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An Analysis of Crop Combination and Crop Diversification in North-Western India

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ABSTRACT

The agriculture of any region is decided by and large, by a number of soils and climatic parameters as well as socio-economic factors that determine overall agro-ecological setting for cultivation of a crop or set of crops for cultivation. The evolving crop combinations have been the net outcome of physio-cultural factors. The north western India has highly varied relief and climatic conditions which resulted in different crop combinations. The present study has been undertaken in Punjab, Haryana and Rajasthan states of north-western India and the data have been collected at district level to analyse the crop combinations and crop diversification. Weaver's method of crop combination reveals that three crop combination was dominant in the study area. Punjab and Haryana experienced two crop combination in most of the districts. Regions having suitable environmental conditions with adequate agricultural infrastructure had experienced low magnitude of crop diversification and vice versa. It is also observed that number of crops has been decreased during the study period which shows that agriculture is going to be more specialized from diversified.

Keywords*: crop combination, crop diversification, cultivation, infrastructure, specialization.*

INTRODUCTION

The study of crop combination regions constitutes an important aspect of agriculture geography as it provides a strong basis for agricultural regionalization. The concept of crops combination is a scientific device to study the existing relationship of crops in association with each other and land utilization [1]. Crops are generally grown in combination and it is rarely that a particular crop occupies a position of total isolation from other crops in a given area [2].

In recent years the crop combination analysis has gained momentum and its importance is increasing day by day. Any study of crops on regional scale must take into consideration the combinational analysis and the relative position of crops. Such analysis would ultimately minimize the change of over simplified generalization [3]. Combination studies are useful in many ways. Firstly they provide an adequate understanding of individual crop. Secondly, combination is in itself integrative reality that demand definition and distribution analysis and last crop combination regions are essential for the construction of still more complex structure of vivid agricultural region [4].

Concept of crop diversification means competition among various grown crops for space in a given region [5]. It also means raising a variety of crops involving intensity of competition amongst field crops for arable land: the keener the competition, the higher the magnitude of crop diversification. It is a concept which is opposite to crop specialization. It is an indicator of multiplication of crops which obviously involves intensive competition among the growing crops [6]. Crop diversification also provides relationship between the relative areal strength

of the crops grown in a region. The magnitude of crop diversification shows the impact of physical, socioeconomic and technological influence on cropping pattern of an area [7].

STUDY AREA AND OBJECTIVE

This research work has been done on three states in north-western India. These states are Punjab, Haryana and Rajasthan.North-Western India is extended between 23°3' N to 32°32' N latitudes and 69°30' E to 78°17' E longitudes, comprising 72 districts of Punjab, Haryana and Rajasthan with 436813 square kilometers area which accounts for 13.29 percents of the total geographical area of India. The study area is inhabited by 12,16,78,329 persons (2011) which accounts for 10.05 percents of India's population; out which 6,37,60,035 are males and 5,79,18,294 are females. Density of population is 279 persons per square kilometer.

The main objectives of the present study are to analyze and present the crop combination and crop diversification in the north-western India for the years 1980-81 to 2010-11.

MATERIAL AND METHODS

The present research is based on secondary data collected from Directorate of Economics and Statistics of Punjab, Haryana and Rajasthan ranging between years 1980 to 2011 at district level as district was the study unit. The crops are arranged and ranked in hierarchical order and then crop combinations are obtained. The ease of these methods is the simplicity in calculation. Moreover these quantitative techniques are more precise, accurate and scientific than qualitative methods.

In the field of agricultural geography J. C. Weaver(1904) was the first geographer who used statistical technique to show the crop combination of the Middle West (U.S.A.). In his work weaver calculated deviation of the real percentage of crops (Occupying one percentage the cropped area) for all the possible combination in the component areal units against a theoretical standard. The theoretical curve for the standard measurement was employed as follows:

Monoculture	=	100% of the TCA in one crop
Two Crop combination	=	50% in each of two crops
Three Crop combination	=	33.3% in each of three crops
Four Crop combination	=	25% in each of four crops
Five Crop combination	=	20% in each of five crops
Ten Crop combination	=	10% in each of ten crops

For the determination of minimum deviation the SD method was used

$$SD = \sqrt{\frac{\sum d^2}{n}}$$

Where 'D' is the different between the actual crop percentage in a given areal unit and the appropriate percentage in the theoretical and 'n' is the number of crops in a given combination. As Weaver pointed out, the relative, not absolute value being significant, square roots were not calculated so the actual formula used as follows:

$$d = \sqrt{\frac{\sum d^2}{n}}$$

The above formula has been used to determine crop combination in the study area. The detail analysis is further described, which is also tabularized in the table 1 and shown in map 1.

