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RESEARCH ARTICLE

A COMPARATIVE ANALYSIS OF CROP COMBINATION IN KHERI DISTRICT, UTTAR PRADESH, INDIA

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ABSTRACT

The crop combination regionalization is a method to examine the cropping pattern of an area. In this process, the existing cropping pattern is analysed and the best combination of crops is proposed for the highest productivity in that area. The combination of crops in an area is influenced by numerous physical and human factors. This study has been carried out on Kheri district, Uttar Pradesh, India. Secondary data has been used gathered from the District Statistical Magazines. The ranking of specific crops is estimated by percentage method. Doi's method has been applied to examine the crop combinations in the different blocks. A comparative analysis of two different agricultural years was presented. The findings show that Sugarcane is the main crop in the district and occupying as the first rank in most of the blocks. However, wheat and rice are other crops occupying second and third positions in different blocks. Oilseed, pulses, maize, fodder, and vegetables are other minor crops of the district. According to Doi's technique, most of the blocks are experiencing three crop combinations, only one block having monoculture and two blocks featuring two crop combinations in 2016-17. Moreover, in the year 2006-07, all the blocks experiencing three crop combinations in the district.

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INTRODUCTION

In agriculture geography, the cropping pattern of a particular space is the result of the interaction between the physical and human aspects of that area. The crop to be cultivated in the field is the decision of a farmer that has been influenced by a number of factors especially with respect to India. In northern India, only a few crops are dominant after the implementation of the Green Revolution associated with modern agricultural inputs. Wheat, rice, and sugarcane are dominating the agricultural scenario in the northern plain tract. Due to the multifaceted agricultural practices, different combination of crops is adopted to increase the income and fulfill the other domestic needs of the farmer. Standard economic theory suggests that a farmer is an economic man who always tries to maximize his/her profit. If we closely look at the decisions of cropping taken by the Indian farmers, it has been found out that they are directed by considerations other than maximisation of short-run profit (Rudra 1983). The cultivation of a single crop or mix cropping depends upon the liability and nature of labour force available to the farmers (Nair et al. 1975).

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India is so rich in the resource availability that this country is called a 'rich country of poor people'. The soil of India is so rich yet the people of the country are suffering from malnutrition and under-nutrition. Agriculture is considered the backbone of the Indian economy (Hussain 1982). Individual crops, like the individual system elements of geography, are commonly studied by and for themselves alone. Just as the definition and interpretation of a geographic pattern of soils without reference to vegetation, or of soils or vegetation without reference to climate, constitute only a partial structure of integrated understanding, so also observations concerning one particular crop without reference to its immediate cultivated companions can illuminate no more than a limited segment of the broad mosaic of cropland use. The only rare crop can be cultivated in isolation, otherwise the agricultural practices are infested with multiplicity of crop combinations (Weaver 1954). Combination studies are useful in many ways. Firstly, they provide an adequate understanding of individual crops. Secondly, the 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 structures of a vivid agricultural region (Shafi, 2006). The cropping pattern of a region highly depends upon various factors like type of soil, productivity, market rates, weather conditions, availability of agricultural inputs, food demand, capital, and the cost of production.

Some of these determinants can be measured and can be quantified. However, factors like precipitation, floods, droughts, cyclones, and other natural calamities are hardly predictable. However, if the available data can be quantified properly, it may provide some valuable suggestions despite the exclusion of non-quantifiable factors (Sarkar et al., 1997). The cultivation of a crop continuously for a long period of time, the land exhausts its fertility and consequently, the yields decrease with the time. Crop diversification is an enhancing factor for the pest resistance, as well as, it enhances nitrogen in the soil to replenish the fertility of the soil. Thus, it enhances the sustainability of arable land. It generates more employment as the agricultural workers remain busy in sowing, weeding, harvesting and marketing of crops throughout the year (Gunasena, 2000).

Literature Review

Murugesan and Gangai(2018) examined cropping patterns, cropping concentration, crop diversification and crop combination in Thiruchirpalli district. They find out that the cropping patterns and crop combination are highly influenced by the irrigational facilities and the market demand. Bandyopadhyay and Desmusk (2017) made a block wise analysis of crop combinations of Nadia district. they find out that regions with paddy dominance are becoming more dependent on rice produced in winter season and Jute is considered as a major crop in the Monsson period for most of the blocks, shifting of rice dominated zone to commercial crop-producing zone is also observed. Chakraborty and Mistry (2017) investigated in their study that soil health and irrigational facilities were the determining factors for crop combinations in this region. In addition to this they suggested crop rotation and diversification improve stability of production, fertility of soil and economics of agriculture. Kumar (2017) examined the change in cropping pattern and cropping combination due to pipeline irrigation in Rohtak district of Haryana. The study results suggest that crop intensity has been increased with time and crop diversification has decelerated. The scarcity of groundwater leads to the present scenario of cropping in the study area.

