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# Analyzing Spatio-temporal Pattern of Crop Diversification in Jalandhar District of Punjab, India

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**Abstract**

This paper analyzed dynamics of crop diversification in one of the agriculturally prosperous districts of Indian Punjab using Gibbs Martin Index. Spatio-temporal analysis of crop diversification in the district shows decline in crop diversification in most of the blocks (administrative sub divisions). The cropping pattern in most of the blocks of the district has become over specialized in the favour of rice-wheat rotation. Net irrigated area is continuously increasing for the cultivation of rice and wheat in the study area. Declining diversity of crops in the district has serious repercussions for natural resources, ecology and socio-economic condition of the farmers.

**Keywords:** Spatio-temporal, diversification, cropping pattern, crop concentration, Gibbs martin index, Jalandhar

## Introduction

Agriculture is an essential occupation for income and employment in developing countries, and particularly for the rural poor, and is widely considered to be the major "engine" of economic growth in most of the developing countries. Agriculture is the mainstay of Indian economy as it contributes nearly 14.6 per cent Gross Domestic Product (GDP) and more than two-thirds of the population is directly or indirectly dependent on it. India experienced rapid strides in agriculture growth with the advent of green revolution in 1960s and it has managed to move from food deficient crisis to self food sufficient situation today. However, increase in agricultural productivity has led to several environmental challenges. Land degradation due to over cropping, over irrigation, loss of biodiversity, declining agricultural genetic diversity and climate change are some of the challenges that potentially threatened the future viability of agricultural systems, particularly at regional and local levels (DFID, 2002). Punjab, the main bread basket of the country gained economic prosperity through new agricultural technology in mid sixties. Since then the state's growing agricultural sector has increased its relative importance in generating income and State Domestic Product (SDP). Adoption of new agricultural technology consisting of high yielding varieties of seeds, chemical fertilizers, insecticides, pesticides, herbicides and modern agricultural machinery set Punjab agriculture on to an impressive trajectory. This led to far reaching implication in the state's cropping pattern (Sidhu, 2005).

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Punjab has recorded an unprecedented growth both in terms of area and production of food grains particularly wheat and rice during the green revolution era and has been contributing significantly to the national pool of food grains (Choudhury *et al.*, 2013). The area under wheat and rice has increased consistently due to availability of inputs at subsidized rates with high remunerative prices for the produce through minimum support prices. The expansion of area under wheat and rice is taking place at the cost of low input crops like pulses, maize cotton, and millets during *kharif* season (summer season), and grams, rape seed and mustard, barley, vegetables, etc during *Rabi* (winter) season (Sood *et al.*, 2000; Sood *et al.*, 2009). With the result more than three fourth area of the state is experiencing decline in water table (Hira *et al.*, 2004). The Green Revolution technologies that contributed increased food grain production have reached a plateau, and the growth in crop yields and total factor productivity has slowed down and, in some cases, stagnated (Evenson *et al.*, 1999; Murgai *et al.*, 2001; Sidhu, 2002). Furthermore, rising population pressure is squeezing agricultural land for cultivation and pastures. Finally, the agricultural sector is under significant adjustment pressure related to market liberalization and globalization.

Crop diversification generally implies for growing a number of crops in different combinations on the same piece of land. Crop diversification in Indian Punjab has become essential since it is facing second generation problem problems like lowering of water table, nutrient imbalance, soil degradation, salinity, resurgence of pests and diseases, environmental pollution and decline in farm profit. Empirical studies shown that the water table in many parts of the state is declining due to excessive use of water in the cultivation of water guzzling crops resulting in poor quality of water (Hira *et al.*, 2004; Singh, 1991; Singh and Sankhayan, 1991; Singh, 1992; Singh, 1995). The practice of rice wheat cultivation culture has degraded soil health across the state (Singh *et al.*, 1997; Sidhu and Johl, 2002). Sustainability of agriculture has declined owing to increase in cost of cultivation and decrease in net farm returns (Chand, 1999; Singh, 2004; Sidhu *et al.*, 2010). Crop diversification shows a lot of promise in alleviating these problems through fulfilling the basic needs and regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the use of chemical fertilizer and pesticide loads, environmental safety and creating employment opportunity. Many studies have demonstrated this (Reddy and Suresh 2009; Palanisami *et al.*, 2009; Chand and Chauhan, 2002; Gupta and Tiwari, 1985). During the current decades, the process of diversification has been wide-spread due to the combined effects of water-seed fertilizer technology as well as some infrastructural development such as market centers, roads, transport, etc in the countryside (Vyas, 1996; Bhalla and Singh, 1997). Keeping in view these implications, present study was conducted in one of the centrally located districts of Punjab to analyze spatio-temporal variation in crop diversification and to suggest alternate diversified plans for sustainable development.

## Material and methods

Jalandhar has been chosen as the study area because it is one of the agriculturally prosperous districts of Punjab and leading contributor of food grain production of the state. It lies in the central part of the state between the latitude of 30° 57′ 35.4″ to 31° 37′ 18.99″ north and longitude of 75° 4′ 27.27″ to 75° 57′ 57.50″ east (Figure 1). Topographically it is more or less a flat terrain, forming a part of Indo-gangetic plains. Physiographically, the district contains vast alluvial plains, having gentle slope from north-east to south-west.

