Journal of Agricultural Development and Policy, 2024
Volume 34, No. 1, 49-59
https://doi.org/10.63066/23220457.34.1.006

NAAS - 4.34
UGC CARE List Journal

Prospects of Crop Diversification through High Value Crops in Punjab

Sukhjit Singh and Parminder Kaur

Department of Economics and Sociology, Punjab Agricultural University, Ludhiana, Punjab, India

Abstract

The present study was undertaken to analyze the trends in cropping pattern and possible diversification avenues in Punjab state. The results reveal that Punjab had a Herfindahl index (HI) score of 0.8 and Crop Diversification Index (CDI) score of 0.24 in 2020-21, both the scores indicating specialization. Analysis of percentage share of cropped area of different crops reveal that specialization has been acquired in the cultivation of wheat and paddy and the combined area under wheat and paddy has increased from 74.38 percent in 2001-2002 to 85.33 percent in 2020-21. The results of markov chain analysis for the period 2011-12 to 2020-21 reveals that foodgrains (96%), fruits (98%) and fiber crops (74%) had higher retention of their respective previous period cropped area. Fruit and vegetable crops offer an excellent opportunity for diversification, as they consume much less water for producing a kilogram of produce compared to paddy crop and are relatively more profitable than paddy and wheat crops. Location Quotient revealed that out of 25 districts, 15 districts had high specialization in Paddy cultivation, 17 had low specialization in fruit cultivation whereas 10 had low specialization in vegetable cultivation during 2020-21 period. More area under fruit and vegetable crops can brought under these districts by formulating district specific crop diversification programme, promoting adoption of fruit and vegetable cultivation over wheat-paddy cropping pattern, taking into consideration the climate and soil suitability, would be highly helpful in sustaining the state's agriculture.

Keywords: *Crop Diversification Index, Cropping Pattern, Herfindahl Index, Location Quotient, Markov chain analysis.*

JEL Classification: Q18, Q19

Introduction

On the eve of Independence, India lacked foodgrain self-sufficiency necessary to feed the growing population of the country. The direness of the situation can be understood from the fact that there were constant incidences of droughts in the Indian sub-continent along with non-sufficient agricultural production. The matter was further worsened by the lack of foreign exchange reserves for importing, thereby, forcing India to depend on the foreign aid provided by the international organizations.

The major concern back then was only of the foodgrain self-sufficiency for the country and it was achieved by way of the green revolution. The green revolution, introduced in the 1960s, brought about a multitude of changes in the Indian agricultural landscape with the introduction of high yielding variety seeds, better production technologies and practices, etc. which helped India in attaining the objective of food self-sufficiency by the year 1978. The HYV seeds increased the productivity manifold, especially of wheat and rice. India had grown out of the periods of acute shortage and has emerged as one of the leading players in international markets. The success of the green revolution was most visible in the states of Punjab and Haryana. The production of wheat increased from 1.1 percent to 27.2 percent in Haryana and 3.8 percent to 25.1 percent in Punjab from1959-60 to 1969-70 respectively. The HYV seeds, introduced in the green revolution, had an adverse impact on the environment and the states that were at the forefront of the green revolution are now facing the adverse consequences of soil and water degradation and severe groundwater resource depletion. From time-to-time suggestion has been given to shift the cereal cultivation away from the Punjab and Haryana, and move it towards the eastern states (Gulati, 2010).

The state of Punjab, having total area of 50,362 square kms and occupying 1.53 percent of country's geographical area, benefitted immensely from the green revolution in terms of increased foodgrain production. But by the time, the charm of the green revolution faded, the Punjab's agrarian economy had already been plagued by dominance of wheat-paddy cropping system, ground water depletion, heavy use

Corresponding author email: sukhjitsingh24101997@gmail.com

of chemical fertilizers, increased vulnerability to disease and pests, reduced productivity of soil, increasing charges of agricultural production and many other environmental problems. Diversification towards other enterprises like fruits, vegetables, fodder, forestry, floriculture, and sericulture, which consume less water, are ecologically compatible, and have much greater potential to generate higher income and employment, has often been recommended as a solution to the Punjab's agrarian crisis.

Moreover, increasing income levels, change in taste and preferences, hectic work schedules and health-conscious nature of modern consumers has led to increased demand for high value agricultural commodities and reduced demand for foodgrains. In contrast to the changing consumption pattern, Punjab has very less area under high value crops and comparatively larger area under foodgrains. Keeping in mind, the changing consumption scenario, prospects exist for farmers to diversify towards high value crops, having large potential for generating employment opportunities and export earnings along with enhancing agricultural sustainability (Neogi and Ghosh, 2022) and earn greater returns. As such, it becomes imperative to analyze the trends in cropping pattern and possible diversification avenues towards high value agricultural crops in Punjab during the period 2001-2021.

Data Sources and Methodology

The secondary data were collected from land use statistics of India (Anonymous, 2023a) pertaining to Punjab state for the period 2001-02 to 2020-21. Microsoft Excel and Lingo software were used. Herfindahl index (HI) and Crop diversification index (CDI) were estimated to analyze the level of diversification or specialization. For analyzing the change in cropped area, simple percentages were estimated. Markov chain transitional probabilities were estimated for analyzing the direction of change in cropping pattern. Location quotient (LQ) was estimated for each district of Punjab pertaining to wheat, paddy, fruits and vegetables.