Crop diversification means competition among various grown crops for space in a given region. It also means raising a variety of crops involving intensity of competition amongst field crops for arable land: the keener the competition, the higher the magnitude of crop diversification. It is a concept which is opposite to crop specialization. It is an indicator of multiplication of crops which obviously involves intensive competition among the growing crops.[8] Crop diversification also provides relationship between the relative areal strength of the crops grown in a region. The magnitude of crop diversification shows the impact of physical, socioeconomic and technological influence on cropping pattern of an area [9].

The level of crop diversification is largely depends on the geo-climatic conditions and socio-economic conditions and the level of technological development in a region. It is generally

considered that higher the level of agricultural technology, lesser the degree of diversification and vice versa. Moreover, rich farmers prefer to specialize in agricultural enterprise, while the poor and subsistent farmers are generally more interested in crop diversification [10].

Many scholars from geography, economics and allied disciplines have developed techniques for measurement of crop diversification. Among them Gibbs and Martin, Bhatia and Singh are prominent. The researcher used Singh's formula for calculation the index of diversification. Jasbir Singh (1976) developed the formula for calculating the degree of crop diversification. According to this method, the index of crop diversification is obtained by summing up the harvested area of those crops which are having 5.0 per cent or more than 5.0 per cent area to the total harvested area. Thus, this formula is also inversely related with the magnitude of crop diversification. Higher the index, lower the magnitude of crop diversification and lower the index higher the magnitude of crop diversification [11].The formula is:

$$\text{Index of crop diversification} = \frac{\text{Percent of total harvested area under N Crops}}{\text{Number of N Crops}}$$

Where 'N' crops are those crops which individually occupy 5 per cent or more of the total cropped area in the study region.With the help of above formula district wise index of diversification has been calculated. The results were partly the result of physical and partly of socio-economic factors. These variations are described; and shown in table 2& map 2 further.

RESULTS AND DISCUSSION
CROP COMBINATION
Weaver's method of crop combination and its results are as follows.
Crop Combination in 1980-81
Punjab - In 1980-81, No district of Punjab was under mono crop category. Four districts made two crops category which had 33.33% of total districts. These two crops were wheat and Rice. 50% districts had three crop combinations and 16.67% districts had four crop category. Wheat and rice made two crop combination. Three crop combination was made by wheat and rice with maize or cotton American. One district also had wheat-gram-cotton American combination. Four crop combination consist of wheat, maize and rice with tobacco or sugarcane.

Haryana - There was no district, which had mono crops combination in 1980-81. Two districts had two crops combination, three districts had three crop combinations and seven districts (58.33%) had four crop combinations. There was no district which had five or six crop combinations. Wheat and rice made two crop combination. Three and four crop combinations were made by wheat, rice, maize, sugarcane, rapeseed & Mustard, Bajra, cotton American, Jowar and gram.

Rajasthan - In 1980-81, four districts (15.38%) were under mono crop (Bajra) combination. Two districts (7.69%) had two crop combinations. 19.23% districts were under three crop category. Both four and five crop combination category had 23.07 % districts. Three districts (11.54%) were under six crop combination. Two crop combinations were made by wheat or Bajra with rapeseed & mustard. Jowar, maize, gram, barley, sesamum, and groundnut were the other important crops in the crop combinations.

Crop Combination in 2010-11
Punjab - There was no districts had mono crop combination. Districts under two crop combinations increased from 33.33% to 55% in 2010-11. 40% Districts had three crop combinations. Four crops combination category decreased from 16.67% to 5% in 2010-11. Wheat and rice made two crop combination. Three crop combination was made by wheat and rice with maize or cotton American. Four crop combination consist of wheat, maize and rice with sugarcane.

Haryana - In 2010-11, no district was under mono crop combination 30% districts had two crops combination and 55% districts had three crops combination. Three districts (15%) had four crops combination. There were no districts which had five or six crop combinations. Wheat and rice made two crop combination. Three and four crop

combinations were made by wheat, rice, maize, sugarcane, rapeseed & Mustard, Bajra, cotton American, Jowar and gram.