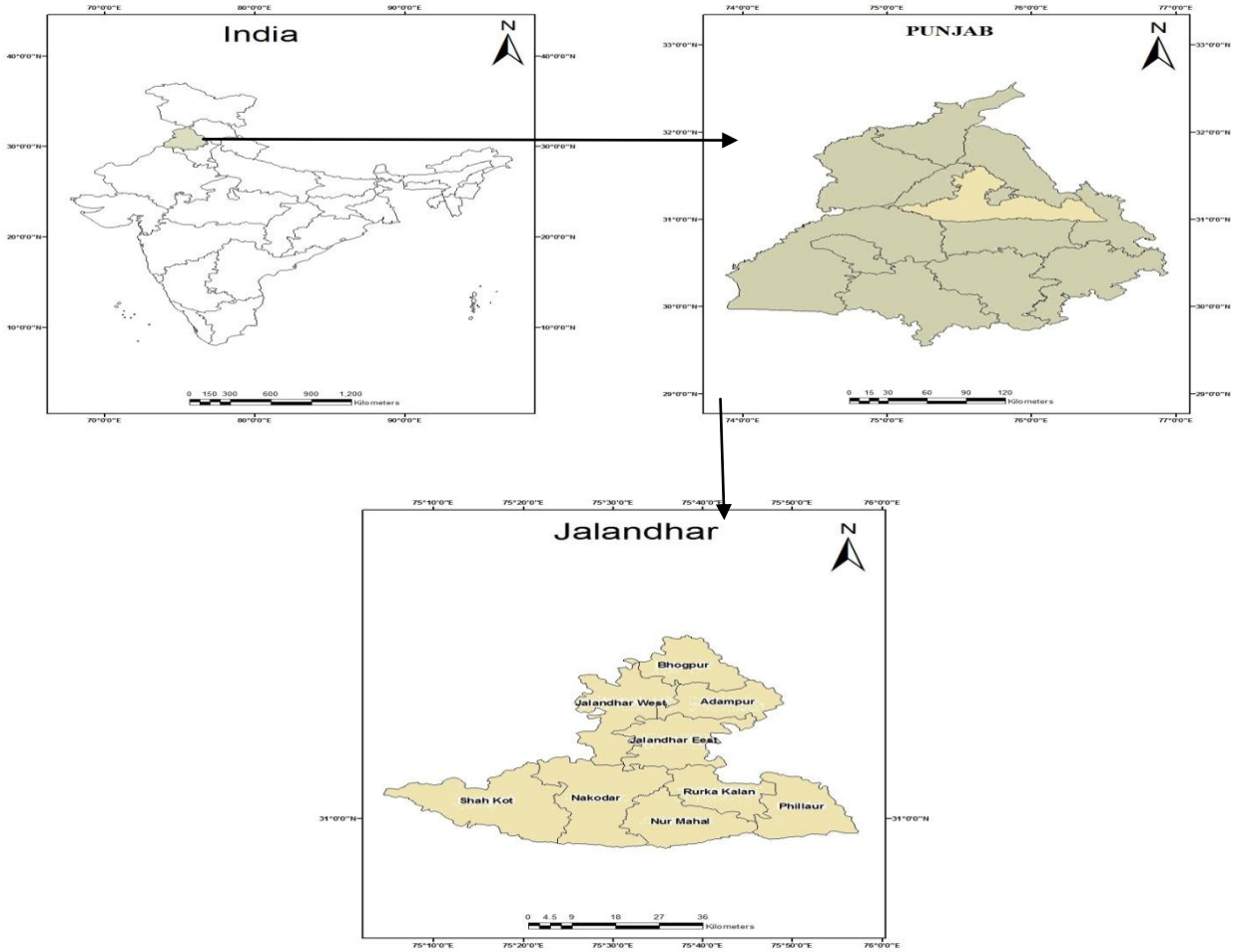


**Figure 1: Location of the study area**

District experiences semi-arid type of climate with an average annual rainfall of 770 mm, most of which is received during the monsoon months of July to September. The total geographical area of Jalandhar district is 263.2 thousand hectares. Agriculture is the backbone of the district as nearly 90% of the total gross cropped area is under cultivation with a cropping intensity of 173% (Sood *et al.,* 2009).The district enjoys excellent irrigation facilities. Tube well is the major source of irrigation contributing more than 90% of the total irrigated area and the rest is irrigated by canal. The total population of the district is 2.2 million. Of the total population, nearly 52 per cent are farmers. Most of the farmers (65%) belong to medium and semi-medium category possessing 2-10 hectares of land holding. The cropping pattern of the district shows that wheat is the dominant crop in the *Rabi* season while rice is the principal crop in the *Kharif* season.

Several methods like Gibbs-Martin index of diversification, Herfindahl Index (HI), Transformed Herfindahl Index (THI), Ogive Index (OI), Entropy Index (EI), Modified Entropy Index (MEI) and Composite Entropy Index (CEI) explain diversification of crops in a given time and space by a single indicator (Islam and Rahman, 2012). In recent years many researches were carried out for analyzing diversification using Gibbs-martin index (Datta, 2012; Das and Mili, 2012; Wen, 2010; Subedi, 2010; Lujan and Gabriels, 2005). In this study Gibbs and Martin index has been used. The Gibbs-Martin Index of Diversification (1962) is a useful alternative index for measuring the extent of diversification in cropping pattern in an area and the mathematical formula for calculating index is given by:

$$GMI = 1 - \frac{\sum_{i=1}^{N} X_i^2}{\left(\sum X_i\right)^2}$$

Where X = percentage of total cropped area occupied by each crop or hectarage under individual crop.