Objectives

The objectives of the study are the following:

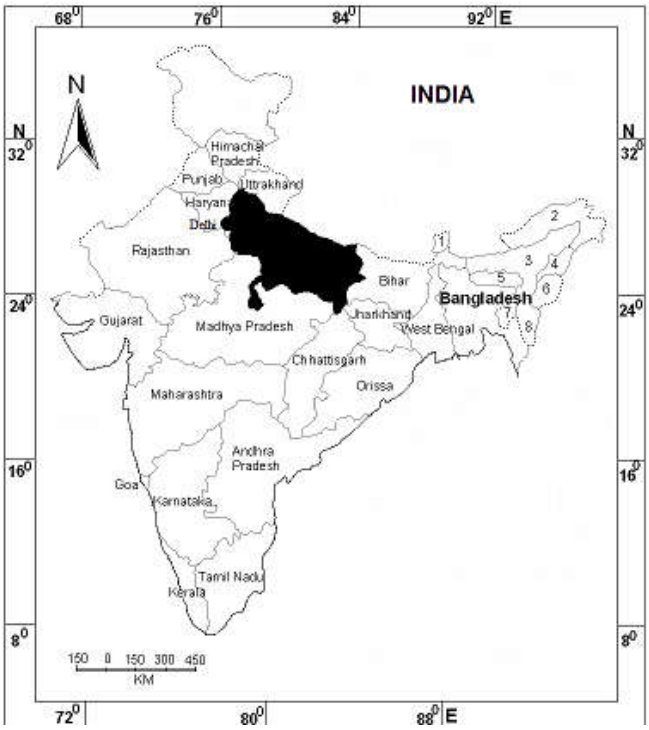
- To assess the crop ranking in the study area.
- To examine the crop combination in the district using Doi's method.
- To make a comparative analysis of crop combination of two different agriculture years.

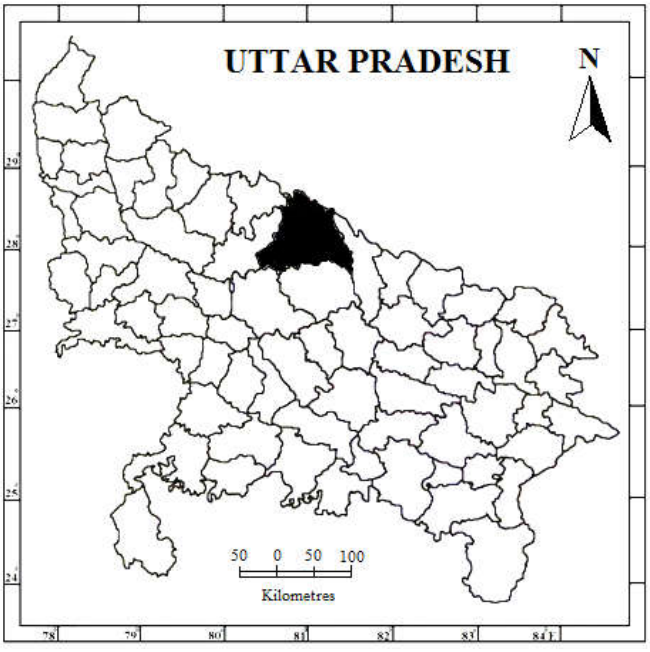
Data and Methodology: The data for the study has been gathered from secondary sources. The data of the area under cultivation of different crops have been collected from Kheri District Statistical Magazine, 2007 and 2018. The percent analysis of the crops was carried out to assess the ranking of different crops. All the crops are of different blocks were arranged in descending order and the ranks of every crop have been estimated. All the results of the crop ranking were shown with the help of maps generated by ARC GIS 10.2. The combination of the crops in Kheri district has been estimated with the help of Doi's An Abridged of Deviation Analysis Table. Doi's An Abridged of Deviation Analysis Table presents the ranking crop percent and cumulative percentage, which suggests a particular crop combination for a specific area. Doi's formula for crop combination is as follows:

$$Doi's\ Crop\ Combination = \Sigma\, d^2$$

Study Area

Lakhimpur Kheri District of Uttar Pradesh state has been taken as the study area for this study. Kheri is the largest district in Uttar Pradesh, lying along the Indo-Nepal Border. It is located in the Terai belt of Indo Gangetic Plain, moreover, the district has been placed in Eastern Uttar Pradesh, regionally. Kheri district has its headquarters in the city of Lakhimpur. Kheri district is roughly triangular in shape, pointing its apex towards the north, it is a part of Lucknow division. Kheri district sprawls between the parallels of 27°41' and 28°42'N latitudes and 80°2' and 81°19E latitudes. Kheri District has an area of 7680 km², ranking first in size in the state.