Herfindahl Index: Herfindahl index was computed for areas under total cereals, total pulses, total sugar crops, total condiments and spices, total fruit & vegetable crops, other food crops, total oilseeds, total fiber crops, total drugs, narcotics and plantation crops, fodder crops, and other non-food crops using the following formula:

$$HI = \sum_{i=1}^{n} Pi$$

where HI is the Herfindahl index, Pi is the proportion of cropped area of i-th crop

Crop Diversification Index: Crop diversification index was estimated using the following formula:

$$CDI = 1 - HI$$

where CDI is the crop diversification index, and HI is the Herfindahl index.

Change in cropped area of a i-th crop was measured using simple percentage of total cropped area in the j-th time period.

$$\text{Percentage share of i –th crop} = \frac{Ai}{TCA} * 100$$

where Pi is the proportion of cropped area of the total cropped area for i-th crop, Ai is area cropped of i-th crop, and TCA is the total cropped area in the state.

Direction of Change in Cropping Pattern: Markov chain transitional probability matrices were estimated for the period 2001-02 to 2010-11 and 2011-12 to 2020-21 to analyze the direction of change in the cropping pattern. The transition probability matrices capture the extent of stability of acreage share and the direction of change over the given period. Diagonal elements represent the probability of retention of cropped area for each respective crop. The closer the diagonal element to one, the greater will be the stability in cropped area of the respective crop. On contrary, the closer the diagonal element is to zero, the greater will be the instability in cropped area of the respective crop. Each column element for a given i-th crop represents the proportion of gain in cropped area for the i-th crop from all other crops previous period cropped area. Each row element for a given i-th crop represents the proportion of loss in previous periods' acreage for the i-th crop to other crops in the row. (Devi *et. al.,* 2019).

Concentration Index: Location quotient (LQ) was estimated using the following formula:

$$LQ = \frac{Aij}{TCAj} / \frac{Ai}{TCA}$$

where Aij is the area cropped under i-th crop in the j-th district of the state, TCAj is the total cropped area in the j-th district, Ai is the cropped area under the i-th crop at the state level, and TCA is the total cropped area under the state.

Results and Discussion

The Herfindahl index (HI) and the crop diversification index (CDI) for the cropped area of various crops during the period 2001-2021 have been presented in Table 1. The HI score of 0.61 in 2001-02 has increased to 0.76 in 2020-21. The closer the Herfindahl index to 1, the greater will be the specialization in an area. The closer the index is to 0, the greater will be the diversification. As such, the HI score indicates that over the period of 2001-02 to 20020-21, the level of specialization has increased. The CDI score of 0.40 in 2001-02 has also decreased to 0.24 in 2020-21. The closer the Crop Diversification Index (CDI) to 0, the greater the specialization in the field, whereas the closer the CDI to 1, the greater the diversification in the field. The CDI scores also indicate an increased level of specialization in Punjab's agriculture.

Table 1. Herfindahl Index and Crop Diversification Index for Punjab, 2001-02 to 2020-21

Period	2001-2002	2005-2006	2010-2011	2015-2016	2020-2021
HI	0.61	0.65	0.69	0.71	0.76
CDI	0.39	0.35	0.31	0.29	0.24

Source: Authors' own computation from secondary data

The information given in Table 2 depicts the crop-wise percentage of total cropped area in Punjab for the period 2001-2021. The share of food crops has increased from 81.21 percent in 2001-02 to 90.47 percent in 2020-21. The share of food grains in the total cropped area has increased from about 77.55 percent in 2001-02 to 86.93 percent in 2020-21 in Punjab. The paddy and wheat are two major important crops grown in Punjab accounting for 85.33 percent of total cropped area in 2020-21. The area of paddy has increased to 40 percent in 2020-21 from 31 percent in 2001-02. In a similar fashion, the cropped area of wheat has increased to 45 percent in 2020-21 from 43 percent in 2001-02. The share of other coarse cereals and millets have significantly decreased 1.5 percent in 2020-21 from 2.5 percent in 2001-02. Similarly, cropped area of pulses have also decreased to 0.13 percent in 2020-21 from 0.7 percent in 2001-02. The decreased crop area of pulses also means decreased levels of nitrogen fixation. There also has been a decrease in share of spice crops (0.01%) in 2020-21. Similarly, Cotton (3.21%), oilseeds (0.47%) and Fodder crops (5.52%) also had a decreased cropped area in 2020-21. Fruits had an increased share from 0.52 percent in 2001-02 to 0.97 percent in 2020-21. Vegetables also had an increased area from 1.28 percent in 2001-02 to 1.41 percent in 2020-21. Total share of fruits and vegetables in total cropped area has increased from 1.8 in 2001-02 to 2.4 percent in 2020-21. The cropped area of narcotics and plantation crops had increased from 0 percent in 2000-01 to 0.34 in 2015-16 and then dropped to 0.08 percent in 2020-21.