Besides, providing a useful measure of diversification in cropping this method has an advantage over other indices in that it is relatively easy to process since the index value may be calculated without reducing the actual statistics to percentages. If the total area in a region is devoted to wholly one crop (i.e., specialization), the index value is zero; and if it is evenly distributed among all crops (i.e. maximum diversification), the index value approaches 0.9. Therefore, the index of diversification varies from 0.0-0.9 in case 10 crops are considered (Singh and Dhillon, 2004). This method considers the number factor and the even factor. Besides the indices are directly related to the magnitude of diversification. The index of diversification provides a method of generalizing the relationship between the relative strength and the number of crops grown.

For this analysis, time series data on crop acreage under different crops were gathered from various issues of Punjab Abstract and triennium averages were taken out for the period 1990 to 2010. Crop Concentration Index was calculated by using location Quotient method. Location quotient method of crop concentration algebraically may be expressed as:

$$L.Q. = \frac{A_{ij}}{A_j} \Bigg/ \frac{\sum_{i=1}^{n} A_{ij}}{\sum_{j} A_j}$$

*A ij* = Gross cropped area under *i*th crop in jth block,
*A j* = Gross cropped area in *j*th block.

$\sum_{j} A_j$ = Gross cropped area in the district which is the summation of the GCA of each block.

When the index value is greater than unity, the component areal unit accounts for a share greater than it would have had if the distribution were uniform in the entire region and therefore, the areal unit has a concentration of great agricultural significance.

## Results and discussion

Jalandhar is the heart of Indian Punjab in producing rice, wheat, potato, maize, sunflower and sugarcane. Out of six agro-climatic zones of Punjab, Jalandhar lies in the central plain region. It enjoys the excellent irrigation facilities. The main source of irrigation is tube well. With adoption of input intensive agriculture by the farmers, the district has made tremendous strides in agricultural production and high rate of agricultural growth and productivity was registered here in the last two decades. Cropping pattern of the district can best be understood in terms of gross cropped area under various crops.

**Table 1: Cropping pattern changes in Jalandhar district, Punjab (1990-2010)**

| | 1990 | | 2000 | | 2010 | |
|---|---|---|---|---|---|---|
| **Crops** | **Area** | **%** | **Area** | **%** | **Area** | **%** |
| Rice | 119.7 | 35.46 | 133.57 | 39.24 | 163.57 | 45.28 |
| Wheat | 169.4 | 50.19 | 165.63 | 48.66 | 169.40 | 46.9 |
| Maize | 18.5 | 5.48 | 15.80 | 4.64 | 9.07 | 2.51 |
| Gram | 0.07 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 |
| Mash | 0.27 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 |
| Arhar | 0.60 | 0.18 | 0.73 | 0.22 | 0.67 | 0.18 |
| Moong | 0.1 | 0.04 | 0.13 | 0.04 | 0.10 | 0.03 |
| Massar | 0.07 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 |
| Groundnut | 1.17 | 0.35 | 0.03 | 0.01 | 0.00 | 0.00 |
| Rapeseed | 2.3 | 0.68 | 2.30 | 0.68 | 1.03 | 0.29 |
| Sesamum | 0.33 | 0.10 | 1.43 | 0.42 | 0.37 | 0.10 |
| Linseed | 0.13 | 0.04 | 0.07 | 0.02 | 0.03 | 0.01 |
| Sugarcane | 14.4 | 4.28 | 15.03 | 4.42 | 8.40 | 2.33 |
| Fruits | 1.40 | 0.41 | 0.43 | 0.13 | 2.63 | 0.73 |
| Vegetables | 9.03 | 2.68 | 5.17 | 1.52 | 5.97 | 1.65 |
| Gross cropped area | 337.5 | 100 | 340.4 | 100 | 361.2 | 100 |

**Source:** Statistical abstract of Punjab (various issues)

Table 1 shows the cropping pattern and its changes in the study area during 1990-2010. At the beginning of study period (1990), the district had 337 thousand hectares gross cropped area. Out of this, 307.53 thousand hectares area was under total cereals and thus contributing 91 per Cent of GCA. Among cereals, wheat was the main cultivating crop in the district. It has made an impact on the agriculture of the state. Wheat occupied half of the gross cropped area. The area under rice was 35 per cent while the area under pulses was only 0.34 per cent of the GCA. This clearly shows that the food grains dominated the cropping pattern of the state. Only 1.5 per cent area was under oil seeds. Sugarcane and vegetables accounted for 4.28 per cent and 2.68 per cent area of the gross cropped area. Fruits were grown on 0.41 per cent area of the district.

