Crop Diversification in Pakistan: Province-Wise Temporal Analysis

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Abstract

This study assess the extent and nature of crop diversification across Pakistan's provinces using the Herfindahl Index (HI) and Composite Entropy Index (CEI) for 1990-91 to 2020-21 with decadal intervals: 1990–91, 2000–01, 2010–11, and 2020–21. Result showed national decline in extent of crop diversification by 2020-21 indicating a trend towards specialization. Punjab diversification decreased until 2010-11 but rose slightly in 2020-21. Khyber Pakhtunkhwa province showed continuous decline over period of study, while Sindh and Balochistan increased crop diversification 1990-91 to 2010-11 followed by a minor drop in diversification showing movements towards specialization. Composite Entropy Index (CEI) was worked out to gauge the nature of crop diversification. CEI result revealed reduced cereal diversification until 2010–11 and a slight recovery in 2020–21, with cereals' share in gross cropped area increasing overall in Pakistan. In 2020–21, CEI was highest for oilseeds (0.695) and lowest for pulses (0.332). The results demonstrated decreased in diversification throughout the study period at Pakistan level. No specific pattern of diversification was observed in case of cash crops in Pakistan. Punjab province showed greater diversification in cereals, oilseeds, and horticultural crops; Khyber Pakhtunkhwa in pulses; and Balochistan in fruits and vegetables. The findings highlight potential to enhance crop diversity, emphasizing the need for field-level research and supportive policies to improve farm income and agricultural growth.

Keywords: Crop Diversification, crop concentration, specialization, Composite Entropy Index, Herfindahl Index, Pakistan

Introduction

The agriculture sector of Pakistan has significant contribution with 22.7 percent of the country's GDP (GOP, 2022). Major industries of country i.e food processing, sugar industry, textile, leather, edible oil, have overwhelming dependence on agriculture. The crop sector is most important subsector of agriculture which significantly contributes in food security of the country. Crop diversification states that in a specific time period how many types of crops are grown. Consequently, crop concentration and crop diversification expose changing pattern of competition among various crops. Crop diversification remains an important strategy to enhance domestic agricultural growth. Barman et al, 2022 argued that in developing countries diversification is one of the most operational path to increase farm income and poverty reduction. Adjimoti &Kwadzo, 2018, research showed that crop diversification has a positive effect on nutrition diversity and household food security.

Agricultural diversification is being considered vital mechanism for economic growth. Farm household decisions to diversify towards high-value crops or not to diversify are influenced by a household resources and the prevailing socioeconomic environment. (Pandey, 2019) Suggest that agriculture management knowledge, technical knowhow of the farmers are important factors in agricultural diversification decision making.

In the literature it is argued that in land use planning that assessment of crop diversification is very important to ensure agricultural growth in future (Narmadha & Karunakaran, 2022). Indeed crop diversification is determined by soil situations, availability of arable land precipitation characteristics and irrigation services (Acharya et al., 2011).

(Neogi & Ghosh, 2022) Argues that crop diversification takes place by the factors i.e urbanization and increase in income on one hand and on the other hand expansion of irrigation facilities, farm to market road access ease of lending is a key factor in crop diversification and Development (Kremen, et al., 2012).

In Bangladesh crop diversification techniques were adopted at large scale to mitigate the risks of crop failure and to respond the negative environmental changes Akber et al., 2022. Lone et al., 2013 stated that diversified crop rotations can reduce negative environmental impact and can improve resource-use efficiency and it also promotes ecosystem services.

A major concern in developing nations is how to rush the agricultural growth in response to this (Lone, 2013) argues that developing countries have only one viable alternative of accelerate crop sector growth is the diversification towards high value agricultural products.

To face the climate change challenges rehabilitation of marginal lands, crop diversification and increasing water use efficiency are needed to produce more food for food security (Hussain, et al., 2020).