The major reason for the increase under the cropped area of wheat and paddy has been assured procurement paddy under minimum support paddy (MSP) scheme. So long farmers keep on getting remunerative prices for their produce, enabling them to meet the cost of inputs, they will continue

Table 2. Shift in cropping pattern in Punjab from 2001-02 to 2020-21

(%age)

Period	2001-2002	2005-2006	2010-2011	2015-2016	2020-2021
Food Crops					
Paddy	31.31	33.64	35.84	37.73	40.2
Wheat	43.07	44.03	44.53	44.55	45.13
Paddy + Wheat	74.38	77.67	80.37	82.28	85.33
Other Cereals and millets	2.47	2.45	1.89	1.80	1.47
Total Cereals and Millets	76.85	80.12	82.26	84.08	86.8
Pulses	0.70	0.40	0.27	0.25	0.13
Total Food Grains	77.55	80.52	82.53	84.33	86.93
Sugar crops	1.78	1.08	0.89	1.16	1.15
Spice crops	0.05	0.03	0.03	0.01	0.01
Fruit crops	0.52	0.77	0.88	0.59	0.97
Vegetable crops	1.28	1.36	1.30	1.81	1.41
Total Fruit and Vegetable crops	1.80	2.13	2.18	2.41	2.38
Total Food Crops	81.21	83.76	85.63	87.91	90.47
Non-food Crops					
Oilseed Crops	1.03	1.05	0.71	0.62	0.47
Cotton	7.63	7.08	6.14	4.25	3.21
Narcotics and Plantation	0.00	0.06	0.24	0.34	0.08
Fodder Crops	9.00	7.28	6.85	6.21	5.52
Total Non-food crops	18.79	16.24	14.37	12.09	9.53

Source: Authors' own computation from secondary data

to invest, bringing larger under the crops for which MSP is offered. Apart from the MSP, the free electricity provided by the state government to farmers is also another cause of the lack of diversification. Paddy, a high-water consuming crop, is grown using the flood irrigation. As such, high levels of ground water extraction have been depleting the fresh ground water reserves at an alarming rate of 0.5 meters per annum on an average. The high level of ground-water extraction, high level use of chemical fertilizers, reduced soil fertility and salinity, the provision of free electricity for farmers, the incentive of MSP and the stagnant crop productivity in the paddy-wheat cropping pattern has created a situation where the long run sustainability of Punjab's paddy-wheat based agriculture is questionable (Kumar *et. al.,* 2022). Moreover, lack of crop and genetic diversity increases the likely chances of pest and disease infestation. Thus, there is an urgent need to diversify from the traditional wheat-paddy cropping pattern.

It may be stated that data presented in table 2 only provided percentage shift in the cropped area over the 2001-02 to 2020-21 time period but it failed to provide an insight into direction of shift in cropping pattern among different crop types. The direction of shift of the cropping pattern for a given period can be easily assessed using the markov chain transition probability matrix. (Table 3) depicts the transition probability matrix of cropped area under different crops in Punjab during the period 2001-02 to 2010-11. Foodgrains had successfully retained 94 percent of its share in cropped area. It has lost 0.6 percent share to Fruits, 1.3 percent to vegetables, 1.9 percent to fiber crops and 1.4 percent to fodder crops. Sugar crops have retained 33 percent of its previous period share and lost 38 percent share to vegetables and 62 percent to other crops. Condiments and Spices had lost 100 percent of its share to Oilseed crops. Fruits managed to retain 33.5 percent of its previous period share and lost 66 percent to fiber crops. Vegetables lost its entire share to Fodder crops. Oilseed crops lost 100 percent of its share to sugar crops (22%), fiber crops (14%) and fodder crops (63.5%). Fiber crops retained 63 percent of its previous share and lost 11 percent to foodgrains, seven percent to sugar crops, two percent to vegetables and 16 percent to fodder crops. Other crops retained 30.6 percent of its previous share in cropping pattern, while losing 1.2 percent to condiments and spices, one percent to vegetables, two percent to oilseed crops, and 8.8 percent to fodder crops. Of all the area under different crops, foodgrains had the highest stability in cropped area.

The data given in Table 4 illustrates the transition probability matrix of cropped area for different crop types in Punjab during the period 2011-12 to 2020-21. The foodgrains have successfully retained 96.4 percent share of previous period's cropped area. It has lost 0.9 percent share to sugar crops and 2.8 percent to fodder crops. The sugar crops retained 19.8 percent of its previous share in cropped area, losing 43.2 percent to foodgrains and 37 percent to vegetables. Condiments and spices retained only 0.2 percent of its share in cropped area, losing most of the share to sugar crops (99.8%). Fruits retained 98.5 percent of its share in cropped area, losing only 0.015 percent to foodgrains. Vegetables managed to retain 23 percent of its share, losing 41.9 percent to foodgrains and 35 percent to other crops. Oilseed crops lost its entire share to fiber crops. Fiber crops retained 74 percent of its share, losing 5.5 percent to oilseed crops and 19.8 percent to fodder crops. Fodder crops retained 43.8 percent of its last period's share, losing 31 percent to foodgrains, three percent to sugar crops, 12.8 percent to vegetables, five percent to oilseed crops and 4.5 percent to fiber crops. Other crops lost their entire share to foodgrains. Foodgrains, fruits and fibers had greater stability of all the crops during this period. Even though fruits had much higher retention of 98.5 percent of its cropped area than foodgrains during 20011-12 to 2020-21, but it had only

Table 3. Transitional probability matrix of cropping pattern in Punjab, 2001-02 to 2010-11