Rajasthan - In 2010-11, Districts under mono crop category were only 3.12%, which were 15.38% in 1980-81. District made two crop combination category increased and extended to 18.75%. District under three crops combination also increased to 46.88%. There were eight district (25%) under five crop combination category and two districts were (6.25%) under six crop combination category. Two crop combinations were made by wheat or bajra with rapeseed & mustard. Jowar, maize, gram, barley, sesamum, and groundnut were the other important crops in the crop combinations.

CROP DIVERSIFICATON

Using the Singh's formula the index of crop diversification has been calculated; categorized and described into the following heads.

The Areas of Low Magnitude of Crop Diversification (> 34 Index Value):

In 1980-81, 33.33 % districts (Kapurthala, Patiala, Gurdaspur and Amritsar) of Punjab and 11.54 % districts (Barmer, Jaisalmer and Jodhpur) of Rajasthan formed this category. In 2010-11, 50 % districts (Gurdaspur, Amritsar, Jalandhar, Ludhiana, Moga, Barnala and Fatehgarh Sahib) of Punjab, 20 % districts of Haryana (Karnal, Kaithal, Panipat and Sonipat) and only one district (Barmer) of Rajasthan were under this category. In Punjab and Haryana, districts are having flat land, fertile soils, developed irrigation, developed transport network etc. all these factors have enabled farmers to select crops which fetch assured and higher economic returns. Thus their choice had fallen on wheat and rice which leads to low magnitude of crop diversification. In case of Barmer, physical adversities as low annual rainfall, high summer temperature with low irrigational facilities lead to grow farmers only few crops. This consequently leads to low magnitude of crop diversification.

The Area of Medium Magnitude of Crop Diversification (22-34 Index Value):

In 1980-81, 41.67 % districts of Punjab, 16.7 % districts of Haryana and 7.69 % districts of Rajasthan were under this category. 45 % districts (Sangrur, Mansa, Makassar, Firozpur, NawanShehar) of Punjab, 50 % districts of Haryana (Ambala, Panchkula, Yamunanagar, Faridabad, Gurgaon, Fatehabad, Rewari, Mahendragarh) and 46.88 % districts (Dholpur, Karuali, Alwar, Banswara, Udaipur, Jalore, Jodhpur, Baran, SawaiMadhopur, Dungarpur, Hanumangarh, Ganganagar) of Rajasthan were under this category in 2010-11. These districts are having some physical adversities, but with the help of adequate irrigational facilities and sufficient agricultural infrastructure, farmers grow limited crops which lead to moderate magnitude of crop diversification.

Areas of High Magnitude of Crop Diversification (<22 Index Value):

There were 25 % districts of Punjab, 83.3 % districts of Haryana and 80.77 % districts of Rajasthan under this category in 1980-81; while, 5 % districts (Hoshiarpur) of Punjab, 30 % districts (Hisar, Jhajjar, Rohtak, Mewat, Sirsa) of Haryana and 50 % districts (Jhalawar, Bikaner, Pali, Sirohi, Nagaur, Bhilwara, Chittorgarh, Tonk, Jaipur, Jaisalmer) of Rajasthan were under this category in 2010-11. In all these areas, the rugged topography, comparatively low rainfall, low extent of irrigation, less developed agricultural infrastructure were the factors responsible for high magnitude of crop diversification resulted into growing of several crops like Bajra, Jowar, barley, wheat, gram, rapeseed etc. by farmers from security point of view which ultimately lead to high magnitude of crop diversification.

Table 1:Crop Combination

Crop Combination	1980-81						2010-11					
	Punjab		Haryana		Rajasthan		Punjab		Haryana		Rajasthan	
	1	2	1	2	1	2	1	2	1	2	1	2
Mono	-	-	-	-	4	15.38	-	-	-	-	1	3.12
Two	4	33.33	2	16.67	2	7.69	11	55	6	30	6	18.75
Three	6	50.00	3	25.00	5	19.23	8	40	11	55	15	46.88
Four	2	16.67	7	58.33	6	23.07	1	5	3	15	8	25.00
Five	-	-	0	0	6	23.07	-	-	-	-	2	6.25
Six	-	-	0	0	3	11.54	-	-	-	-	-	-
Total	**12**	**100.0**	**12**	**100.0**	**26**	**100.0**	**20**	**100.0**	**20**	**100.0**	**32**	**100.0**

