DOI: https://doi.org/10.37075/EA.2025.4.15 Economic Alternatives, 2025, Issue 4, pp. 1275-1289

Diversification within Fruits and Vegetable Crops: An Inter-District Analysis from Punjab State of India

Received: 11.07.2024
Available online: 30.12.2025

Pooja Choudhary*, Neeraj Kumar**

Abstract

India's geography and diversified agro-climatic conditions make it ideal for producing various horticultural crops. India needs to catch up to China regarding fruit and vegetable production. Horticulture accounts for more than a third of all agricultural output. Like the rest of the country, Punjab places a high value on horticultural development. In this context, the current research focuses on the expansion and diversity of fruits and vegetable crops at the district level in Punjab. The study's scope is confined to fruits and vegetable crops grown at the district level in Punjab for two periods, 2004-05 and 2018-19. The Herfindahl index (HI) has been used to calculate the degree of diversity based on the area under various horticulture crops in a given location at a given time. In the case of fruits, the study found that the production of almost all crops has increased. However, productivity for vegetables has decreased for some crops. Ludhiana district had the most diversification, with an H-Index of 0.188, followed by Nawashahar and Patiala districts, with H-Indexes of 0.189 and 0.192, respectively. Ferozpur district, on the other hand, has a high level of specialism, with an H-Index of 0.600, followed by Muktsar and Hoshiarpur districts, with H-Indexes of 0.476 and 0.420, respectively. Overall, horticulture in the state exhibits a high level of diversification. However, farmers should be taught about the new cultivation measures and ensure that the prices of their produce are appropriate to raise the overall income of the farming community and make agriculture sustainable.

Keywords: Agriculture, Crops, Horticulture, Diversification, Productivity

JEL: Q10, Q19, Q20

1. Introduction

The relevance of the horticulture sector was also recognized in the Fourth Five-Year Plan (1969-74). Moreover, the need to increase food grain output to ensure adequate availability of staple foods was essential during the same period, so horticulture development was seen as less significant at that time. Besides policy considerations, the green revolution technology favored wheat and paddy over other crops. By the late 1970s, reliance on imports to meet food

* Department of Economics, ICFAI School of Social Sciences, IFHE Hyderabad, Telangana, India
** Department of Economics, ICFAI School of Social Sciences, IFHE Hyderabad, Telangana, India

grain demand had practically dissipated, and food self-sufficiency was on the horizon. This prompted a shift in strategy toward diversification, and for the first time since 1983-84, the area under cereal crops began to decline (Chand et al., 2008). India's horticulture crops include various fruits, vegetables, mushrooms, flowers, plantations, and spices. India's geography and diverse agro-climatic conditions make it excellent for growing a wide range of horticulture crops (Subrahmanyam, 1998). Certain fruit crops have emerged as the most profitable for substituting subsistence farming in rain-drain-fed, dry land, hilly, arid, and coastal agroecosystems (Bhattacharyya, 2008).—

Nowadays, horticulture, which includes a wide variety of crops such as fruits, vegetables, spices, plantation crops, medicinal and aromatic plants, cashews, etc., is recognized as an essential product for potential diversification and value addition in agriculture (Sarmah & Deko, 2012). Horticulture crops are known for their exceptional yields per unit area, substantially higher returns, more significant job creation and export prospects, a lower water requirement, and ease of adaptation to arid and wasteland conditions. Horticulture crops are vital in offering livelihood opportunities, reducing excess grain demand to some extent, and contributing to food and nutritional security (Rai, 2013). It is a prominent segment in agriculture and is the fastest-growing sector. Thus, the scenario of horticulture is very encouraging in India, and it has undergone a significant shift in the recent past due to the growth of technology, modernization, and changing food habits of the people. As per the estimates, it can push the overall agricultural growth above the targeted 4 percent (Bahadur, 2010). The percentage share of horticulture output in total agriculture is more than 33 percent (National Horticulture Board, 2019).

Traditionally, horticulture involves four areas of study, i.e., Pomology (fruit culture), Olericulture (vegetable culture), Floriculture (culture of ornamental crops), and Post-Harvest Technology (management of produce after harvest). However, over the years, the scope of horticulture has expanded, including mushrooms, bamboo, plantation crops, and beekeeping. (Chattopadhyay and Roy, 2011). Horticulture is a derivative of the Latin words *hortus*, which means garden, and *culture*, which means culture. Thus, horticulture is the art and science of growing and managing fruits, vegetables, herbs, nuts, and ornamental plants (trees, shrubs, flowering plants, and turf).

In India, the production of horticulture has increased from 145.79 million tonnes to 268.85 million tonnes, whereas the production of food grains has increased from 212.85 million tonnes to just 257.13 million tonnes during the period 2001-02 to 2012-13 respectively. Thus, the production of horticulture even surpassed the food grain production in 2012-13, with again the same trend in 2013-14, where its production is estimated to be 280.79 million tonnes as compared to 264.38 in the case of the latter (Government of India, 2014). Further, during 2013-14, the total value of exporting horticultural produce from India to different countries was Rs. 14365 crores. In the Twelfth Five Year Plan (2012-17), the outlay of Rs. 16840 crores (4.6 percent) has been allocated for the development of horticulture compared to Rs 15800 crores (11.6 percent) in the Eleventh Five Year Plan (2007-12).