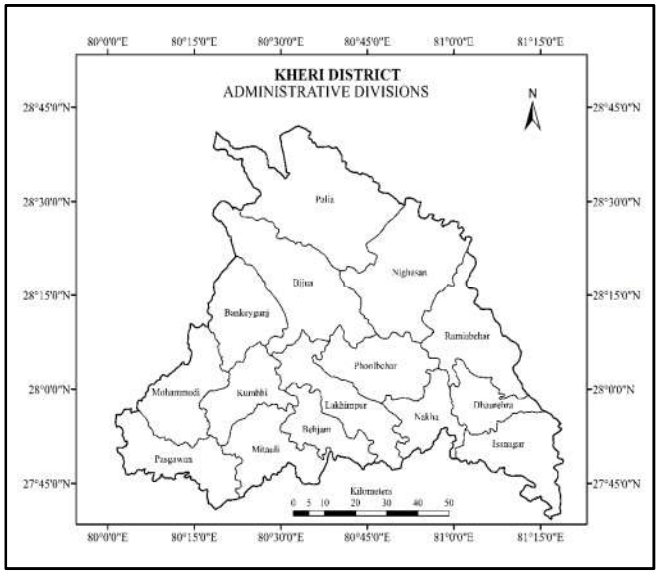


Figure 1. Study Area (Kheri District, Uttar Pradesh, India)

RESULTS AND DISCUSSION

The percentage of the crops was calculated blockwise, and all the crops were arranged in descending order to obtain their ranking in a particular block. In both text and maps, letter symbols are used to represent the major crops: S- sugarcane, W- wheat, R-rice, O-oilseeds, M-maize, P-pulses, F- fodder, V-vegetables. Figure 2 demonstrates the spatial distribution of the first ranking crops in the district of Kheri in the year 2006-07 and 2016-17. In the year 2006-07, sugarcane was the leading crop in the eight blocks of Kheri district i.e. Palia, Nighasan, Bijua, Ramiabehar, Dhaurehra, Nakha, Behjam, and Mitauli. While, in the year 2016-17, the sugarcane interestingly became the leading crop of 12 blocks consisting of Palia, Nighasan, Ramiabehar, Dhaurehra, Isanagar, Nakha, Bijua, Bankeyganj, Lakhimpur, Behjam, Mitauli, and Kumbha. Wheat was sprawling over the largest area in Mohammdi, Pasgawan, Kumbhi and Isanagar blocks in the year 2006-07, but, Isanagar block was excluded from this list in 2016-17. Hence, wheat was the leading crop in Pasgawan, Mohammadi and Phoolbehar Block.

Second Rank Crops

Figure 3 shows a comparative analysis of second-order crops in the Kheri district of two different agriculture years of 2006-07 and 2016-17. Rice is the second leading crop in 6 blocks i.e. Palia, Nighasan, Ramiabehar, Bijua, Mohammadi, and Behjam in 2006-07, while, after 10 years rice was second rank crop in 7 blocks consisting Palia, Nighasan, Bijua, Bankeyganj, Lakhimpur, Behjam and Mohammadi in 2016-17. In the year of 2006-07, wheat was the second leading crop in Bankeyganj, Phoolbehar, Nakha, Dhaurehra and Mitauli, on the other hand, Mitauli, Kumbhi, Isanaar, Nakha, Dhaurehra, and Ramibehar recorded wheat as the second-ranked crop in 2016-17. Moreover, the blocks of Pasgawan, Kumbhi, Lakhimpur, and Isanagar registered sugarcane as the second rank crop in 2006-07. However, only two blocks Phoolbehar and Pasgawanrecorded sugarcane as the second leading crop in 2016-17.

Third Rank Crops: Figure 4 examines the spatial distribution of third rank crops in Kheri district in the year of 2006-07 and 2016-17. In the year of 2006-07, wheat was the third-largest crop in 7 blocks namely Palia, Nighasan, Ramiabehar, Bijua, Bankeyganj, Lakhimpur, and Behjam. Similarly, rice was the third predominant crop in 6 blocks comprising Pasgawan, Mitauli, Kumbhi, Nakha, Dhaurehra, and Isanagar. Mohammadi and Phoolbehar registered sugarcane as the third largest crop. In the year 2016-17, Wheat was third ranked crop in six blocks, i.e. Palia, Nighasan, Bijua, bankeyganj, Lakhimpur and Behjam. Parallelly, rice was third largest crop in seven blocks consisting Pasgawan, Mitauli, Kumbhi, Ramiabehar, Phoolbehar, Nakha, Dhaurehra and Isanagar. Mohammadi was the only block having sugarcane as third largest crop.