It was argued that under climate change challenge one of the coping strategy is crop diversification. This strategy will also play a vital role in future. Crop diversification studies are vital to evaluate the potential of cropping systems for adaptation in response to climate change (Sjulgård, et al., 2020). A number of studies have appeared globally which calculate regional level extent of crop diversification in a country. (Sharma, 2011) has elucidated temporal changes for 43 years (1960-2002) in extent of crop diversification in Himachal Pradesh. Very little information is available for Pakistan in the domain of crop diversification in Pakistan. Therefor an updated information is required for country, which will support needed mechanisms of land allocation for different crops to ensure the agricultural sector growth and food security in country.

Materials And Methods

This analysis is based on secondary data for four time pints 1990-91, 2000-01, 2010-11 and 2020-21 with decadal interval. Country and Province was the unit of analysis in this research. The cropping pattern was studied using the commodity group's percentage share. In this study, cereals crops include wheat, rice, maize, millet, sorghum and barley. Cash crop includes cotton, sugarcane, tobacco and guar seed. In Pulses, gram, lentil, mung bean, mash bean, mattri, other rabi and other kharif pulses. In oilseeds crops, rapeseed and mustard, groundnut, seas mum, sun flowerer were included. All fruits and vegetables reported by Pakistan bureau of Statistics was included in the analysis. The extent and nature of crop diversification can be determined by employing number of well recognized indices i.e Simpson's Index (SI), Herfindahl Index (HI), Ogive Index (OI), Entropy Index (EI), Modified Entropy Index (MEI) and Composite Entropy Index (CEI). Among these indices, the Herfindahl Index (HI) and Composite Entropy index (CEI) are extensively used to quantify the extent and nature of crop diversification at different levels. Shinde et al., 2013 have deliberate variations in extent and nature of crop diversification in Maharashtra state of India by using CEI, (Kumar and Gupta 2015) also measured extent of diversification for different group i.e cereals, non-food, pulses, cash crops, oilseeds crops and overall crop sector in India during 1980-81to 2011-12. More (2016) studied sub region level crop diversification status of Gujarat by covering crop groups i.e cereals, pulses, food grains, commercial crops oilseeds, and overall crop sector during 1970-71 to 2011-12 by employing CEI.

Herfindahl Index (HI)

Herfindahl index is also called the index of concentration. The higher value HI is an indication of specialization in crop. Here, the Herfindahl

index, Simpson index, have been computed districts wise in Pakistan for the years 1990-91, 2000-01, 2010-11 and 2020-21. The Harfindhal index (HI) is a sum of the square of the proportion of individual activities in a portfolio HI is can be computed as under

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

P_i = Proportion of area under i^{th} crop $P_i = A_i / \Sigma A_i$ in which A_i = Area under i^{th} crop and ΣA_i= Total cropped area.

The HI index ranges from 0 to 1. Therefore, to attain diversification index, it is subtracted from one, which is the simplified form of Simpson Index of diversification. The value of HI index varies between 0 to 1. It is "1" in case of perfect diversification and "0" in case of perfect concentration. Composite entropy index (CEI)

The C.E.I. has two constituents, viz., distribution and diversity (number of crops). The value of index increases with the decrease in concentration and rises with the number of crops/activities increases. In this study CEI was measured for crop groups like cereals crops, cash crops, oilseeds crops, Fruits and vegetables; The CEI was estimated using the following formula.

$$CEI = -\left[\sum_{i=1}^{i=n} p_i \log_N P_i \right] X\{1 - \{1|N\} \dots (2)$$

Where, N is the number of the crops in group. P_i is the proportionate area of i^{th} crop/crop sector in the gross cropped area. The CEI ranges between 0 and 1. The values close to 1 indicates high diversification and values close to 0 indicates concentration.