Further, in order to promote horticulture extensively in the nation, the National Horticulture Mission was launched in 2005-06 by the Government of India with a

mandate to promote integrated development in horticulture to help in coordinating, stimulating, and sustaining the production and processing of fruits and vegetables and to establish a sound infrastructure in the field of production, processing, and marketing with a focus on post-harvest management to reduce losses (Mittal, 2007). Currently, India is just after China in producing fruits and vegetables. Among fruits, the country is the largest exporter of mango, banana, coconut, cashew, papaya, pomegranate, and spices (Singha et al., 2014).

Agricultural diversification is an essential instrument for economic growth, and it largely depends upon the opportunities and responsiveness of farmers to technological breakthroughs, consumer demand, government policy, trade arrangements, and the development of irrigation, roads, and other infrastructure (Kumar & Mittal, 2003). Punjab has witnessed the highest productivity in the horticulture crops. Thus, much emphasis has been placed on developing Punjab's horticulture sector. Among all the horticultural crops, fruits and vegetables are the most profitable. In this context, the theme of the study revolves around the development of fruits and vegetables in Punjab, along with diversification at the district level.

2. Methodology

For analyzing the productivity of horticulture crops at the state level, data have been collected from the Indian Horticulture Database for the year 2014, published by the Ministry of Horticulture, Government of India. The data were collected from the official website of the government of Punjab to analyze the growth in area, production, and productivity of horticulture crops in Punjab. The scope of the study is limited to the fruits and vegetable crops at the district level in Punjab for the two time periods, i.e., 2004-05 and 2018-19. Compound annual growth rates have been calculated to analyze growth over the years.

Following Singh and Mathur (2008), the Herfindahl index (HI) has been used to measure the degree of diversification based on area under various horticulture crops at a point in time in a particular region. The Index is computed by taking the sum of squares of the proportion of the value of each crop in the system mathematically expressed as follows:

$$HI = \sum_{i=1}^{n} P_i^2 \quad (i=1,2,3,\ldots\ldots n)$$

Where P_i is the proportion of area under i^{th} crop in the total system and n is the number of crops in the system.

HI's value ranges from 0 to 1, where 0 indicates perfect diversification, and 1 indicates perfect specialization. Thus, the Index bears an inverse relationship with diversification, i.e., the higher the index value, the lesser the diversification.

3. Results and Discussion

Although horticulture and agriculture have many practices in common, such as weeding, fertilizing, watering, etc., horticulture is distinguished from agriculture by its specialized practices, e.g., grafting, and by a smaller scale of its operations. The productivity of various horticulture crops, i.e., fruits, vegetables, flowers, A&M, plantation, and spices for the year 2012-13 at the state level depict that the highest productivity is observed in the case of Punjab followed by Bihar, Uttar Pradesh, Lakshadweep, Madhya Pradesh with the productivity of 17.30, 17.26, 16.32 and 16.06 thousand kg/hectare, respectively (Choudhary, 2016). As far as fruits and vegetables are concerned, they

are the most profitable venture of all farming activities, providing ample employment opportunities and the opportunity to raise the income of the farming community. As per the Agricultural Policy of Punjab, horticulture should get high priority to improve farms' economy and promote crop diversification. The percentage share of Punjab in total exports of India's fruits and vegetables has increased from 3.3 percent in 2005-06 to 4.5 percent in 2007-08 and again decreased to 3.3 percent in 2009-10.

Although India is in the second place, just behind China, in the contribution to the World's production of fruits and vegetables, Punjab's share of the total exports is relatively low. The outlay under the National Horticulture Mission in Punjab has increased from Rs. 60.74 crores in 2005-06 to Rs. 62.90 crores in 2012-13, and out of this outlay, the released amount has increased from just 28.69 crores in 2005-06 to 57.90 crores in 2012-13, whereas, the actual expenditure has increased from just 6.97 crores in 2005-06 to 42.09 crores in 2012-13 (Government of India, 2013).

a) Growth of Fruit Crops in Punjab

Table 1 shows the growth of fruits in Punjab during the study period, i.e., from 2004-05 to 2018-19. It is clear from the table that in 2004-05, the highest productivity in fruits was observed in the case of grapes followed by pear and guava. However, the highest area under cultivation is kinnow, i.e., 19.36 thousand hectares. However, in 2018-19, the highest productivity was observed in the case of bananas, followed by grapes and kinnow. Between these two study periods, the highest growth in the area was observed in the case of kinnow, followed by litchi, whereas the area under cultivation of grapes and ber fruit declined. As far as production is concerned, the highest growth is observed in the case of kinnow, followed by litchi, along with a decline in the case of grapes and ber fruit. The growth analysis of productivity shows that the highest growth is observed in the case of litchi, followed by guava and kinnow. The overall growth in area, production, and productivity has been 84.06, 47.94, and 172.28 percent, respectively, between 2004-04 and 2018-19.