	Food grains	Sugar crops	Condiments and Spices	Fruits	Vegetables	Oilseeds	Fibres	Fodder	Other Crops*
Food grains	**0.949**	0.000	0.000	0.006	0.013	0.000	0.019	0.014	0.000
Sugar crops	0.000	**0.334**	0.000	0.000	0.038	0.000	0.000	0.000	0.628
Condiments and Spices	0.000	0.000	**0.000**	0.000	0.000	1.000	0.000	0.000	0.000
Fruits	0.000	0.000	0.000	**0.335**	0.000	0.000	0.665	0.000	0.000
Vegetables	0.000	0.000	0.000	0.000	**0.000**	0.000	0.000	1.000	0.000
Oilseeds	0.000	0.222	0.000	0.000	0.000	**0.000**	0.143	0.635	0.000
Fibres	0.113	0.071	0.000	0.000	0.022	0.000	**0.630**	0.164	0.000
Fodder	0.503	0.000	0.002	0.000	0.021	0.090	0.000	**0.385**	0.000
Other Crops*	0.000	0.000	0.012	0.000	0.011	0.189	0.394	0.088	**0.306**

** Other crops include other food crops, other non-food crops & total drugs, narcotics, and Plantation crops*

Table 4. Transitional probability matrix of cropping pattern in Punjab, 2011-12 to 2020-21

	Food grains	Sugar crops	Condiments and Spices	Fruits	Vegetables	Oilseeds	Fibres	Fodder	Other Crops*
Food grains	**0.964**	0.009	0.000	0.000	0.000	0.000	0.000	0.028	0.000
Sugar crops	0.432	**0.198**	0.000	0.000	0.370	0.000	0.000	0.000	0.000
Condiments and Spices	0.000	0.998	**0.002**	0.000	0.000	0.000	0.000	0.000	0.000
Fruits	0.015	0.000	0.000	**0.985**	0.000	0.000	0.000	0.000	0.000
Vegetables	0.419	0.000	0.000	0.000	**0.230**	0.000	0.000	0.000	0.351
Oilseeds	0.000	0.000	0.000	0.000	0.000	**0.000**	1.000	0.000	0.000
Fibres	0.000	0.000	0.000	0.000	0.000	0.055	**0.747**	0.198	0.000
Fodder	0.308	0.030	0.000	0.000	0.128	0.050	0.045	**0.438**	0.000
Other Crops*	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**

** Other crops include other food crops, other non-food crops & total drugs, narcotics, and Plantation crops*

Table 5. District-wise location quotient for paddy in Punjab, 2001-02 to 2020-21

District	Paddy				
	2001-02	2005-06	2010-11	2015-16	2020-21
Amritsar	1.24	1.25	1.23	1.09	1.11
Barnala	-	-	1.12	1.17	1.18
Bathinda	0.47	0.51	0.53	0.65	0.79
Faridkot	0.90	1.01	1.11	1.17	1.17
Fatehgarh Sahib	1.34	1.33	1.22	1.19	1.14
Fazilka	-	-	-	0.56	0.58
Ferozepur	0.81	0.82	0.81	1.22	1.14
Gurdaspur	1.24	1.14	1.13	1.13	1.06
Hoshiarpur	0.52	0.51	0.57	0.54	0.59
Jalandhar	1.02	1.05	1.12	1.06	1.05
Kapurthala	1.25	1.19	1.22	1.17	1.10
Ludhiana	1.24	1.24	1.20	1.14	1.14
Malerkotla	-	-	-	-	1.12
Mansa	0.59	0.58	0.59	0.67	0.82
Moga	1.24	1.35	1.25	1.25	1.17
Muktsar	0.46	0.52	0.71	0.93	1.01
Pathankot	-	-	-	0.81	0.76
Patiala	1.36	1.31	1.26	1.19	1.15
Rupnagar	0.77	0.78	0.72	0.72	0.66
S.A.S Nagar	-	0.69	0.82	0.83	0.60
Sangrur	1.26	1.24	1.23	1.17	1.16
Shaheed Bhagat Singh Nagar	0.81	0.83	0.88	0.83	0.85
Tarn Taran	-	1.28	1.22	1.20	1.16

Source: Authors' own computation from secondary data

0.97 percent acreage share in total cropped area in 2020-21. When compared to paddy's share of 40.2 percent of total cropped area, the fruits share is quite small. So, even the higher retention of fruits in its cropped area will be of no use unless a greater area is brought under the cultivation of fruits.

The district wise analysis of crop specialization will be further helpful in gaining a better understanding of the complex situation of Punjab's agriculture. Table 5 explains the district wise concentration of area under paddy in Punjab using the LQ method. The districts of Amritsar (1.24), Fatehgarh Sahib (1.34), Gurdaspur (1.24), Jalandhar (1.02), Kapurthala (1.25), Ludhiana (1.24), Moga (1.24), Patiala (1.36), and Sangrur (1.26) had higher concentration of area under paddy. Faridkot (0.90), Ferozepur (0.81), Hoshiarpur (0.52), Mansa (0.59), Rupnagar (0.77), S.B.S Nagar (0.81) had moderate concentration of area whereas Bathinda (0.47) and Muktsar (0.46) had low concentration of area under paddy in 2001-02. In the period 2020-21, Amritsar, Barnala, Faridkot, Fatehgarh Sahib, Ferozepur, Gurdaspur, Jalandhar, Kapurthala, Ludhiana, Malerkotla, Moga, Muktsar, Patiala, Sangrur, and Tarn Taran had demonstrated higher concentration of area under paddy whereas Bathinda (0.79), Fazilka (0.58), Hoshiarpur (0.59), Mansa (0.82), Pathankot (0.76), Rupnagar (0.66), S.A.S Nagar (0.60) and S.B.S Nagar (0.85) had witnessed moderate concentration of area under paddy. Table 6 explains the concentration of wheat crop across different districts of Punjab using LQ method during the period 2001-2021. For all the periods under study, none of the districts had very high or very low specialization in wheat. The LQ score for all the districts was very close to one. Wheat was grown equivalently in all districts of Punjab. The results are very much similar to the findings of Kaur and Kaur, 2018.