Fourth Rank Crops: Figure 5 explains a comparative spatial distribution of fourth ranked crop in Kheri district in the years of 2006-07 and 2016-17. As a whole, in a curser view oilseed seems the fourth dominant crop in most of the blocks in both years. The map of 2006-07 clearly shows that oilseeds are the dominant crops in 13 out of 15 blocks. These blocks are Palia, Nighasan, Ramiabehar, Dhaurehra, Nakha, Phoolbehar, Bijua, Bankeyganj, Lakhimpur, Mitauli, Kumbhi, Mohammadi and Pasgwan. However, two blocks- Behjam and Isanagar registered pulses as the fourth ranked crop. In the year 2016-17, all the thirteen crops that wereregistering oilseed as fourth ranked crops were also experiencing oilseed as the fourth ranked crop in the year 2016-17. Moreover, Pulse was the fourth ranked crop only in the block of Behjam and Maize occupied the fourth rank in the block of Isanagar in 2016-17.

Fifth Rank Crops: Figure 6 assesses the block wise distribution of fifth ranked crop in the Kheri District in the year 2006-07 and 2016-17. In the year 2006-07, pulses were fifth dominant crop in 10 blocks including Nighasan, Dhaurehra, Nakha, Bijua, Bankeyganj, Lakhimpur, Kumbhi, Mohammadi, Pasgawan and Mitauli. Fodder was the fifth ranked cropped in Palia and Behjam blocks. Moreover, Ramiabehar and Isanagarhave reported maize as the fifth ranked crop. In the year 2016-17, pulses were fifth leading sprawling crop in 11 blocks consisting Nighasan, Dhaurehra, Nakha, Bijua, Bankeyganj, Lakhimpur, Kumbhi, Mohammadi, Pasgawan, Phoolbehar, and Mitauli blocks. However, Isanagar and Behjam block registered oilseed as the fifth ranked crop, and maize and fodder were reported fifth ranked crop only in single blocks of Ramiabehar and Palia respectively.

Sixth Rank Crops: Figure 7 depicts the comparative distribution of sixth ranked crops in the Kheri districts of two agricultural years. In the year 2006-07, fodder was reported as the sixth ranked crop in 8 blocks namely Bijua, bankeyganj, Mohammadi, Kumbhi, Pasgawan, Mitauli, behjam, and Lakhimpur. Moreover, pulses were the sixth predominant crop in Palia, Phoolbehar, and Ramiabehar blocks.

Three blocks, Nighasan, Nakha and Dhaurehra were experiencing maize as the sixth largest crop, while Isanagar registered oilseeds as the sixth largest crop. In the year of 2016-17, Fodder was predominant as sixth largest crop 10 blocks except all the blocks bordering Nepal. These blocks include Bijua, Phoolbehar, Nakha, Lakhimpur, Behjam, Mitauli, Pasgawan, Mohammadi, kumbha and Bankeyganj. Moreover, pulses were sixth ranked crop in 4 blocks consisting of Palia, Nighasan, Ramiabehar, and Isanagar, while, maize was sixth ranked crop in Dhaurehra.

Table 1. Crop combination 2006-07

Blocks	1st Ranking crop	2nd Ranking	3rd Ranking	4th Ranking	5th Ranking	6th Ranking	7th Ranking	8th Ranking
Palia	S	R	W	O	F	P	M	V
Nighasan	S	R	W	O	P	M	F	V
Ramiyabehar	S	R	W	O	M	P	F	V
Kumbhi	W	S	R	O	P	F	V	M
Bijua	S	R	W	O	P	F	V	M
Bankeyganj	R	S	W	O	P	F	V	M
Mohammadi	W	R	S	O	P	F	V	M
Mitauli	S	W	R	O	P	F	V	M
Pasgawan	W	S	R	O	P	F	V	M
Behjam	S	R	W	P	O	F	V	M
Lakhimpur	R	S	W	O	P	F	V	M
Phoolbehar	R	W	S	O	F	P	M	V
Nakha	S	W	R	O	P	M	F	V
Dhaurehra	S	W	R	O	P	M	F	V
Isanagar	W	S	R	P	M	O	V	F
Kheri District	S	W	R	O	P	F	M	V