Table 1. Crop-wise growth of the fruits sector in Punjab

FRUITS	2004-05			2018-19			Growth (%)		
	Area	Productivity	Production	Area	Productivity	Production	Area	Productivity	Production
Kinnow	19.36	15	290.4	53.045	23.505	1246.821	173.99	56.70	329.35
Sweet Orange	2.47	7	17.26	3.123	8.375	26.154	26.44	19.64	51.53
Lime Lemon	0.66	7	4.63	1.12	7.73	8.657	69.70	10.43	86.98
Mango	6.37	10	63.74	7.024	16.908	118.759	10.27	69.08	86.32
Litchi	1.26	10	12.63	2.885	16.27	46.94	128.97	62.70	271.65
Guava	7.31	17.5	127.91	9.142	22.545	206.106	25.06	28.83	61.13
Pear	2.45	20	49	3.205	23.022	73.784	30.82	15.11	50.58
Peach	1.28	15	19.22	1.971	17.853	35.187	53.98	19.02	83.07
Plum	0.17	15	2.52	0.322	17.72	5.706	89.41	18.13	126.43
Grapes	1.2	27	32.3	0.29	28.584	8.289	-75.83	5.87	-74.34

FRUITS	2004-05			2018-19			Growth (%)		
	Area	Productivity	Production	Area	Productivity	Production	Area	Productivity	Production
Ber	2.87	15	43.1	1.767	16.766	29.626	-38.43	11.77	-31.26
Amla	-	-	-	0.601	13.67	8.216	-	-	-
Banana	-	-	-	0.078	56.386	4.398	-	-	-
Others	1.69	10	16.85	2.1	15.055	31.616	24.26	50.55	87.63
Total	47.09	14.43	679.55	86.673	21.348	1850.26	84.06	47.94	172.28

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

b) Growth of Vegetable Crops in Punjab

Table 2 shows the growth of vegetables in Punjab during the study period, i.e., from 2004-05 to 2018-19. It is clear from the table that in 2004-05, the highest productivity in vegetables is observed in the case of tomato followed by cauliflower and cabbage. However, in 2018-19, potatoes' highest productivity growth was observed, followed by tomatoes and onions. Between the study periods, the highest growth in the area was observed in the case of garlic, followed by muskmelon and watermelon. As far as production is concerned, the highest growth is observed in the case of garlic, followed by muskmelon and watermelon, which is the same as in the case of the area. However, the productivity analysis depicts that the highest growth is observed in the case of other vegetable crops, followed by peas and brinjal. The productivity of cauliflower, cabbage, musk melon, watermelon, and vine crops has declined. The overall growth in area, production, and productivity has been 72.2, 17.99, and 103.27 percent, respectively, between 2004-04 and 2018-19.

Table 2. Crop-wise growth of the vegetable sector in Punjab

Vegetables	2004-05			2018-19			Growth (%)		
	Area	Productivity	Production	Area	Productivity	Production	Area	Productivity	Production
Potato	72.85	20.18	1470.19	102.966	26.381	2716.33	41.34	30.73	84.76
Onion	7.41	21.15	159.78	10.233	22.863	233.959	38.10	8.10	46.43
Garlic	1.31	12.09	15.81	7.615	14.112	107.462	481.30	16.72	579.71
Tomato	7.75	24.23	187.31	10.168	24.846	252.631	31.20	2.54	34.87
Brinjal	2.61	14.18	37	5.826	21.725	126.568	123.22	53.21	242.08
Cauliflower	5.45	23.5	128.09	19.588	18.547	363.305	259.41	-21.08	183.63
Cabbage	3.14	21.58	68.8	6.818	18.472	125.94	117.13	-14.40	83.05
Okra	1.83	7.32	13.79	5.014	10.442	52.358	173.99	42.65	279.68
Chillies	9.61	1.6	15.41	9.524	1.899	18.087	-0.89	18.69	17.37
Peas	16.75	6	100.51	38.818	10.439	405.228	131.75	73.98	303.17
Musk melon	1.05	19.34	20.22	5.656	17.804	100.698	438.67	-7.94	398.01
Watermelon	0.28	19.91	5.59	1.467	17.872	26.218	423.93	-10.24	369.02
Vine crops	10.76	19.39	154.92	17.009	15.9	270.449	58.08	-18.00	74.57

Vegetables	2004-05			2018-19			Growth (%)		
	Area	Productivity	Production	Area	Productivity	Production	Area	Productivity	Production
Root crops	14.77	19.98	205.08	27.559	22.809	628.582	86.59	14.16	206.51
Others	3.07	1.58	4.86	4.992	2.886	14.405	62.61	82.66	196.40
Total	158.64	16.88	2677.38	273.253	19.916	5442.22	72.25	17.99	103.27

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

c) District-wise growth of fruits and vegetables in Punjab

Table 3 elucidates the district-wise growth in area, production, and productivity of fruits and vegetables between 2004-05 and 2018-19. It is clear from the table that as far as fruits are concerned, in the year 2014-15, the highest area under cultivation is in the Fazilka district, productivity in the Barnala district, and production in the Bathinda district. However, in the case of the year 2018-19, the highest area under fruits is in the Fazilka district, productivity in Ludhiana, and production in the Pathankot district. Regarding vegetable status, in the year 2014-15, the highest area under cultivation and production was observed in the Jalandhar district. However, as far as productivity is concerned, it is maximum in the case of the Faridkot district of Punjab.