Results And Discussion

Share of Varies Crop Groups in Gross Cropped Area (GCA)

Share of varies crop groups in GCA for the last four decades i.e 1990-91 to 2020-21 are presented in table 1. It was observed that cereals crops, which accounted for 55.7 percent of GCA in 1990-91 was increased to 58.7 percent in 2020-21 in Pakistan. The share of cereals crops has demonstrated an increase in Pakistan. The result showed that cereals crops share in GCA was highest in Khyber Pakhtunkhwa, with 73.9 to 76.6 percent with exhibited an increasing trend followed by Balochistan, Punjab and Sindh respectively. The result showed that Sindh has the largest share of cash crops for the total cultivated area followed by Punjab, Khyber Pakhtunkhwa, and Balochistan. Khyber Pakhtunkhwa and Balochistan have registered an increase in the share of cash crops during the reviewed period.

The result showed that the share of pulses area in gross cropped area was about 6 percent in Pakistan. The pulses area was highest in Punjab followed by Balochistan, Khyber Pakhtunkhwa, and Sindh respectively.

In oilseed crops area allocation in Sindh is on top followed by Balochistan, Punjab and Khyber Pakhtunkhwa in order. During the last three decades the oilseed cropped area was only 2.5 percent of gross cropped area of Pakistan.

The result showed that horticulture crops share in gross cropped area was highest in Balochistan, fluctuating between 12 to 27 percent followed by Sindh, Khyber Pakhtunkhwa and Punjab respectively.

A preliminary insight into crop diversification can be gained from the changes in area share of crops. The average shares of different crops showed that Pakistan agriculture has remained dominated in food crops (table 2). Cash crops are the next important crops, pulses, fruits and vegetables and oilseeds crops in order. While, area shares of pulses has been decreasing in Pakistan 7.2 % to 4.7 % during 1990-91 to 2020-21. While, area shares of oilseeds, cash crops, fruits and vegetables have been fluctuating pattern in gross cropped area. In overall Pakistan shares of cereals crops in GCA have been continuously rising. Khyber Pakhtunkhwa province has registered a continuously rising share of cereals crops in GCA.

Table 1: Province wise share of crop groups in gross cropped area (%)

Period	Punjab	Sindh	Khyber Pakhtunkhwa	Balochistan	Pakistan
	Cereals crops				
1990-91	53.0	53.8	73.9	71.6	55.7
2000-01	55.4	51.1	75.0	62.9	56.8
2010-11	58.1	50.5	75.6	56.9	58.2
2020-21	56.7	60.2	76.6	59.4	58.7
	Cash crops				
1990-91	19.6	22.5	6.9	0.5	18.3
2000-01	19.6	25.7	7.1	2.7	18.7
2010-11	17.7	25.0	7.5	3.9	17.4
2020-21	13.0	25.6	8.2	6.5	14.1
	Pulses				
1990-91	7.7	5.3	7.4	4.5	7.2
2000-01	6.7	4.9	4.3	2.7	6.1
2010-11	6.8	2.8	3.3	5.8	5.9
2020-21	5.5	1.1	2.2	6.6	4.7
	Oilseeds crops				
1990-91	2.0	2.5	2.6	4.6	2.2
2000-01	1.9	3.8	2.1	5.7	2.4
2010-11	1.8	9.7	1.6	2.7	3.0
2020-21	2.5	3.0	1.2	2.7	2.5
	Fruits and vegetables				
1990-91	3.1	3.0	3.4	12.4	3.4
2000-01	3.6	5.0	4.3	22.4	4.6
2010-11	4.1	5.8	5.7	27.3	5.5
2020-21	3.6	6.2	5.4	21.0	4.9

Source: Authors calculation by using GOP data 1990-91 to 2020-21

Crop Diversification in Pakistan

To have a closer look at the changes in crop diversification index (cdi) across provinces we have picked up four different time points of decadal interval viz. 1990-91, 2000-01 and 2010-11, 2020-21. The results exhibited that the extent of crop diversification has decreased in 2020-21 as compared to 1990-91 at national level. In comparison of different provinces crop diversification in 1990-91 was highest in Punjab

