed at promoting pulse cultivation for nutritional security. The negative trend in the oilseed cultivation area during Period I reversed in Period II, accompanied by increased production. Nutri-cereals (such as millet) show remarkable productivity gains. The overall productivity rose by 2.98 times.

Production increased as these crops are valuable for nutrition and climate resilience [15]. Fruit crops demonstrated robust growth in both area and production, suggesting a positive response to favorable climatic conditions. There has been a significant increase in the area and production of fruits in India. Fruit production in India has increased 8 times since the 1980s and 1.6 times since 1991[30]. The increase in fruit production can be attributed to the

Adoption of modern horticultural practices, improved varieties, and better crop management and the implantation of the Mission for Integrated Development of Horticulture (MIDH) [21]. Vegetable crops showcased consistent growth in both area and production across the two periods. Vegetable crops showcased consistent growth in both area and production across the two periods. Similar results pointed out, growth trends in the area, production and productivity of vegetable crops in the region and country during the last 16 years [24]. Policy factors, geographical factors, market factors and farmer-oriented factors were the major determinants influencing the growth of the hybrid vegetable seed industry in India [27]. The private sector has started to play a significant role in the production and distribution of seeds in India over some time.

Crop	1951-60	1961-70	1971-80	1981-90	1991-00	2001-10	2011-18	2017-18
Rice	22.09	22.54	22.99	23.03	23.20	22.87	22.22	22.53
Wheat	8.07	9.03	11.96	13.15	13.68	14.41	15.75	15.58
Total cereals	60.28	60.10	60.77	58.58	54.23	52.57	50.57	49.95
Total pulses	15.72	14.72	13.74	13.15	12.51	12.34	12.13	14.03
Total food grains	76.00	74.82	74.51	71.73	66.73	64.91	62.70	63.98
Sugarcane	1.34	1.55	1.71	1.90	2.27	2.53	2.66	2.52
Condiments and spices	0.94	1.02	1.14	1.28	1.46	1.63	1.81	1.82
Total fruits and vegetables	1.62	2.01	2.46	3.24	4.01	4.97	5.27	5.63
Oilseeds	8.39	8.85	9.08	11.07	14.42	14.47	14.36	13.30
Fibres	5.89	5.81	5.44	4.88	5.07	5.32	6.47	6.55

Table 2: Changes in percentage distribution of Gross Cropped Area.

Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmer's Welfare, Government of India.

Table 2 shows that the percentage of rice cultivation has remained relatively stable, fluctuating between 22.09 percent (1951-60) and 23.20 percent (1991-00). In recent years (2011-18), it declined slightly to 22.22 percent. Wheat cultivation has seen consistent growth over the decades. It increased from 8.07 percent (1951-60) to 15.58 percent (2017-18). A similar trend was reported by Evenson et al. 1999, and it is thought that the wheat area will remain around this figure in the coming decades [23]. The overall proportion of land allocated to cereals has seen a decline from 60.28 percent in 1951-60 to 49.95 percent in 2017-18, indicating a shift in crop choices or land use patterns. In the case of cereals, both for India and China, daily per capita intake increased until the 1980s, and since then a declining trend can be noticed, which is perhaps related to the changes in diet patterns related to economic development. The decline in cereal consumption is substituted by the increased consumption of nutritional food products like fruits, vegetables, and animal products [22,25]. The area under pulses has experienced a decline over the years, reaching 14.03 per cent in 2017-18 from 15.72 per cent in 1951-60. The total land used for food grain cultivation has decreased from 76.00 per cent in 1951-60 to 63.98 per cent in 2017-18, reflecting changes in agricultural practices. Sugarcane cultivation has shown a steady increase from 1.34 per cent to 2.52 per cent. Condiments and spices exhibited a gradual rise over the years, reaching 1.82 per cent in 2017-18. The percentage of land used for fruit and vegetable cultivation has increased significantly, from 1.6 per cent in 1951-60 to 5.63 per cent in 2017-18, suggesting a growing focus on horticulture. Oilseed cultivation witnessed significant growth. It rose from 8.39per cent (1951-60) to 13.30per cent (2017-18). The land allocated to fiber crops has shown an overall increase, reaching 6.55 per cent in 2017-18. There is evidence of a shift in cropping patterns, with an increase in the cultivation of cash crops like sugarcane, condiments, and spices, as well as fruits and vegetables which suggests overall crop diversification. A sustained rise in per capita income, increasing urbanization, and changing lifestyle, accompanied by the liberalization of agri-food markets, have been triggering rapid changes in the food basket in favor of high-value food commodities, including fruits, vegetables [1] and animal sources [7,18,19]. These factors have been quite robust in the recent past, and are unlikely to subside in the foreseeable future, implying a faster growth in the demand for high-value food commodities [18,19]. Besides, increasing globalization of agri-food markets is also crafting opportunities for exports of high-value food commodities.