The growth of fruits and vegetables during the study period 2004-05 to 2018-19 shows that in the case of fruits, the highest growth in the area and production is observed in Gurdaspur and the highest productivity in the case of S.B.S. Nagar. However, certain districts like Hoshiarpur, Amritsar, Kapurthala, Faridkot, Fatehgarh Sahib, and Barnala have shown negative growth rates, indicating a decline in area under cultivation. The decline in production was observed in the case of Hoshiarpur, Amritsar, Kapurthala, Faridkot, Fatehgarh Sahib, and Barnala districts during the same period. The growth in the case of vegetables during the study period shows that the highest growth in the area is observed in the case of Pathankot. However, productivity and production have shown the highest growth in S.B.S. Nagar and Pathankot, respectively. Further, districts like Amritsar, Faridkot, Barnala, and Pathankot have shown a decline in productivity over the study period. The production has declined in the case of Ropar, Faridkot, and Barnala districts, whereas the area has declined in the case of Amritsar, Patiala, and Barnala districts during the study period.

Table 3. District-wise growth of fruits and vegetables in Punjab

Districts	Variables	Fruits		Vegetables		Fruits Growth Rate	Vegetable Growth Rate
		2004-051515	2018-19	2014-15	2018-19		
Hoshiarpur	Area	8912	8740	27911	34096	-1.93	22.16
	Productivity	21129	261703	20399	21131	1138.60	3.59
	Production	188304	182006	569347	720486	-3.34	26.55
Jalandhar	Area	1736	2017	33587	37631	16.19	12.04
	Productivity	19964	266838	22226	23304	1236.60	4.85
	Production	34657	40693	746511	876948	17.42	17.47

Districts	Variables	Fruits		Vegetables		Fruits Growth Rate	Vegetable Growth Rate
		2004-051515	2018-19	2014-15	2018-19		
Ludhiana	Area	2626	2818	20117	27413	7.31	36.27
	Productivity	19953	277907	21175	21883	1292.81	3.34
	Production	52397	56525	425973	599867	7.88	40.82
Ferozpur	Area	389	394	3656	8634	1.29	136.16
	Productivity	21064	191885	13758	15096	810.96	9.73
	Production	8194	8527	50297	130338	4.06	159.14
Amritsar	Area	2137	2087	20755	34161	-2.34	64.59
	Productivity	19943	174266	18120	16257	773.82	-10.28
	Production	42619	42217	376081	555364	-0.94	47.67
Gurdaspur	Area	792	1151	5916	8236	45.33	39.22
	Productivity	18423	252429	17644	18255	1270.18	3.46
	Production	14591	21238	104385	150346	45.56	44.03
Kapurthala	Area	387	365	17495	19659	-5.68	12.37
	Productivity	18906	179762	22070	22503	850.82	1.96
	Production	7316	7071	386109	442380	-3.35	14.57
Bathinda	Area	4622	5150	8242	9444	11.42	14.58
	Productivity	20450	162577	21519	22179	695.00	3.07
	Production	94521	114992	177363	209462	21.66	18.10
Sangrur	Area	1697	1737	8649	11413	2.36	31.96
	Productivity	18903	252934	16744	17475	1238.06	4.37
	Production	32078	32985	144822	199438	2.83	37.71
Patiala	Area	2337	2503	15771	17978	7.10	13.99
	Productivity	19235	224217	18825	19237	1065.67	2.19
	Production	44951	48719	296886	345850	8.38	16.49
Ropar	Area	2766	3100	3060	2822	12.08	-7.78
	Productivity	17584	190485	18022	19469	983.29	8.03
	Production	48636	54933	55148	54941	12.95	-0.38
Faridkot	Area	1455	1421	1501	2237	-2.34	49.03
	Productivity	20608	196624	35406	16967	854.11	-52.08
	Production	29984	29890	53145	37955	-0.31	-28.58
Mansa	Area	967	994	1119	1702	2.79	52.10
	Productivity	20417	134862	14982	15196	560.54	1.43
	Production	19744	21691	16765	25863	9.86	54.27

Districts	Variables	Fruits		Vegetables		Fruits Growth Rate	Vegetable Growth Rate
		2004-051515	2018-19	2014-15	2018-19		
Fatehgarh Sahib	Area	621	616	8367	9829	-0.81	17.47
	Productivity	18800	167374	20736	21052	790.29	1.52
	Production	11675	11449	173495	206921	-1.94	19.27
Moga	Area	427	453	9866	12233	6.09	23.99
	Productivity	20563	140203	20798	23350	581.82	12.27
	Production	8781	9519	205197	285641	8.40	39.20
Shri Muktsar Sahib	Area	6892	7411	1274	2117	7.53	66.17
	Productivity	21527	200287	14341	15513	830.40	8.17
	Production	148362	166715	18270	32842	12.37	79.76
S.B.S Nagar	Area	1370	1603	10309	13060	17.01	26.69
	Productivity	18185	272144	14812	16776	1396.53	13.26
	Production	24914	28551	152694	219094	14.60	43.49
S.A.S Nagar	Area	2381	2676	4970	7048	12.39	41.81
	Productivity	17919	247053	17851	18185	1278.72	1.87
	Production	42665	48178	88720	128167	12.92	44.46
Tarn Taran	Area	1623	1805	7185	8601	11.21	19.71
	Productivity	20788	195617	15824	16324	841.01	3.16
	Production	33739	37645	113692	140406	11.58	23.50
Barnala	Area	375	286	2698	1863	-23.73	-30.95
	Productivity	55647	242934	19578	14638	336.56	-25.23
	Production	20868	5689	52820	27271	-72.74	-48.37
Fazilka	Area	29315	34833	1813	2549	18.82	40.60
	Productivity	22694	198206	16378	16966	773.39	3.59
	Production	665280	800394	29693	43246	20.31	45.64
Pathankot	Area	3924	4513	145	527	15.01	263.45
	Productivity	17933	177543	20210	17825	890.04	-11.80
	Production	70368	80634	2930	9394	14.59	220.61
State	Area	77751	86673	214406	273253	11.48	27.45
	Productivity	21153	21348	19777	19916	0.92	0.70
	Production	1644641	1850260	4240344	5442220	12.50	28.34