The gross cropped area of the district increased to 344 thousand hectares in 2000 from 337 thousand hectares in 1990. The area under cereals increased from 307.60 thousand hectares to 315 thousand hectares during this period. There was also an upward shift in the area under rice from 119.70 thousand ha in 1990 to 133.57

thousand ha in 2000 but the area under wheat declined from 169.40 hectares in 1990 to 165.53 hectares in 2000. The area under total pulses declined from 1.14 thousand ha to 0.96 thousand ha, a relative decline in the area from 0.34 per cent to 0.96 per cent of the GCA during 1990-2000. Among cereals, the area under maize, mash and massar declined during this period. Oil seeds registered downward shift in their area coverage while sugarcane witnessed a slight increase in its area. The GCA in the district increased to 361 thousand hectares in 2010 from 340 thousand hectares in 2000. The same trend was observed in the case of cereals. The area under rice increased from 35 per cent in 1990 to 39 per cent in 2000. It again increased to 39 per cent in 2000 to 45 per cent in 2010. The area under wheat declined from 48.6 per cent in 2000 to 46.9 per cent in 2010. The area under maize and sugarcane declined but the area under fruits and vegetables increased during 2000-2010. Spatio-temporal analysis of area under various crops shows that area under rice and wheat increased while the area under maize, pulses, oil seeds and sugarcane declined from 1990 to 2010.

**Measures of concentration/ diversification: Gibbs martin index**

Gibbs Martin index of crop diversification was calculated for three time periods. The indices for each block and area under various crops are shown in the Table 2, 3 and 4.

Crop diversification index in Jalandhar district has decreased from 0.62 in 1990 to 0.57 in 2010 (Table 2 & 4). The decrease in the index value is directly related with increase in area under few crops at the cost of others. The crops which have become more profitable in due course of time with the introduction of high yielding variety of seeds and assured market through state trading and support prices have recorded considerable increase in the area. Rationalization of such cropping system has been largely facilitated by the expansion and intensification of irrigation and use of chemical fertilizers as an essential input for increasing agricultural production. Rice has become the dominating crop of the district since it has recorded a considerable increase in its cropped area. The increase in its area occurred at the cost of decrease in area of maize, sugarcane, vegetables, oilseeds and pulses.

A close perusal of the Figure 2(a) shows that during 1990, there was only one highly diversified block viz. Bhogpur block with 0.65 GMI. Jalandhar West, Jalandhar East, Adampur, Nakodar, Nur Mahal, Rurka Kalan and Phillaur were medium diversified blocks With GMI ranging between 0.59 and 0.64. Shahkot was only low diversified block with GMI less than 0.59. In the next phase of the study (1990-2000), Bhogpur remained highly diversified block. Shahkot turned to be the medium diversified block. Jalandhar East and Jalandhar West became low diversified blocks. Adampur, Nakodar, Nur Mahal, Rurka Kalan and Phillaur remained medium diversified blocks (Figure 2 b). During the final period (2000-2010), out of 9 blocks, 6 blocks showed tendency of increasing specialization. Only Adampur, Bhogpur and Nakodar showed medium tendency of increasing diversification (Figure 2 c). During the entire period of the study (1990 to 2010), Shahkot, Phillaur, Nur Mahal and Rurka Kalan showed the maximum tendency of crop specialization. Nakodar, Adampur, Bhogpur, Jalandhar East and Jalandhar west were found to have medium tendency of crop specialization.

**Table 2: Block-wise area under various crops and crop diversification index in Jalandhar district, Punjab (1990)**

| Blocks | Rice | Wheat | Maize | Gram | Mash | Arhar | Moong | Massar | Groundnut | Rapeseed | Sesamum | Linseed | Sugarcane | Fruits | Vegetables | GMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nakodar | 18.13 | 28.70 | 3.63 | 0.03 | 0.10 | 0.17 | 0.03 | 0.00 | 0.27 | 0.50 | 0.03 | 0.03 | 2.10 | 0.10 | 1.43 | 0.62 |
| Shah Kot | 24.57 | 32.13 | 2.47 | 0.03 | 0.07 | 0.03 | 0.10 | 0.00 | 0.83 | 0.43 | 0.23 | 0.00 | 1.07 | 0.13 | 0.93 | 0.59 |
| Phillaur | 13.27 | 17.23 | 2.33 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.37 | 0.03 | 0.03 | 2.33 | 0.13 | 0.30 | 0.63 |
| Nur Mahal | 15.67 | 20.80 | 2.33 | 0.00 | 0.03 | 0.20 | 0.00 | 0.00 | 0.00 | 0.37 | 0.03 | 0.03 | 1.70 | 0.07 | 0.30 | 0.60 |
| Rurka Kalan | 10.97 | 14.00 | 1.87 | 0.00 | 0.03 | 0.10 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.03 | 2.23 | 0.03 | 0.20 | 0.63 |
| Jalandhar East | 8.83 | 12.80 | 0.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.73 | 0.17 | 1.70 | 0.61 |
| Jalandhar West | 13.3 | 19.43 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.77 | 0.27 | 2.83 | 0.60 |
| Bhogpur | 8.43 | 13.10 | 1.73 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.07 | 0.10 | 0.00 | 0.00 | 2.63 | 0.40 | 0.53 | 0.65 |
| Adampur | 6.53 | 11.20 | 2.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.10 | 0.00 | 0.00 | 0.87 | 0.10 | 0.80 | 0.64 |
| Jalandhar district | 119.7 | 169.4 | 18.5 | 0.07 | 0.27 | 0.60 | 0.13 | 0.07 | 1.17 | 2.30 | 0.33 | 0.13 | 14.43 | 1.40 | 9.03 | 0.62 |