The information shown in Table 7 explains the district wise concentration of fruits in Punjab. In 2001-02, the highest concentration of area under fruits was found in Ferozepur (3.65) and Muktsar (2.42) followed by Ludhiana (1.82) and Kapurthala (1.55), moderate concentration was observed in

Table 6. District wise location quotient for wheat in Punjab, 2001-02 to 2020-21

District	Wheat				
	2001-02	2005-06	2010-11	2015-16	2020-21
Amritsar	1.03	0.99	1.00	0.96	1.02
Barnala	-	-	0.99	1.03	1.03
Bathinda	1.00	1.00	1.02	1.02	1.01
Faridkot	1.04	1.05	1.03	1.05	1.04
Fatehgarh Sahib	1.01	1.00	1.01	0.99	0.99
Fazilka	-	-	-	0.96	0.93
Ferozepur	0.99	1.02	1.00	1.04	1.06
Gurdaspur	1.01	1.03	1.01	1.00	1.00
Hoshiarpur	0.88	0.92	0.97	0.95	0.94
Jalandhar	0.94	0.90	0.93	0.92	0.92
Kapurthala	1.00	0.93	0.90	0.92	0.92
Ludhiana	0.98	0.96	0.97	0.94	0.98
Malerkotla	-	-	-	-	1.00
Mansa	1.04	1.02	1.04	1.04	1.04
Moga	0.99	1.07	1.04	1.01	1.01
Muktsar	1.01	1.02	0.99	1.04	1.05
Pathankot	-	-	-	1.01	1.00
Patiala	1.04	1.04	1.02	1.02	1.02
Rupnagar	0.96	0.97	1.01	1.04	1.00
S.A.S Nagar	-	0.87	0.93	1.14	0.93
Sangrur	1.03	1.03	1.04	1.03	1.03
Shaheed Bhagat Singh Nagar	0.93	0.93	0.91	0.93	0.95
Tarn Taran	-	1.05	1.06	1.06	1.04

Source: Authors' own computation from secondary data

the districts of Bathinda (0.56), Hoshiarpur (0.61), Jalandhar (0.58) whereas relatively lower concentration was observed in all other districts. In 2020-21, the highest concentration was found in Fazilka (10.82) followed by Kapurthala (2.25), Pathankot (1.60), and Muktsar (1.14). All other districts except Bathinda (0.56) had lower concentration of fruits.

The perusal of Table 8 reveals the concentration of vegetables in different districts of Punjab during the period 2001-2021. In 2001-02, Amritsar (1.11), Hoshiarpur (2.18), Jalandhar (2.86), Kapurthala (3.18), Ludhiana (1.29), Moga (1.23), Patiala (1.15) and SBS Nagar (1.33) had higher concentration of area under vegetables, Bathinda (0.75), Fatehgarh Sahib (0.61) and Rupnagar (0.58) had moderate concentration of area under vegetables and districts of Faridkot (0.32), Ferozepur (0.48), Gurdaspur (0.38), Mansa (0.26), Muktsar (0.44) and Sangrur (0.42) had relatively lower concentration of area under vegetables. In the period 2020-21. Jalandhar (3.64), Kapurthala (3.43), S.A.S Nagar (3.03), Ludhiana (1.84), Fatehgarh Sahib (1.49), Malerkotla (1.43), Moga (1.31), Patiala (1.20) and Ferozepur (1.05) had a higher concentration of area under vegetables. Hoshiarpur (0.84), Bathinda (0.79), Barnala (0.66) and Amritsar (0.54) had moderate concentration of area under vegetables whereas all other remaining districts had lower concentration of area under vegetables. It may be stated that districts having high concentration of urban population had more area under vegetables vis-à-vis districts with low urban population.

The data given in Table 9 explains the concentration of area under paddy, fruit and vegetables in different districts of Punjab during 2020-21 based on Location Quotient method. Out of the 23 districts, 15 were highly specialized in paddy cultivation. Amritsar, Barnala, Faridkot, Gurdaspur, Sangrur, Tarn Taran had higher specialization for paddy cultivation. Jalandhar, Kapurthala, Ludhiana, Malerkotla, Moga, Patiala and Fatehgarh Sahib, vegetable crops had higher specialization in both vegetable and paddy cultivation.