(0.652) followed by Sindh (0.639), Balochistan (0.464) and Khyber Pakhtunkhwa (0.439). During 2020-21 the level of crop diversification was again highest in Punjab (0.622) province, followed by Balochistan (0.592), Sindh (0.565). Khyber Pakhtunkhwa (0.398). Temporal comparison through 1990-91 to 2020-21 demonstrates that the extent of crop diversification has decreased in all provinces except in Balochistan province. During 1990-91 agriculture in Punjab, has remained more diversified than other provinces however temporal changes revealed that Punjab have shown a continuous decrease in crop diversification especially during 1990-91 to 2010-11. The analysis revealed that in 2010-11 Sindh remained more diversified province than other provinces and Punjab has regained its position of more diversified province in agriculture in 2020-21.

Sindh and Balochistan have shown an increase in crop diversification index since 1990-91 to 2010-11 and then slight decline is observed in 2020-21. The result exhibited that the extent of crop diversification in Balochistan increased from 0.464 in 1990-91 to 0.595 in 2010-11 achieved highest level, and then slight decline to 0.592 in 2020-21 was observed in diversification. In Sindh result indicates that the level of diversification increased from 0.639 in 1990-91 to 0.665 in 2010-11 as achieved highest and then slightly decrease 0.565 in 2020-21. In KP result level of crop diversification decreased from 0.439 in 1990-91 to 0.398 in 2020-21. The degree of diversification in Khyber Pakhtunkhwa remained at the bottom of crop diversification index as compared to other provinces. It can be concluded that overall in Pakistan there is tendency of crop concentration rather than crop diversification. However profiles of crop diversification vary across provinces due to different socio-economic and natural conditions.

Positive growth rate in area under cereals validate decreasing trend in crop diversification. It showed the rigidities in cropping system of Pakistan that has not any conflict with self-sufficiency objective in food grains.

In view of increasing trends in globalization, trade liberalization and climate changes, agricultural diversification is getting larger importance for sustainability. However in the country like Pakistan, crop diversification should not unfavorably affect the food grains supply. There is a realization

that export-led diversification might lead to some trade-off with the domestic food grains supply.

Table 2: Province wise crop diversification index in Pakistan

Period/Province	Punjab	Sindh	Khyber Pakhtunkhwa	Balochistan	Pakistan
1990-91	0.652	0.639	0.439	0.464	0.632
2000-01	0.633	0.657	0.423	0.548	0.623
2010-11	0.611	0.665	0.414	0.595	0.614
2020-21	0.622	0.565	0.398	0.592	0.608

Source: Authors Calculation by using GOP data

Nature of crop Diversification in Pakistan

Considering the objective of assessing the nature of crop diversification within different crop groups. Composite Entropy Index (CEI) have been calculated for crop group's i.e cereals, cash crops, pulses, oilseeds, fruits and vegetables. The calculated CEI for cereals was observed a decrease in diversification during 1990-91 to 2010-11 and slight increase in 2020-21. This indicates that the farmers are more interested in cultivating cereals. Punjab demonstrates an increase in the values of the index indicates an increasing diversification towards cereals crops. Sindh demonstrate a decreasing crop diversification or increasing specialization in cereals crops. Khyber Pakhtunkhwa demonstrates a decrease in the values of the index indicates towards decreasing crop diversification or increasing specialization interested in cultivating cereals crops. No specific pattern of diversification was observed in case of cereals crops in Balochistan. The cash crop showed decrease in CEI from 1990-91 (0.394) to (0.305) in 2020-21 The reason for declining trend of CEI values for cash crop group in Khyber Pakhtunkhwa and mixed trend in other provinces.