**Source:** Statistical abstract of Punjab

**Table 3: Block-wise area under various crops and crop diversification index in Jalandhar district, Punjab (2000)**

| Districts | Rice | Wheat | Maize | Gram | Arhar | Moong | Massar | Groundnut | Rapeseed | Sesamum | Linseed | Sugarcane | Fruits | Vegetables | GMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nakodar | 20.53 | 27.20 | 3.10 | 0.03 | 0.20 | 0.07 | 0.00 | 0.00 | 0.33 | 0.67 | 0.00 | 2.07 | 0.00 | 1.27 | 0.62 |
| Shah Kot | 28.80 | 32.13 | 1.90 | 0.00 | 0.07 | 0.07 | 0.00 | 0.03 | 0.43 | 0.60 | 0.00 | 1.57 | 0.00 | 1.20 | 0.58 |
| Phillaur | 17.20 | 20.13 | 1.23 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 | 0.03 | 2.57 | 0.03 | 0.37 | 0.60 |
| Nur Mahal | 15.07 | 19.10 | 1.50 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.37 | 0.17 | 0.03 | 2.03 | 0.00 | 0.37 | 0.60 |
| Rurka Kalan | 10.57 | 12.13 | 1.40 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 2.17 | 0.00 | 0.13 | 0.63 |
| Jalandhar East | 9.30 | 12.53 | 1.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.57 | 0.07 | 0.50 | 0.58 |
| Jalandhar West | 14.23 | 18.20 | 1.73 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.10 | 0.00 | 0.00 | 0.60 | 0.17 | 0.83 | 0.59 |
| Bhogpur | 9.93 | 12.50 | 1.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 8.80 | 0.13 | 0.20 | 0.69 |
| Adampur | 7.93 | 11.70 | 2.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.67 | 0.03 | 0.30 | 0.61 |
| Jalandhar district | 133.5 | 165.63 | 15.80 | 0.03 | 0.73 | 0.13 | 0.03 | 0.03 | 2.30 | 1.43 | 0.07 | 15.03 | 0.43 | 5.17 | 0.60 |

**Source:** Statistical abstract of Punjab

**Table 4: Block-wise area under various crops and crop diversification index in Jalandhar district, Punjab (2010)**

| Districts | Rice | Wheat | Maize | Arhar | Moong | Rapeseed | Sesamum | Linseed | Sugarcane | Fruits | Vegetables | GMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nakodar | 28.83 | 28.80 | 1.43 | 0.20 | 0.10 | 0.17 | 0.20 | 0.03 | 0.77 | 1.03 | 2.47 | 0.59 |
| Shah Kot | 33.73 | 29.50 | 0.60 | 0.07 | 0.00 | 0.27 | 0.10 | 0.00 | 0.23 | 0.33 | 0.90 | 0.53 |
| Phillaur | 20.00 | 21.53 | 0.67 | 0.10 | 0.00 | 0.10 | 0.00 | 0.00 | 1.17 | 0.20 | 0.43 | 0.55 |
| Nur Mahal | 18.30 | 20.43 | 0.73 | 0.17 | 0.00 | 0.10 | 0.07 | 0.00 | 0.83 | 0.17 | 0.43 | 0.55 |
| Rurka Kalan | 12.80 | 14.13 | 0.53 | 0.13 | 0.00 | 0.10 | 0.00 | 0.00 | 1.17 | 0.17 | 0.13 | 0.57 |
| Jalandhar East | 10.87 | 12.63 | 0.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.27 | 0.50 | 0.57 |
| Jalandhar West | 18.70 | 17.27 | 0.90 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.63 | 0.27 | 0.73 | 0.56 |
| Bhogpur | 11.87 | 13.23 | 1.07 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 2.30 | 0.17 | 0.23 | 0.61 |
| Adampur | 8.47 | 11.87 | 2.27 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.90 | 0.07 | 0.13 | 0.61 |
| Jalandhar district | 163.57 | 169.40 | 9.07 | 0.67 | 0.10 | 1.03 | 0.37 | 0.03 | 8.40 | 2.63 | 5.97 | 0.57 |