Table 7. District wise location quotient of fruits for period, 2001-21 to 2020-21

District	Fruits				
	2001-02	2005-06	2010-11	2015-16	2020-21
Amritsar	0.48	0.53	0.22	0.24	0.36
Barnala	-	-	0.03	0.03	0.01
Bathinda	0.56	0.98	0.47	0.58	0.56
Faridkot	0.34	0.57	0.36	0.39	0.22
Fatehgarh Sahib	0.13	0.05	0.09	0.10	0.05
Fazilka	-	-	-	8.62	10.82
Ferozepur	3.65	4.18	5.10	0.00	0.05
Gurdaspur	0.42	0.43	0.39	0.19	0.10
Hoshiarpur	0.61	0.66	0.26	0.77	0.34
Jalandhar	0.58	0.40	0.88	0.22	0.13
Kapurthala	1.55	2.29	1.93	2.39	2.25
Ludhiana	1.82	0.04	0.16	0.21	0.11
Malerkotla	-	-	-	-	0.04
Mansa	0.13	0.20	0.31	0.31	0.15
Moga	0.03	0.11	0.08	0.04	0.04
Muktsar	2.42	2.56	2.29	2.40	1.14
Pathankot	-	-	-	2.70	1.60
Patiala	0.37	0.32	0.28	0.34	0.19
Rupnagar	0.19	0.18	0.12	0.24	0.21
S.A.S Nagar	-	3.00	0.53	0.03	0.48
Sangrur	0.22	0.14	0.15	0.14	0.07
Shaheed Bhagat Singh Nagar	0.29	0.14	0.29	0.37	0.20
Tarn Taran	-	0.30	0.25	0.23	0.12

Source: Authors' own computation from secondary data

Fazilka and Pathankot had higher specialization in fruit cultivation whereas SAS Nagar had higher specialization in vegetable cultivation only. Out of 25 districts, 17 had lower specialization in fruit cultivation whereas 10 had lower specialization in vegetable cultivation.

Fruits excluding nuts (962 kg/liter) and vegetables (322 kg/liter) consume comparatively less water for producing a kilogram of produce (GOI, 2021b). In contrast, paddy requires about 5000 liters of water per kilogram of rice produced (Gupta, 2023). Based on the water requirements, fruits and vegetables do offer an excellent option for diversification of cropping pattern. Higher production in fruits per unit area do offer a great scope of diversification away from the wheat-paddy crop rotation along with enhancement of farmers' income. Nowadays, consumers are becoming increasingly health conscious. They pay close attention to their dietary requirements and the nutrition intake. The National Institute of Nutrition (NIN) recommends consumption of 100 grams of raw fruits per day (excluding 40-45 g/day of nuts) and 400 grams of vegetables per day (100 g/day of green leafy vegetables, 100 g/day of roots and tubers excluding potatoes and 200 g/day of other vegetables) for both males and females (both active and sedentary) (GOI, 2023d). As a result of increasing demand in domestic and international market for high value agricultural commodities, multiple avenues open up for farmers to diversify towards fruits and vegetables.

Punjab, having vast agro-climatic and geographical conditions, is suitable for the cultivation of various varieties of fruit and vegetable crops. In 2020-21, the area under the cultivation of fruits was 93.6 thousand hectares with a production of 2.03 million metric tonnes (GOP, 2022). Kinnow, a major fruit crop grown in Punjab, occupied highest cropped area of 47.80 percent of the total cropped area of fruits in 2020-21. It gained exceeding popularity among producers and consumers alike because of its rich quality and economic significance. It is majorly grown in the south-

Table 8. District-wise location quotient of vegetables in Punjab for period, 2001-02 to 2020-21.

District	Vegetables				
	2001-02	2005-06	2010-11	2015-16	2020-21
Amritsar	1.11	0.77	1.43	0.90	0.54
Barnala	-	-	0.49	0.46	0.66
Bathinda	0.75	1.22	1.00	0.79	0.79
Faridkot	0.32	0.28	0.28	0.43	0.42
Fatehgarh Sahib	0.61	1.13	1.94	1.52	1.49
Fazilka	-	-	-	0.22	0.26
Ferozepur	0.48	0.38	1.52	1.23	1.05
Gurdaspur	0.38	0.24	0.37	0.29	0.34
Hoshiarpur	2.18	2.54	1.10	0.84	0.84
Jalandhar	2.86	4.07	1.11	3.42	3.64
Kapurthala	3.18	3.80	4.23	2.71	3.43
Ludhiana	1.29	1.06	0.68	2.09	1.84
Malerkotla	-	-	-	-	1.43
Mansa	0.26	0.21	0.26	0.26	0.31
Moga	1.23	0.11	1.02	1.26	1.31
Muktsar	0.44	0.34	0.34	0.38	0.18
Pathankot	-	-	-	0.19	0.30
Patiala	1.15	0.96	1.18	1.08	1.20
Rupnagar	0.58	0.53	0.30	0.30	0.36
S.A.S Nagar	-	1.29	1.42	2.28	3.03
Sangrur	0.42	0.49	0.35	0.36	0.27
Shaheed Bhagat Singh Nagar	1.33	1.44	2.27	0.74	0.39
Tarn Taran	-	0.32	0.31	0.37	0.17

Source: Authors' own computation from secondary data

western part of Punjab, popularly known as the kinnow belt of Punjab, comprising of Fazilka, Ferozepur, Muktsar, Bathinda, Faridkot and Mansa, accounting for an aggregate 75 percent area under kinnow cultivation (Guleria *et. al.,* 2022). Kinnow starts bearing fruit in the fourth year of cultivation after proper caring and maintenance of the orchard for the first three years. Commercial bearing of kinnow begins from the 9th year onwards. Table 10 illuminates that the net annual returns (1,58,156 Rs/ha) from kinnow orchard during its stable yield phase ranging from 9 to 25 years which are far greater than wheat (44500 Rs/ha) and paddy (23495 Rs/ha) returns. Investment in kinnow orchard is profitable as it yields greater returns than the cost incurred (Kaur and Singla, 2016).