Note
1. *Number of Districts*
2. *Percents to Total Districts*
Source: Computed

Table 2:Index of Crop Diversification

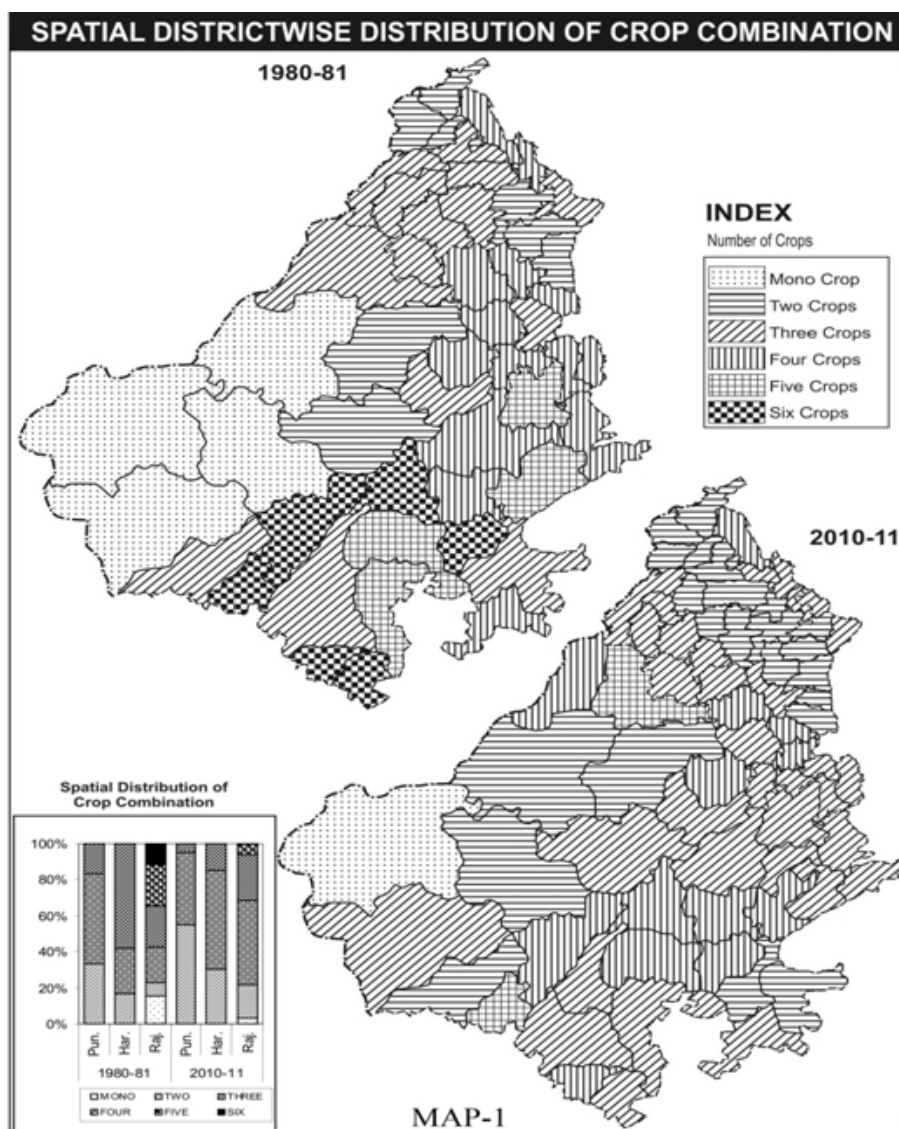| Category	Value	1980-81						2010-11					
		Punjab		Haryana		Rajasthan		Punjab		Haryana		Rajasthan	
		1	2	1	2	1	2	1	2	1	2	1	2
High	<22	3	25.00	10	83.30	21	80.77	1	5.00	6	30.00	14	43.75
Medium	22-34	5	41.67	2	16.70	2	7.69	9	45.00	10	50.00	17	53.12
Low	>34	4	33.33	0	0.00	3	11.54	10	50.00	4	20.00	1	3.13
Total		**12**	**100.0**	**12**	**100.0**	**26**	**100.0**	**20**	**100.0**	**20**	**100.0**	**32**	**100.0**