**Source:** Statistical abstract of Punjab

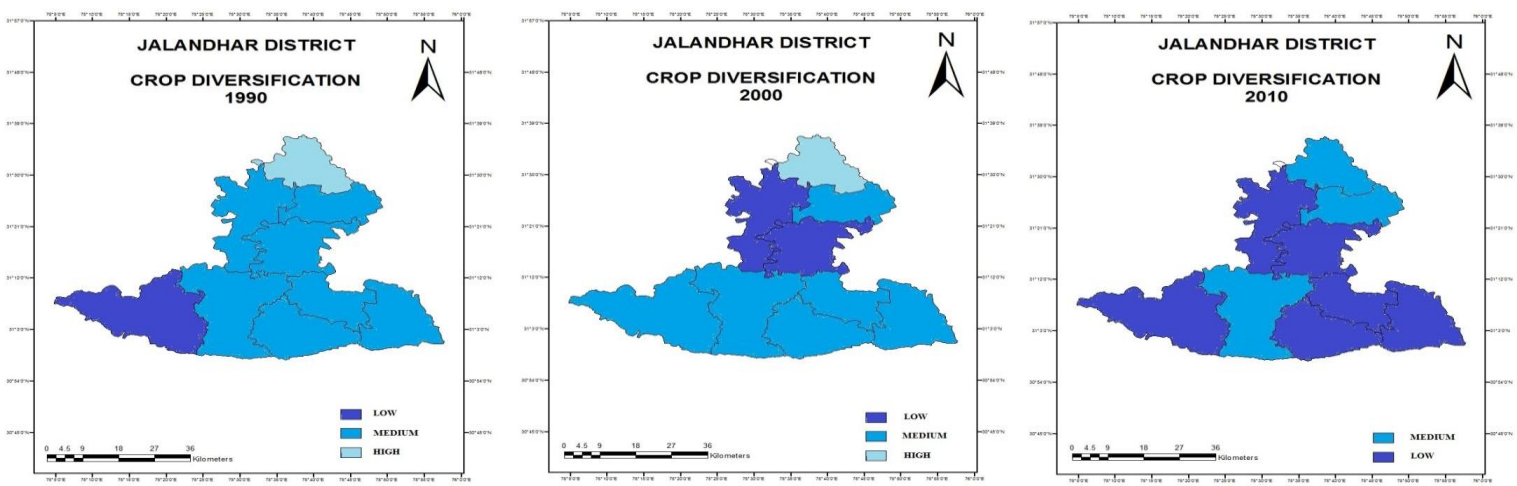


**Figure 2: Spatio-temporal variation of crop diversification in Jalandhar district (1990-2010)**

Spatio-temporal analysis of crop diversification from 1990 to 2010 shows that Shahkot, Jalandhar East, Jalandhar West, Nur Mahal, Rurka Kalan and Phillaur were found to be low diversified blocks (Figure 3). Shahkot, Jalandhar West and Nur Mahal have the largest area under rice crop while Jalandhar East, Rurka Kalan and Phillaur have rice and wheat rotation system. There were only three blocks having medium crop diversification status. These include Nakodar, Bhogpur and Adampur. Rice occupied the largest area in Nakodar while rice and wheat were the major crops in Bhogpur and Adampur. Thus it is evident that most of the blocks are experiencing crop specialization either in rice or rice-wheat cycle in the study area.

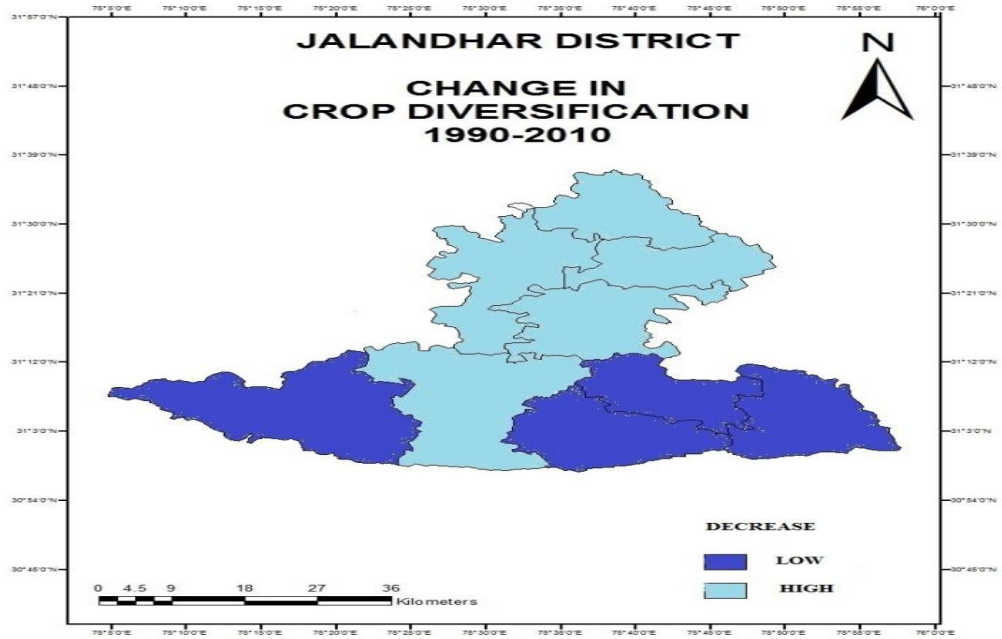


**Figure 3: Degree of change in crop diversification in Jalandhar district (1990-2010)**

From the crop concentration table, it is clear that in those blocks where specialization is taking place, mostly the area shares of food grain crops viz., rice and wheat are going up at the cost of other non-food grain crops (Table 5). In Nakodar block, during first period, the rice and wheat were the most concentrated crops. In second period rice's concentration increased and the concentration of wheat, maize, sugarcane and vegetables reduced while in the final phase of the study, rice remained the main concentrating crops of the farmers in the block. This block has shown the medium diversification of crops throughout the study period. GMI of this block shows that it is going towards specialization but at a slow rate.

In Shahkot block, high concentration of rice and wheat was recorded during 1990. During the next phase, the concentration of rice increased and concentration of wheat decreased while sugarcane and vegetables made slight improvement in their concentrations. During 2010, the concentration of rice increased while the concentration of all the other crops declined. It has lowest GMI with 0.54 in 2010 and has moved towards specialization.