Guava had the second highest share of 10.39 percent of the total fruit crops in 2020-21. Apart from kinnow and guava, other fruit crops grown in Punjab were citrus (orange and malta, lemon), mangoes, litchi, pear, peach, plum, grapes, ber, amla, banana, etc. Because of high initial cost of orchard establishment along with long gestation periods, only large and medium scale farmers opt for fruit cultivation. Large and medium landholding farmers usually do not prefer to opt for vegetable farming. Small and marginal farmers tend to stay clear of such capital-intensive crops and prefer vegetable crops over them. The cash returns on the vegetable crops are much frequent and sometimes even more than fruits (Mahapatra *et. al.,* 2013). Despite fruits and vegetables being an excellent replacement for wheat-paddy cropping pattern several constraints like deficiencies in marketing facilities, lack of storage, high spoilage, infestation of pests and diseases, lack of value addition infrastructure, lack of market information, etc., often limit and curtail fruit and vegetable crops from achieving their true potential. Ultimately, these very constraints hinder the diversification of cereal centric cropping pattern towards fruits. As per Table 9, the districts of Amritsar, Barnala, Faridkot, Fatehgarh Sahib, Ferozepur, Hoshiarpur, Jalandhar, Ludhiana, Malerkotla, Mansa, Moga, Patiala, Rupnagar, S.A.S. Nagar, Sangrur, S.B.S Nagar, and

Table 9. Concentration of paddy, fruit, and vegetable crops under different districts of Punjab in 2020-21.

	Concentration		
District	**High**	**Moderate**	**Low**
Amritsar	Paddy	Vegetables	Fruits
Barnala	Paddy	Vegetables	Fruits
Bathinda	-	Paddy, Vegetables, Fruits	-
Faridkot	Paddy	-	Fruits, Vegetables
Fatehgarh Sahib	Paddy, Vegetables	-	Fruits
Fazilka	Fruits	Paddy	Vegetables
Ferozepur	Paddy, Vegetables	-	Fruits
Gurdaspur	Paddy	-	Vegetables
Hoshiarpur	-	Paddy, Vegetables	Fruits
Jalandhar	Paddy, Vegetables	-	Fruits
Kapurthala	Paddy, Vegetables, Fruits	-	-
Ludhiana	Paddy, Vegetables	-	Fruits
Malerkotla	Paddy, Vegetables	-	Fruits
Mansa	-	Paddy	Fruits, Vegetables
Moga	Paddy, Vegetables	-	Fruits
Muktsar	Paddy, Fruits	-	Vegetables
Pathankot	Fruits	Paddy	Vegetables
Patiala	Paddy, Vegetables	-	Fruits
Rupnagar	-	Paddy	Fruits, Vegetables
S.A.S Nagar	Vegetables	Paddy	Fruits
Sangrur	Paddy		Fruits, Vegetables
Shaheed Bhagat Singh Nagar	-	Paddy	Fruits, Vegetables
Tarn Taran	Paddy	-	Fruits, Vegetables

Source: Authors' own computation from secondary data

Table 10. Returns from kinnow v/s foodgrain crops

Crop	Returns (Rs/ha)
Kinnow	158156*
Kharif crops**	
Cereals	
Paddy	23495
Jowar	7214
Bajra	8294
Maize	20247
Ragi	2277
Pulses	
Arhar	24038
Moong	6359
Urad	6890
Rabi crops***	
Cereals	
Wheat	44500
Barley	36858
Pulses	
Gram	24348
Lentil	27438

** Annual net return for stable yield phase of kinnow orchard from Yogi et. al., 2019*
*** All India average gross returns over cost of cultivation A_2 + FL for kharif crops from Anonymous, 2023b*
**** All India average gross returns over cost of cultivation A_2 + FL for rabi crops from Anonymous, 2023c*

Tarn Taran had low concentration of area under fruit crop. Similarly, Faridkot, Fazilka, Gurdaspur, Mansa, Muktsar, Pathankot, Rupnagar, Sangrur, S.B.S Nagar and Tarn Taran had low concentration of vegetable crops. More area under fruit and vegetable crops can brought under these districts by formulating district specific crop diversification programme, promoting adoption of fruit and vegetable cultivation over paddy-wheat cropping pattern, taking into consideration the climate and soil suitability, would be highly helpful in sustaining the state's agriculture.