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

d) The district-wise extent of diversification in fruit crops for the year 2004-05

Since Punjab's agriculture is limited to two major crops, wheat, and rice, crop diversification is a serious concern. Many issues arise from these crop cycles, such as groundwater depletion, soil degradation, ecological imbalance, and agricultural growth slowdown (Singh, 2004; Bhogal & Vatta, 2021). Diversification will be the answer to this problem. The government uses a variety of programs to do this, but the diversification is growing steadily (Kumar & Singh, 2019). The present section deals with crop diversification. The diversification analysis of the fruits section in Punjab for 2004-05 is shown in Table 4. It is clear from the table that the highest diversification is observed in the case of Ludhiana district with an H-Index of 0.188, followed by Nawashahar and Patiala district with an Index of 0.189 and 0.192, respectively.

In contrast, high specialization is observed in the case of the Ferozpur district, with an H-Index of 0.600, followed by Muktsar and Hoshiarpur districts, with an H-Index of 0.476 and 0.420, respectively. Overall, the state observes a high level of diversification within horticulture, with an H-Index of 0.224. The highest cultivation is in Kinnow, followed by guava and mango cultivation in 2004-05.

Table 4. Diversification within fruits sector (2004-05) in Punjab

Districts	Kinnow	Sweet orange	Lime Lemon	Mango	Litchi	Guava	Pear	Peach	Plum	Grapes	Ber	Others	H Index	Rank
Hoshiarpur	0.350	0.000	0.000	0.064	0.001	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.420	15
Jalandhar	0.002	0.000	0.002	0.025	0.000	0.122	0.039	0.008	0.000	0.000	0.003	0.002	0.203	4
Ludhiana	0.005	0.000	0.003	0.024	0.000	0.127	0.005	0.003	0.000	0.001	0.014	0.006	0.188	1
Ferozepur	0.580	0.017	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.600	17
Amritsar	0.005	0.000	0.001	0.006	0.000	0.063	0.193	0.001	0.000	0.000	0.000	0.002	0.271	10
Gurdaspur	0.007	0.000	0.000	0.291	0.065	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.366	14
Kapurthala	0.009	0.000	0.001	0.030	0.000	0.207	0.007	0.001	0.000	0.000	0.003	0.003	0.260	7
Bathinda	0.167	0.002	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.056	0.019	0.000	0.264	9
Sangrur	0.002	0.000	0.004	0.001	0.000	0.100	0.000	0.003	0.000	0.000	0.132	0.006	0.249	6
Patiala	0.002	0.000	0.002	0.053	0.000	0.094	0.002	0.002	0.000	0.000	0.007	0.030	0.192	3
Ropar	0.050	0.000	0.000	0.158	0.001	0.051	0.000	0.000	0.000	0.000	0.000	0.003	0.264	8
Faridkot	0.114	0.006	0.000	0.000	0.000	0.135	0.000	0.000	0.000	0.001	0.013	0.002	0.272	11
Mansa	0.183	0.000	0.000	0.000	0.000	0.048	0.000	0.000	0.000	0.010	0.053	0.000	0.294	12
Fatehgarh	0.006	0.000	0.003	0.082	0.000	0.123	0.005	0.004	0.000	0.000	0.001	0.005	0.228	5
Moga	0.021	0.000	0.001	0.000	0.000	0.248	0.000	0.000	0.000	0.000	0.061	0.000	0.333	13
Mukatsar	0.449	0.014	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.001	0.001	0.000	0.476	16
Nawanshahar	0.009	0.000	0.000	0.037	0.001	0.037	0.009	0.091	0.000	0.000	0.000	0.003	0.188	2
Total	0.169	0.003	0.000	0.018	0.001	0.024	0.003	0.001	0.000	0.001	0.004	0.001	0.224	

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

e) The district-wise extent of diversification in fruit crops for the year 2018-19

The diversification analysis of the fruits sector in Punjab for the year 2018-19 is shown in Table 5. It is clear from the table that the highest diversification is observed in the case of S.B.S. Nagar, with an H-Index of 0.174, followed by Jalandhar and Ludhiana, with an H-Index of 0.179 and 0.186, respectively. In contrast, high specialization is observed in the case of Fazilka, with an H-Index of 0.833, followed by Shri Muktsar Sahib and Bathinda, with an H-Index of 0.642 and 0.562, respectively. Overall, a moderate level of diversification is observed in the case of the entire state, with the H-Index being 0.397. The highest cultivation in the case of fruits is observed again in the case of kinnow, followed by guava and mango for 2014-15.