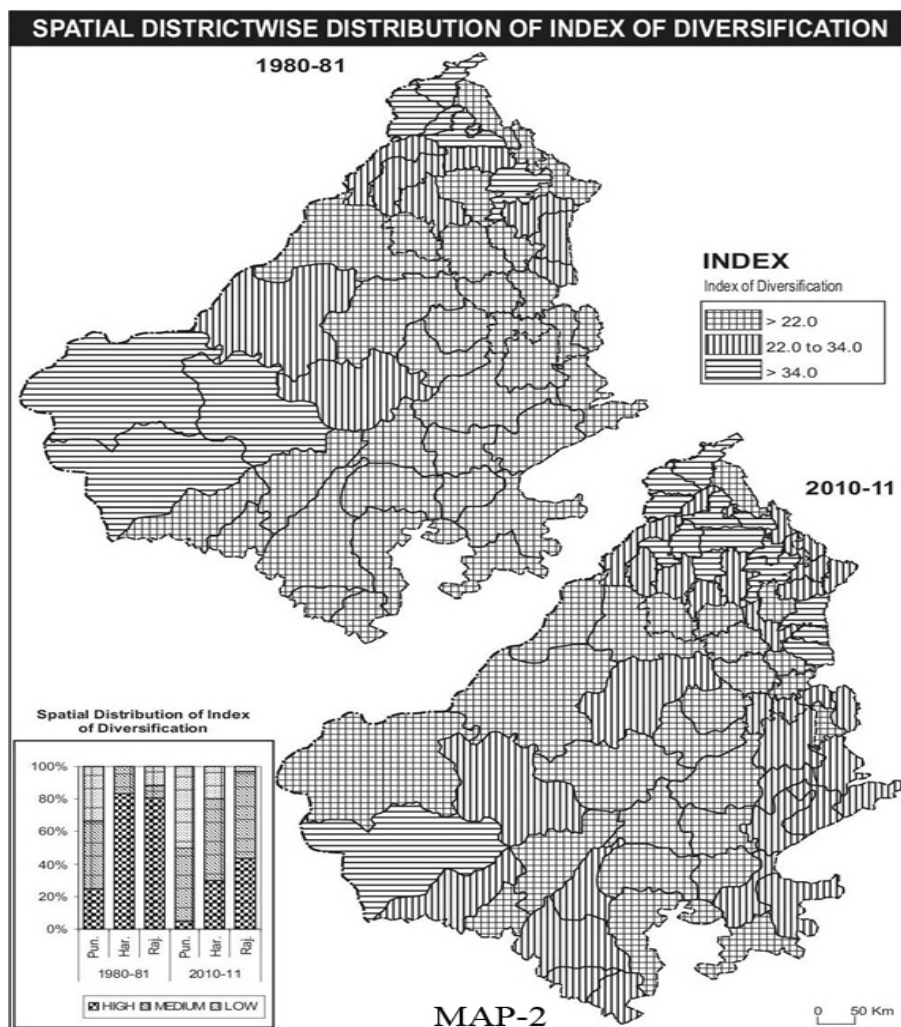*Note*
1. *Number of Districts*
2. *Percents to Total Districts*
Source: Statistical Abstracts of Punjab, Haryana and Rajasthan

SPATIAL DISTRICTWISE DISTRIBUTION OF CROP COMBINATION

SPATIAL DISTRICTWISE DISTRIBUTION OF INDEX OF DIVERSIFICATION

MAP-2

CONCLUSION

The detail analysis of crop combination in the study area reveals that wheat and rice with maize and cotton American are the main crops in Punjab state as most of the part have fertile soil, adequate irrigational facilities and developed agricultural infrastructure. Haryana had the same condition in some extent. Western part of the state has arid climate with less developed irrigational facilities which lead farmer to cultivate more number of crops that are more suited with the physical environment. In case of Rajasthan, wheat, rapeseed & mustard, rice and sugarcane crops are grown in areas with adequate irrigational facilities. Bajra and Jowar crops grow in western part of Rajasthan.

Areas having favorable physical conditions with well developed agricultural infrastructure had experienced low magnitude of crop diversification while farmers struggling with either adverse physical environment or less developed agricultural infrastructure or both had witnessed moderate to high magnitude of crop diversification. Increase in irrigation facilities, development of infrastructure, agricultural innovation etc. were responsible for shifting districts from high to medium and medium to low magnitude of crop diversification.

This analysis also reveals that introduction of green revolution technology and developments in agricultural infrastructure, organizational reforms, government policy etc. have led to the cultivation of few crops by the farmers.

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