Crop diversification index

Figure 3 Depicts the Simpson Index of Crop Diversification (SID) for various states in India for the years 2008-09 and 2018-19. The SID values, ranging from 0 to 1, reflect the diversity of crops culti-

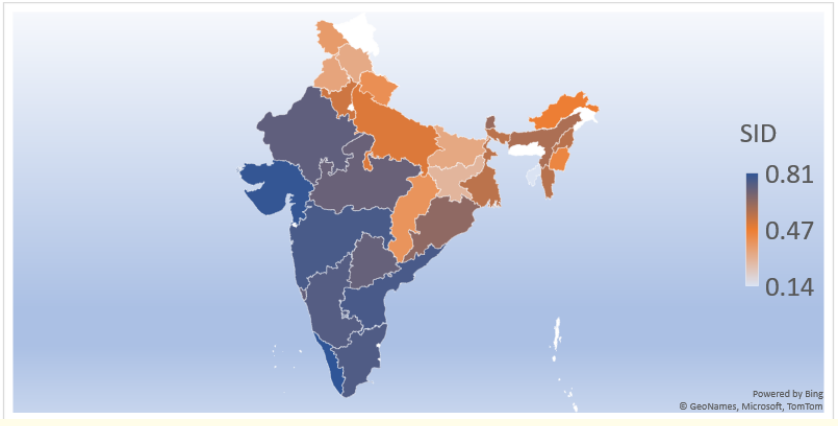

Figure 1: State-wise diversification index (SID) for crops TE 2008-09.

Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmer's Welfare, GOI. (2008-09).

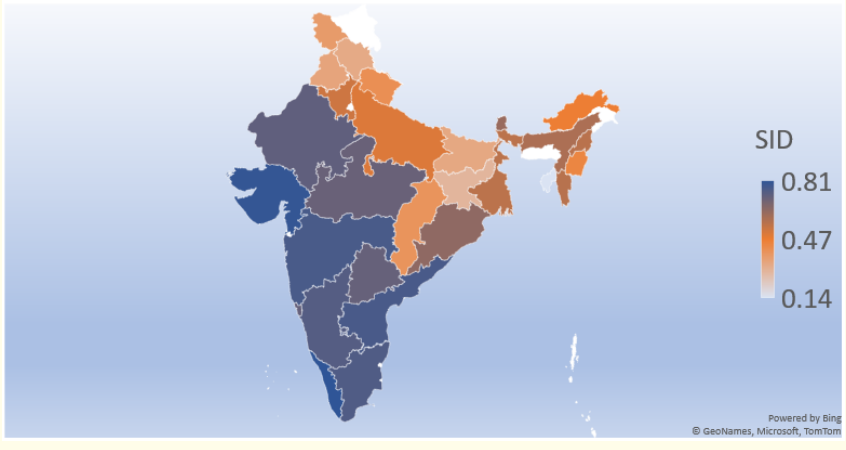

Figure 2: State-wise diversification index (SID) for crops TE 2018-19.

Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmer's Welfare, GOI. (2018-19).