Table 5. Diversification within fruits sector (2018-19) in Punjab

Districts	Kinnow	Sweet Orange	Lime/ Lemon	Mango	Litchi	Guava	Pear	Peach	Plum	Grapes	Ber	Amla	Banana	Others	Herfindhal Index	Rank
Hoshiarpur	0.4212	0.0005	0.0003	0.0241	0.0024	0.0007	0.0001	0.0003	0.0000	0.0000	0.0000	0.0012	0.0000	0.0002	0.4509	17
Jalandhar	0.0366	0.0002	0.0027	0.0077	0.0000	0.0933	0.0279	0.0066	0.0001	0.0000	0.0005	0.0000	0.0000	0.0039	0.1795	2
Ludhiana	0.0218	0.0002	0.0023	0.0165	0.0000	0.1274	0.0061	0.0031	0.0000	0.0001	0.0051	0.0000	0.0004	0.0035	0.1865	3
Ferozpur	0.0372	0.0000	0.0000	0.0000	0.0000	0.4558	0.0002	0.0002	0.0002	0.0000	0.0066	0.0000	0.0000	0.0000	0.5003	18
Amritsar	0.0275	0.0012	0.0002	0.0036	0.0007	0.0267	0.2055	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0021	0.2681	12
Gurdaspur	0.0234	0.0000	0.0005	0.0386	0.1501	0.0111	0.0050	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0005	0.2296	9
Kapurthala	0.0457	0.0013	0.0019	0.0003	0.0002	0.1136	0.0327	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0159	0.2121	5
Bathinda	0.5433	0.0002	0.0000	0.0000	0.0000	0.0117	0.0000	0.0002	0.0000	0.0007	0.0058	0.0000	0.0000	0.0003	0.5622	20
Sangrur	0.0081	0.0000	0.0141	0.0027	0.0000	0.1699	0.0005	0.0026	0.0000	0.0002	0.0199	0.0000	0.0000	0.0091	0.2270	8
Patiala	0.0013	0.0001	0.0012	0.0226	0.0000	0.1780	0.0027	0.0052	0.0001	0.0000	0.0030	0.0000	0.0000	0.0238	0.2379	11
Ropar	0.1108	0.0017	0.0015	0.0957	0.0012	0.0216	0.0002	0.0006	0.0000	0.0000	0.0000	0.0006	0.0000	0.0010	0.2349	10
Faridkot	0.2646	0.0018	0.0000	0.0000	0.0000	0.0911	0.0000	0.0000	0.0000	0.0000	0.0032	0.0000	0.0000	0.0029	0.3639	15
Mansa	0.4903	0.0000	0.0000	0.0000	0.0000	0.0429	0.0000	0.0000	0.0000	0.0003	0.0036	0.0000	0.0000	0.0001	0.5372	19
Fatehgarh Sahib	0.0562	0.0000	0.0006	0.0418	0.0000	0.0726	0.0029	0.0056	0.0000	0.0000	0.0000	0.0000	0.0000	0.0152	0.1949	4
Moga	0.2068	0.0000	0.0001	0.0000	0.0000	0.2274	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.4356	16
Shri Muktsar Sahib	0.6308	0.0029	0.0000	0.0000	0.0000	0.0078	0.0000	0.0008	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.6429	21
S.B.S Nagar	0.0580	0.0003	0.0008	0.0275	0.0036	0.0199	0.0012	0.0610	0.0000	0.0000	0.0001	0.0000	0.0000	0.0022	0.1746	1
S.A.S Nagar	0.0197	0.0001	0.0008	0.0841	0.0016	0.0999	0.0006	0.0008	0.0000	0.0000	0.0001	0.0002	0.0000	0.0099	0.2178	6
Tarn Taran	0.0049	0.0000	0.0005	0.0028	0.0000	0.0389	0.3106	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.3614	14
Barnala	0.0533	0.0000	0.0059	0.0008	0.0000	0.1374	0.0000	0.0040	0.0000	0.0006	0.0167	0.0000	0.0000	0.0031	0.2219	7
Fazilka	0.8296	0.0032	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.8330	22
Pathankot	0.0111	0.0003	0.0000	0.2096	0.1282	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0008	0.0000	0.0000	0.3502	13
State	0.3746	0.0013	0.0002	0.0066	0.0011	0.0111	0.0014	0.0005	0.0000	0.0000	0.0004	0.0000	0.0000	0.0006	0.3978	

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

f) The district-wise extent of diversification in vegetable crops for 2004-05

The diversification within the vegetable sector in Punjab for the year 2004-05 is given in Table 6. It is clear from the table that the highest diversification of vegetables is observed in Ferozpur with an H-Index of 0.122, followed by Gurdaspur and Faridkot with an H-Index of 0.132 and 0.142, respectively. On the other hand, as far as specialization is concerned, it is highest in Moga with an H-Index of 0.808, followed by Hoshiarpur and Bathinda with an H-Index being 0.497 and 0.452, respectively. For 2004-05, potato cultivation was the highest, followed by peas and root vegetables. Overall, the entire state depicts an H-Index of 0.246, signifying a high level of diversification.