Conclusion and Policy Implications

The diversification indices and analysis of percentage share of cropped area under various crops has revealed that Punjab has specialized in the cultivation of paddy-wheat cropping pattern and the combined area under wheat and paddy has increased from 74.38 percent in 2001-2002 to 85.33 percent in 2020-21. But the specialization has costed the Punjab in terms of loss of crop and genetic diversity, groundwater depletion and soil fertility ultimately endangering the sustainability of the state's agriculture. Possible remedies for Punjab's present cereal centric cropping pattern include adoption of short duration, high stress tolerant and less water consuming paddy varieties, adoption of better resource conserving technologies, adoption of organic farming for enhancing environmental sustainability. Moreover, to avoid the overuse of the ground water resources by the Punjabi farmers, metered charges for use of electricity should be levied on the farmers. MSP and other incentives to farmers are some possible measures for instigating diversification away from present cereal-centric cropping pattern and towards less water consuming crops. Fruit and vegetable crops offer an excellent opportunity as they consume much less water for producing a kilogram of produce compared to paddy crop, and often have greater net returns than most of the cereal crops. Location Quotient revealed the districts of Amritsar, Barnala, Faridkot, Fatehgarh Sahib, Ferozepur, Hoshiarpur, Jalandhar, Ludhiana, Malerkotla, Mansa, Moga, Patiala, Rupnagar, S.A.S. Nagar, Sangrur, S.B.S Nagar, and Tarn Taran had low concentration of area under fruit crop. Similarly, Faridkot, Fazilka, Gurdaspur, Mansa, Muktsar, Pathankot, Rupnagar, Sangrur, S.B.S Nagar and Tarn Taran had low concentration of vegetables. More area under fruit and vegetable crops can brought under these districts by formulating district specific crop diversification programme, promoting adoption of fruit and vegetable cultivation over paddy-wheat cropping pattern, taking into consideration the climate and soil suitability would be, highly helpful in sustaining the state's agriculture.

References

Armstrong M 2021. Which food need the most water to produce? World Economic Forum. https://www.weforum.org/agenda/2021/06/water-footprint-food-sustainability

Devi D, Reddy R, Madavi B, Ravi P, and Sadvi P 2019. Dynamics of Cropping Pattern in Karimnagar District of Telangana – A Markov Chain Approach. *Asian Journal of Agricultural Extension, Economics & Sociology*. **37**:1-5

Government of India 2023a. Web based land use statistics information system. Special Data Dissemination Standard Division, Directorate of Economics & Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi. https://www.aps.dac.gov.in/LUS/Index.htm

Government of India 2023b. Price policy for kharif crops: the marketing season 2023-24. Commission for Agricultural Costs and Prices, Department of Agriculture & Farmer Welfare, Ministry of Agriculture & Farmer Welfare, Government of India, New Delhi. https://cacp.dacnet.nic.in/ViewReports.aspx?Input=2&PageId=39&KeyId=818

Government of India 2023c. Price policy for rabi crops: the marketing season 2024-25. Commission for Agricultural Costs and Prices, Department of Agriculture & Farmer Welfare, Ministry of Agriculture & Farmer Welfare, Government of India, New Delhi. https://cacp.dacnet.nic.

in/ViewReports.aspx?Input=2&PageId=40&KeyId=821

Government of India 2023d. Revised Short Summary Report-2023, Short Summary Report of Nutrient Requirements for Indians, Recommended Dietary Allowances (RDA) and Estimated Average Requirements (EAR). ICMR-National Institute of Nutrition, Department of Health Research, Ministry of Health and Family Welfare, Government of India. https://www.nin.res.in/RDA_short_Report_2020.html

Government of Punjab 2022. Punjab Economic Survey 2021-22. Economic and Statistical Organization, Department of Planning, Government of Punjab.

Gulati A and Ganguly K 2010. The changing landscape of Indian Agriculture. *Agricultural Economics* **41**:37-45. DOI: https://doi.org/10.1111/j.1574-0862.2010.00486.x

Guleria A, Mouzam S, and Kamra A 2022. Punjab's kinnow value chain: problems and prospects. https://epubs.icar.org.in/index.php/IndHort/article/view/123787

Gupta V 2023. Punjab sticks to paddy amid depleting groundwater. Mongabay. https://india.mongabay.com/2023/01/punjabs-paddy-dilemma-amid-depleting-groundwater/

Kaur M and Kaur P 2018. Diversification and specialization of Punjab in growing various crops: a district level approach. *Economic Affairs*. **63**: 963-972. DOI: 10.30954/0424-2513.4.2018.20

Kaur M and Singla N 2016. An economic analysis of kinnow cultivation and marketing in Fazilka district of Punjab. Indian *Journal of Economics and Development*. **12**:711-718. DOI: 10.5958/2322-0430.2016.00195.5

Kumar N, Chhokar R, Meena P, Kharub S, Gill S, Tripathi S, Gupta O, Mangrauthia S, Sunderam R, Sawant C, Gupta A, Naorem A, Kumar M and Singh G 2022. Challenges and opportunities in productivity and sustainability of paddy cultivation system: a critical review in Indian perspective. *Cereal research communications* **50**:573–601. https://doi.org/10.1007/s42976-021-00214-5

Mahapatra R, Gupta A and Bera S 2013. Veggies delight. Down To Earth. https://www.downtoearth.org.in/coverage/agriculture/veggies-delight-40710

Neogi S and Ghosh B 2022. Evaluation of crop diversification on Indian farming: A panel regression approach. *Sustainability*. **14**:1-18.

Shankar IAS Academy 2021. Paddy-wheat monoculture in Punjab. Shankar IAS Parliament. https://www.iasparliament.com/current-affairs/paddy-wheat-monoculture-in-punjab#:

Yogi V, Kumar P, Prakash P, Kar A, Singh D, Singh R, Arya P and Awasthi O 2019. An economic evaluation of kinnow cultivation in north western India. *Indian Journal of Agricultural Sciences*. **89**:1684–1687

Received: October 28, 2023 Accepted: January 01, 2024