The pulses crop showed decrease in CEI from 1990-91 (0.473) to (0.332) in 2020-21 in Pakistan. In case of vegetable and fruit crops the composite entropy index (CEI) exhibited increasing trend throughout the study period in Pakistan. Balochistan province exhibited increasing trend in all sub period throughout the study period. In Pakistan overall diversification index was noticed highest (0.695) during 2020-21 for oilseeds, with increasing trend throughout the study period. In Pakistan overall diversification index was lowest (0.332) in pulses 2020-21 and decreasing trend throughout the study period. No specific pattern of diversification was observed in case of cash crops.

The calculated CEI for different crop groups demonstrated that overall in Pakistan diversification is found to be increasing over time in oilseeds, fruits and vegetables and decreasing in pulses since 2000-01. An increase was observed in pulses during 1990-91 to 2000-01. In cereals a decrease in CEI was registered (1990-91 to 2010-11) and afterward there

was an increase in index 2020-21. No specific pattern of diversification was observed in cash crops in Pakistan. The results demonstrate that in Punjab the degree of crop diversification is found to be increasing over time in cereals, oilseeds and (fruits and vegetables) and Khyber Pakhtunkhwa in pulses and Balochistan in fruits and vegetables. In Punjab declining pattern during 1990-91 to 2010-11 among the cash crops and pulses crops with little bit improvement in recent decade 2020-21. Sindh decreasing in cereals. KP decrease in cereals and cash crop. Balochistan decrease in cereals, cash crops and oilseeds. It can be concluded that to achieve the objective of crop diversification in future both natural and socioeconomic factors need to be considered.

Table 3. Province wise nature of crop diversification in Pakistan Composite Entropy Index (CEI)

Period	Punjab	Sindh	Khyber Pakhtunkhwa	Balochistan	Pakistan
Cereals					
1990-91	0.423	0.555	0.488	0.483	0.498
2000-01	0.432	0.510	0.464	0.434	0.484
2010-11	0.440	0.412	0.440	0.454	0.464
2020-21	0.452	0.402	0.448	0.396	0.467
Cash crops					
1990-91	0.420	0.479	0.394	0.590	0.465
2000-01	0.367	0.376	0.356	0.384	0.401
2010-11	0.363	0.536	0.342	0.362	0.446
2020-21	0.419	0.513	0.305	0.328	0.478
Pulses					
1990-91	0.420	0.520	0.338	0.501	0.473
2000-01	0.402	0.543	0.430	0.661	0.474
2010-11	0.264	0.569	0.455	0.587	0.362
2020-21	0.269	0.465	0.529	0.599	0.332
Oilseeds					
1990-91	0.488	0.338	0.142	0.479	0.549
2000-01	0.652	0.383	0.363	0.226	0.648
2010-11	0.590	0.298	0.257	0.177	0.665
2020-21	0.648	0.754	0.225	0.196	0.695
Fruits and vegetables					
1990-91	0.384	0.361	0.438	0.422	0.537
2000-01	0.388	0.336	0.437	0.212	0.507
2010-11	0.391	0.304	0.437	0.247	0.524
2020-21	0.424	0.342	0.441	0.312	0.600

Source: Author's calculation by using GOP data

Conclusions

The rising share of cereals crops and overall decline in crop diversification indicates a growing specialization in Pakistan's agriculture

reflecting farmer's preferences for cereal crops. This trend underscore the continuing challenge of achieving food self- sufficiency and the strategic importance of ensuring food security for growing population. A notable variation demonstrated by provincial pattern as Balochistan and Sindh experienced increased diversification until 2010–11, followed by a slight decline, while Punjab and Khyber Pakhtunkhwa showed decreasing diversification, with only a modest recovery in Punjab afterward. Punjab remained the most diversified province overall, whereas Khyber Pakhtunkhwa consistently ranked lowest. These spatial and temporal variations suggest that both natural and socioeconomic factors outline crop diversity. The findings emphasize the need for district level analyses to better understand local dynamics. From a policy perspective, evidence based insights into the drivers of diversification are essential to guide land use planning and promote sustainable agricultural growth in Pakistan.

Conflict Of Interest

The authors declared no conflict of interest.

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