Table 6. Diversification within vegetable sector (2004-05) in Punjab

Districts	Potato	Onion	Garlic	Tomato	Brinjal	Cauli-flower	Cab-bage	Okra	Chil-lies	Peas	Musk melon	Water-melon	Vine veg.	Root veg.	Other veg.	Total	H Index	Rank
Hoshiar-pur	0.447	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.048	0.000	0.000	0.000	0.001	0.000	1.000	0.497	16
Jalandhar	0.361	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.003	0.018	0.000	1.000	0.388	13
Ludhiana	0.414	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.006	0.008	0.000	1.000	0.432	14
Firozpur	0.051	0.025	0.001	0.004	0.001	0.001	0.000	0.001	0.016	0.001	0.000	0.000	0.002	0.016	0.003	1.000	0.122	1
Amritsar	0.020	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.040	0.058	0.000	0.000	0.016	0.012	0.001	1.000	0.153	5
Gurdaspur	0.052	0.001	0.000	0.007	0.001	0.022	0.000	0.000	0.001	0.005	0.000	0.000	0.018	0.021	0.002	1.000	0.132	2
Kapurthala	0.174	0.000	0.000	0.019	0.003	0.002	0.002	0.000	0.001	0.001	0.000	0.000	0.005	0.005	0.002	1.000	0.215	9
Bathinda	0.434	0.006	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.004	0.005	0.000	1.000	0.452	15
Sangrur	0.107	0.013	0.000	0.001	0.000	0.003	0.001	0.000	0.020	0.002	0.000	0.000	0.022	0.003	0.000	1.000	0.173	7
Patiala	0.117	0.035	0.035	0.004	0.000	0.001	0.000	0.000	0.003	0.009	0.000	0.000	0.003	0.010	0.000	1.000	0.218	9
Ropar	0.200	0.042	0.000	0.002	0.000	0.005	0.000	0.000	0.001	0.000	0.000	0.000	0.007	0.002	0.000	1.000	0.259	12
Faridkot	0.072	0.001	0.006	0.002	0.003	0.024	0.000	0.000	0.001	0.000	0.000	0.000	0.019	0.006	0.008	1.000	0.142	3
Mansa	0.031	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.004	0.001	0.000	0.000	0.027	0.085	0.018	1.000	0.169	6
Fatehgarh Sahib	0.151	0.001	0.000	0.010	0.000	0.013	0.016	0.000	0.001	0.002	0.000	0.000	0.004	0.002	0.000	1.000	0.201	8
Moga	0.806	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.808	17
Muktsar	0.157	0.003	0.000	0.001	0.000	0.000	0.000	0.000	0.004	0.048	0.000	0.000	0.004	0.003	0.001	1.000	0.223	11
Nawan Shehar	0.052	0.001	0.000	0.005	0.000	0.002	0.001	0.001	0.001	0.048	0.000	0.000	0.006	0.031	0.001	1.000	0.149	4
State	0.211	0.002	0.000	0.002	0.000	0.001	0.000	0.000	0.004	0.011	0.000	0.000	0.005	0.009	0.000	1.000	0.246	

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

g) The district-wise extent of diversification in vegetable crops for 2018-19

The diversification analysis for the year 2018-19 in the case of vegetables is shown in table 7. It is clear from the table that the highest diversification is observed in the case of Barnala with an H-Index of 0.084, followed by Fazilka and Mansa with an H-Index of 0.0.089 and 0.102, respectively. Further, districts like Moga and Bathinda, with an H-Index of 0.402 and 0.404, respectively, have shown moderate diversification. Overall, the entire state has shown a high level of diversification, with an H-Index of 0.188.