**Table 5: Crop concentration index of five major crops in Jalandhar district (1990-2010)**

| Blocks | Rice | | | Wheat | | | Maize | | | Sugarcane | | | Vegetables | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2010 | 1990 | 2000 | 2010 | 1990 | 2000 | 2010 | 1990 | 2000 | 2010 | 1990 | 2000 | 2010 |
| Nakodar | 2.00 | 2.27 | 2.54 | 3.17 | 3.01 | 2.54 | 0.40 | 0.34 | 0.13 | 0.23 | 0.23 | 0.07 | 0.16 | 0.14 | 0.22 |
| Shah Kot | 2.09 | 2.20 | 2.82 | 2.73 | 2.45 | 2.47 | 0.21 | 0.14 | 0.05 | 0.09 | 0.12 | 0.02 | 0.08 | 0.09 | 0.08 |
| Phillaur | 3.43 | 3.30 | 3.70 | 4.46 | 3.86 | 3.98 | 0.60 | 0.24 | 0.12 | 0.60 | 0.49 | 0.22 | 0.16 | 0.14 | 0.22 |
| Nur Mahal | 3.07 | 3.39 | 3.89 | 4.07 | 4.30 | 4.34 | 0.46 | 0.34 | 0.16 | 0.33 | 0.46 | 0.18 | 0.06 | 0.08 | 0.09 |
| Rurka Kalan | 4.17 | 5.02 | 5.44 | 5.32 | 5.76 | 6.00 | 0.71 | 0.67 | 0.23 | 0.85 | 1.03 | 0.50 | 0.08 | 0.06 | 0.06 |
| Jalandhar East | 4.71 | 5.38 | 6.02 | 6.82 | 7.24 | 7.00 | 0.48 | 0.69 | 0.48 | 0.33 | 0.46 | 0.18 | 0.91 | 0.29 | 0.28 |
| Jalandhar West | 3.16 | 3.70 | 4.53 | 4.62 | 4.73 | 4.19 | 0.24 | 0.45 | 0.22 | 0.18 | 0.16 | 0.15 | 0.67 | 0.22 | 0.18 |
| Bhogpur | 3.90 | 3.09 | 5.11 | 6.05 | 3.88 | 5.70 | 0.80 | 0.43 | 0.46 | 1.22 | 2.73 | 0.99 | 0.25 | 0.06 | 0.10 |
| Adampur | 4.60 | 5.08 | 5.40 | 7.88 | 7.49 | 7.57 | 1.57 | 1.49 | 1.45 | 0.61 | 0.43 | 0.57 | 0.56 | 0.19 | 0.09 |

**Source:** Statistical abstract of Jalandhar District (Various Issues)

**Table 6: Area, net irrigated area and production in Jalandhar district, Punjab (1998-2011)**

| | 1998-99 | | | 2008-09 | | | 2010-11 | | |
|---|---|---|---|---|---|---|---|---|---|
| Crops | Area* | Net irrigated area* | Production** | Area* | Net irrigated area* | Production** | Area* | Net irrigated area* | Production** |
| Rice | 134316 | 133290 | 436 | 155095 | 155095 | 588 | 163057 | 163057 | 588 |
| Wheat | 161325 | 161236 | 748 | 170562 | 170479 | 788 | 169336 | 169336 | 793 |
| Maize | 13049 | 12799 | 34 | 11886 | 11842 | 41 | 8996 | 8996 | 35 |
| Sugarcane | 13156 | 13155 | 730 | 9454 | 9454 | N.A | 8625 | 8625 | 4.2 |

**Source:** Directorate of economics and statistics, department of agriculture and cooperation, ministry of agriculture, Government of India
* Hectares, ** thousand tonnes

In Phillaur, during the first phase of the study, rice, wheat, sugarcane and maize were the main crops. During the next phase, the concentration of wheat, maize, and sugarcane declined and the concentration of rice increased. It was observed that the concentration of rice, wheat and vegetables increased in Phillaur during the final phase of the study and sugarcane and maize experienced decline in their concentration. Its GMI has decreased from 0.63 in 1991 to 0.56 in 2010 indicating specialization. Wheat and rice were the dominating crops of Nur Mahal during the entire phase of the study but the concentration of maize declined in this block. Its GMI has decreased from 0.60 in 1990 to 0.56 in 2010. The block is experiencing specialization.

In Rurka Kalan block during, 1990, the five most concentrated crops were rice, wheat, maize, sugarcane and vegetables with wheat at the top with an index value of 5.32. During the next period (1990-2000), rice and wheat became the most concentrating crops while the concentration of maize and vegetables declined. In 2000-10, wheat was the most dominating crop but the concentration of maize, sugarcane and vegetables declined. The area under rice increased here at the expense of these crops. Its GMI has also decreased from 0.63 in 1990 to 0.57 in 2010. It indicates that this block is specializing in rice and wheat crops. In Jalandhar east block, rice and wheat were the concentrating crops during 1990. In the next phase, wheat and rice remained the most concentrated crops and experienced phenomenal increase in their concentration. In the final period of the study, rice and wheat were the most dominating crops. There was a substantial increase in the concentration of rice and it was the most concentrated crops while the concentration of all the crops declined. The farmers of this block are rational and they wanted to maximize their profit by growing only these two crops. It has experienced decrease in its GMI from 0.61 in 1990 to 0.57 in 2010.