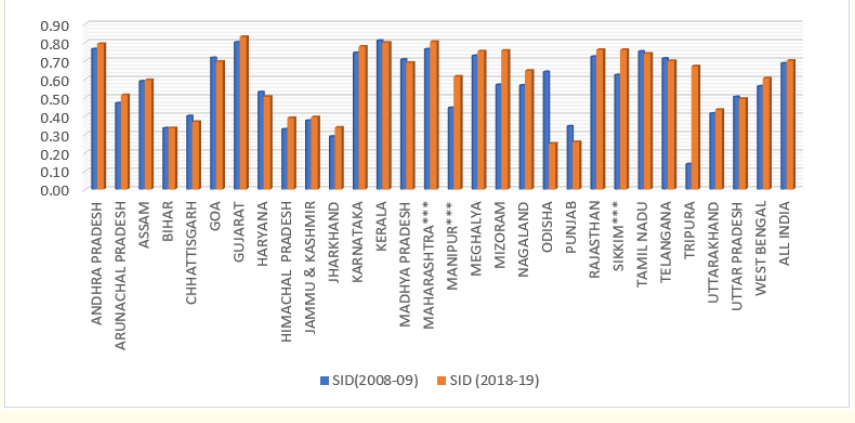

Figure 3: State-wise diversification index (SID) for crops TE 2008-09 and TE 2018-19.

vated in each state during the respective years. The overall trend across states suggests a slight increase in crop diversification from 2008-09 to 2018-19, with the national average SID rising marginally from 0.69 to 0.70. Gujarat, Kerala, and Karnataka stand out as states with consistently high levels of crop diversification, recording SID values of 0.80, 0.81, and 0.78, respectively, in 2018-19. Several states demonstrated an improvement in crop diversification over the decade, including Arunachal Pradesh, Assam, Goa, Jharkhand, Maharashtra, Manipur, Mizoram, Nagaland, Rajasthan, Sikkim, and West Bengal. On the other hand, Odisha and Punjab experienced a decline in crop diversification, with noticeable drops in SID values from 0.64 to 0.25 and 0.34 to 0.26, respectively. Some states, such as Bihar, Haryana, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Tamil Nadu, Telangana, and Uttar Pradesh, maintained relatively stable SID values over the years. Tripura remains a state with low crop diversification, although it showed a notable increase in SID from 0.14 in 2008-09 to 0.67 in 2018-19. The extent of diversification within food crops was low in the northern region, especially in Punjab and Haryana, as more than 90% of the area of food crop cultivation in these states was under wheat and rice. Specialization towards paddy and wheat cultivation adversely affected the agricultural sustainability of the region through the degradation of natural resources [12,13] About 80% of the gross cultivated area in Odisha and Bihar was under cereals and millets, indicating a low level of diversification in the region. The southern region exhibited a higher degree of diversification within the food crops. Rice, maize, pulses, oilseeds, and fruits and vegetables were the major crops cultivated in this region. As per the study, cropping patterns at the state level are shifting from food grains to high-value crops [5] but the transition is not uniform across states/regions [2,19].

Conclusion

The analysis of agricultural data from 2008-09 to 2018-19 indicates significant positive shifts in food grain productivity, driven by technological advancements. Government initiatives contribute to increased pulse production, while oilseeds and nutri-cereals show improved productivity. Fruit and vegetable crops respond positively to favorable conditions, with the private sector playing an increasing role leading to overall crop diversification. Cereal consumption in India rose until the 1980s, declining afterward, likely due to evolving diet patterns. Pulses' area decreased, sugarcane cultivation increased steadily, and condiments/spices rose. Fruit and vegetable cultivation grew significantly, suggesting a focus on horticulture. Oilseed cultivation, fiber crops, and cash crops like sugarcane showed increased allocation, reflecting a shift in cropping patterns. Factors like rising per capita income, urbanization, lifestyle changes, and global agri-food market trends are driving a shift toward high-value food commodities. The northern region, notably Punjab and Haryana, demonstrates low diversification, with over 90% of food crop cultivation dedicated to wheat and rice, impacting agricultural sustainability. Conversely, the southern region exhibits higher diversification, emphasizing rice, maize, pulses, oilseeds, and fruits and vegetables. Addressing regional variations is crucial, tailoring policies to the specific challenges and opportunities in each state. Support initiatives promoting diversification in states like Arunachal Pradesh, Assam, Goa, Jharkhand, Maharashtra, Manipur, Mizoram, Nagaland, Rajasthan, Sikkim, and West Bengal, while implementing targeted interventions for those experiencing declines, such as Odisha and Punjab. Invest in research for climate-resilient crops, enhance infrastructure, and launch educational programs to encourage sustainable farming practices [16]. Learn from high-diversity states like Gujarat, Kerala, and Karnataka, fostering knowledge exchange. Regular monitoring and evaluation will ensure the effectiveness of these policies, promoting a resilient and sustainable agricultural landscape.

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