Table 7. Diversification in vegetable crops for 2018-19

Districts	Potato	Onion	Garlic	Tomato	Brinjal	Cauli flower	Cabbage	Okra	Chillies	Peas	Musk Melon	Water Melon	Vine Crops	Root crops	Others	Herfindhal Index	Rank
Hoshiarpur	0.1963	0.0001	0.0000	0.0001	0.0001	0.0045	0.0000	0.0000	0.0000	0.0321	0.0000	0.0000	0.0008	0.0485	0.0002	0.2826	18
Jalandhar	0.3593	0.0002	0.0006	0.0004	0.0003	0.0003	0.0002	0.0002	0.0010	0.0009	0.0028	0.0002	0.0037	0.0076	0.0000	0.3777	20
Ludhiana	0.2324	0.0022	0.0014	0.0006	0.0007	0.0030	0.0011	0.0011	0.0005	0.0026	0.0002	0.0000	0.0019	0.0121	0.0003	0.2601	15
Ferozepur	0.0222	0.0005	0.0133	0.0016	0.0033	0.0008	0.0003	0.0002	0.0390	0.0067	0.0001	0.0000	0.0046	0.0208	0.0020	0.1156	7
Amritsar	0.0551	0.0000	0.0000	0.0022	0.0001	0.0009	0.0003	0.0001	0.0001	0.2872	0.0000	0.0000	0.0016	0.0017	0.0003	0.3496	19
Gurdaspur	0.0098	0.0013	0.0001	0.0015	0.0012	0.1671	0.0003	0.0005	0.0004	0.0052	0.0001	0.0000	0.0073	0.0103	0.0014	0.2067	14
Kapurthala	0.2488	0.0002	0.0000	0.0026	0.0002	0.0056	0.0004	0.0001	0.0001	0.0010	0.0084	0.0004	0.0035	0.0065	0.0005	0.2782	17
Bathinda	0.3911	0.0017	0.0009	0.0009	0.0004	0.0007	0.0003	0.0005	0.0019	0.0005	0.0000	0.0000	0.0029	0.0027	0.0003	0.4047	22
Sangrur	0.0062	0.0309	0.0004	0.0008	0.0008	0.0374	0.0043	0.0006	0.0063	0.0073	0.0001	0.0000	0.0131	0.0056	0.0007	0.1142	6
Patiala	0.0685	0.0137	0.0007	0.0059	0.0015	0.0045	0.0029	0.0006	0.0025	0.0151	0.0008	0.0000	0.0024	0.0035	0.0004	0.1231	10
Ropar	0.1296	0.0088	0.0014	0.0088	0.0031	0.0110	0.0035	0.0038	0.0015	0.0053	0.0004	0.0000	0.0000	0.0000	0.0000	0.1773	13
Faridkot	0.0131	0.0006	0.0037	0.0084	0.0027	0.0120	0.0049	0.0043	0.0005	0.0007	0.0000	0.0000	0.0472	0.0152	0.0005	0.1137	5
Mansa	0.0146	0.0026	0.0027	0.0010	0.0012	0.0055	0.0032	0.0038	0.0032	0.0084	0.0000	0.0000	0.0390	0.0146	0.0026	0.1024	3
Fatehgarh Sahib	0.2471	0.0016	0.0017	0.0004	0.0004	0.0161	0.0031	0.0006	0.0009	0.0010	0.0001	0.0000	0.0018	0.0033	0.0000	0.2781	16
Moga	0.3765	0.0003	0.0192	0.0005	0.0002	0.0016	0.0002	0.0000	0.0001	0.0001	0.0000	0.0000	0.0042	0.0010	0.0002	0.4042	21
Shri Muktsar Sahib	0.0151	0.0013	0.0025	0.0021	0.0086	0.0054	0.0030	0.0025	0.0016	0.0041	0.0000	0.0000	0.0331	0.0223	0.0016	0.1030	4
S.B.S Nagar	0.0458	0.0009	0.0004	0.0005	0.0004	0.0022	0.0002	0.0002	0.0005	0.0569	0.0000	0.0000	0.0189	0.0342	0.0006	0.1618	12
S.A.S Nagar	0.0463	0.0134	0.0004	0.0032	0.0003	0.0288	0.0018	0.0008	0.0014	0.0008	0.0013	0.0000	0.0115	0.0095	0.0006	0.1199	9
Tarn Taran	0.0486	0.0001	0.0001	0.0140	0.0004	0.0029	0.0002	0.0003	0.0165	0.0485	0.0000	0.0000	0.0041	0.0106	0.0004	0.1466	11
Barnala	0.0070	0.0021	0.0017	0.0034	0.0032	0.0102	0.0017	0.0019	0.0032	0.0133	0.0017	0.0000	0.0174	0.0061	0.0110	0.0840	1
Fazilka	0.0033	0.0053	0.0059	0.0110	0.0042	0.0135	0.0033	0.0004	0.0131	0.0024	0.0000	0.0000	0.0072	0.0173	0.0024	0.0894	2
Pathankot	0.0009	0.0260	0.0009	0.0405	0.0023	0.0073	0.0000	0.0023	0.0002	0.0113	0.0000	0.0000	0.0076	0.0073	0.0109	0.1174	8
State	0.1420	0.0014	0.0008	0.0014	0.0005	0.0051	0.0006	0.0003	0.0012	0.0202	0.0004	0.0000	0.0039	0.0102	0.0003	0.1883	

Source: Author's calculations based on data available at www.punjabhorticulture.com/fruits

4. Conclusion and policy recommendations

the scenario of horticulture is very encouraging in India. Crop diversification undoubtedly produces positive externalities regarding more significant farmer income, improved rural infrastructure, and more trade prospects (Chand et al., 2008; Singh & Kaur, 2015). In Punjab's case, much devotion is also given to the development of horticulture. The state witnessed the highest horticulture productivity for 2012-13. In the case of fruits, the productivity of almost all the crops has grown. However, in the case of vegetables, productivity has declined for specific crops. Overall, both fruits and vegetables have shown a rise in productivity over the years. The diversification analysis of fruits shows that it has declined from the H-Index of 0.224 in 2004-05 to 0.397 in 2018-19. Crop diversification in many districts of Punjab has observed negative growth. In most of the districts and blocks, the cropping pattern has grown overly specialized in favor of rice-wheat rotation. The net irrigated area for rice and wheat agriculture is steadily rising, negatively impacting natural resources, the environment, and farmer socioeconomic conditions (Datta, 2013; Sajjad & Prasad, 2014). However, in the case of vegetables, the diversification has increased from the H- Index of 0.246 in 2004-05 to 0.188 in 2018-19.

Hence, the analysis shows bright prospects for diversification within the horticulture sector of fruits and vegetables.

Further, there must be a supportive, appropriate national trade policy in agriculture for export-led diversification. In Punjab, protected cultivation of vegetables has been introduced. Since Kandi areas are more suitable for horticulture crops, special efforts should be made to develop these areas as a horticulture belt of fruits like amla, guava, and kinnow. The scenario of horticulture crops in India has become very encouraging. Farmers should be taught about the new measures of cultivation and be ensured appropriate prices for their produce to raise the overall income of the farming community and make agriculture sustainable.

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