In Jalandhar west, rice and wheat were the most concentrating crops throughout the entire period of the study while the concentration of maize, sugarcane and vegetables declined continuously. Though wheat and rice were the most dominating crops of the block but the concentration of rice has decreased continuously. The concentration of rice is increasing while the concentration of wheat, maize, sugarcane and vegetables is decreasing. The block experienced decline in its GMI from 0.60 in 1990 to 0.56 in 2010. In Bhogpur and Adampur, the concentration of rice and wheat are high throughout the study period but the farmers of these blocks are more interested in growing rice crop. The crop diversification of both these blocks declined from 1990 to 2010.

## Policy implications

The district has witnessed a paradigm shift in its cropping pattern. From a diversified practice, it has shifted to a specialized one. It was observed that no new crop emerged to the top five most concentrated crops; only there happened a little change in the ordering of the crops. The increase in area under rice has led to decline in area under other major *Kharif* crops like maize, sugarcane, pulses, etc. Wheat has, however, been the dominant crop of the district in *Rabi* season from the very beginning. The increase in wheat cultivation has been at the expense of cutting down the area under other *Rabi* season crops especially oil seeds. Hence, after the green revolution, the farmers of Punjab abandoned their traditional cropping practices in favour of the government-supported wheat-rice cropping pattern. The dominance of the wheat-paddy system has led to increase in area, net irrigated area under their cultivation while production has remained almost constant (Table 6).

Declining diversity of crops in the district has serious repercussions for the farming economy of the district in terms of over

exploitation of natural resources, ecological problems and growing income risks. The other districts of Punjab mainly Gurdaspur, Amritsar, Kapurthala, Ludhiana, Patiala, Faridkot and Sangrur also show declining crop diversification (Sajjad & Prasad, 2012). The state experienced rapid strides in agriculture through expansion in area, growth in land productivity and shifts in the cropping pattern in favour of rice and wheat till 1980s.Having achieved the comfort and complacency of quantum jump in production propelled by ostracized green revolution, agriculture in Punjab has passed through several phases of intermittent growth with the terminal agrarian distress in recent years. The situation has arisen due to increasing cost of cultivation, falling crop prices and increasing indebtedness among farmers. During 1990s the agricultural growth stagnated due to limited expansion in cropped area and plateauing in the productivity of major crops (Singh and Sidhu, 2004).

The contribution of agriculture in the gross state domestic product has declined from 32% in 2004-05 to 25% in 2009-10 (Economic Survey of Punjab 2010-11). Some of the negative effects of intensive resource use in post green revolution era are falling ground water table, water logging, salinity, etc (Sood *et al.*, 2000). Diversity decline in variety of rice and wheat has also been registered as nearly 93% of wheat area in the state is under only one variety and 55% of rice area is under two crops (PAU 2003). Wheat and rice have together removed 83% of major nutrients of the soil (Aulakh and Bahl, 2001). The government is contemplating reduction of public stocking of wheat and rice and freezing their minimum support prices (Kurosaki 2003). Under such a scenario, the basic question to be answered is: how can agricultural growth be accelerated? The best answer is to promote crop diversification. Many studies in South and Southeast Asia and Sub Saharan Africa have demonstrated that diversification towards high-value food commodities supports the development of innovative supply chains and opens new vistas for augmenting income, generating employment and promoting exports (Joshi *et al.*, 2002; Barghouti *et al.*, 2005; Pingali 2004; Deshingkar *et al.*, 2003; Birthal *et al.*, 2007; Goletti, 1999; Jacobson, 2010). Policy makers in the state are trying their best to promote crop diversification through contact farming of high value crops like fruits, vegetables, oil seeds and pulses. Attempts are also being made to educate farmers about ill effects of rice-wheat crop culture on ecology. All these efforts have hardly made any dent in the cropping pattern. Hence, strong policy framework towards reduction in area under rice crop, technological change, value addition and public-private partnership are needed to arrest the dismal condition of agriculture in the state. Contact farming experience as a great boost to the economy of Thailand, Zimbabwe, Sub Saharan African countries, if replicated and adopted as alternative to crop specialization can perhaps make a difference.

## Conclusion

From the foregoing analysis it is observed that the crop diversification in Jalandhar district is decreasing over time. The cropping pattern in the district in terms of allocation of acreage has been shifted in favour of wheat and rice. The cropping pattern turned against pulses, maize sugarcane, oil seeds and vegetables. Therefore, the district is experiencing specialization of the wheat – rice system. From the block level analysis it has been found that during 1990-2010, Shahkot, Jalandhar east, Jalandhar west, Nur Mahal, Rurka Kalan and Phillaur were low diversified blocks. All these blocks have shown specialization in rice and wheat. Nakodar, Bhogpur and Adampur were medium diversified district. Bhogpur and Adampur showed very high concentration towards rice and wheat while Nakodar is specialised in rice crop. The increase in area under rice has resulted in higher

demand for water. Due to limited availability of surface water, ground water resources have been over exploited to meet the growing demand. Declining diversity in agriculture has led to serious implications for the farming economy of the district in the form of resource depletion, nutrition deficiency, fall in ground water table and growing income risk. The government is freezing the minimum support price of wheat and rice. This has affected the economic returns of the farmers. Hence, there is urgent need to explore the strategies for improving the diversification. Contract farming through vegetables, fruits, oilseeds, suitable alternate cropping pattern, reorganization of sustainable agriculture management, empowering farmers, appropriate policy formation, dissemination of knowledge to the farmers should be adopted to protect the interest of the farmers and the sustainable development of the district.

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