Table 2. Crop combination 2016-17

Blocks	1st Rank crop	2nd Rank Crop	3rd Rank Crop	4th Rank Crop	5th Rank Crop	6thRank Crop	7th Rank Crop	8th Rank Crop
Palia	S	R	W	O	F	P	M	V
Nighasan	S	R	W	O	P	P	M	V
Ramiyabehar	S	W	R	O	M	P	F	V
Kumbhi	S	W	R	O	P	F	M	V
Bijua	S	R	W	O	P	F	V	M
Bankeyganj	S	R	W	O	P	F	V	M
Mohammadi	W	R	S	O	P	F	V	M
Mitauli	S	W	R	O	P	F	M	V
Pasgawan	W	S	R	O	P	F	V	M
Behjam	S	R	W	P	O	F	V	M
Lakhimpur	S	R	W	O	P	F	V	M
Phoolbehar	W	S	R	O	P	F	M	V
Nakha	S	W	R	O	P	F	M	V
Dhaurehra	S	W	R	O	P	M	F	V
Isanagar	S	W	R	M	O	P	F	V
Kheri District	S	W	R	O	P	F	M	V

Source: Kheri District Statistical Magazine

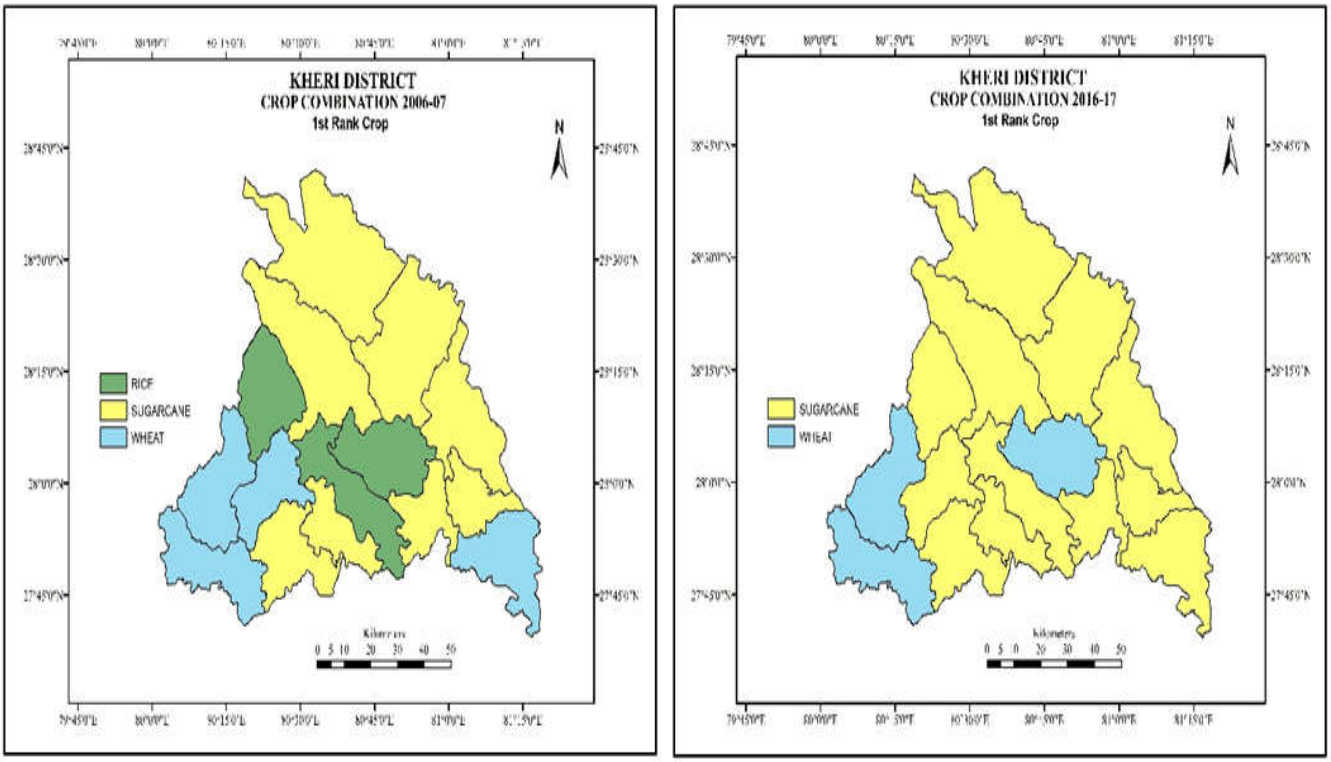


Figure 2. First Rank Crops

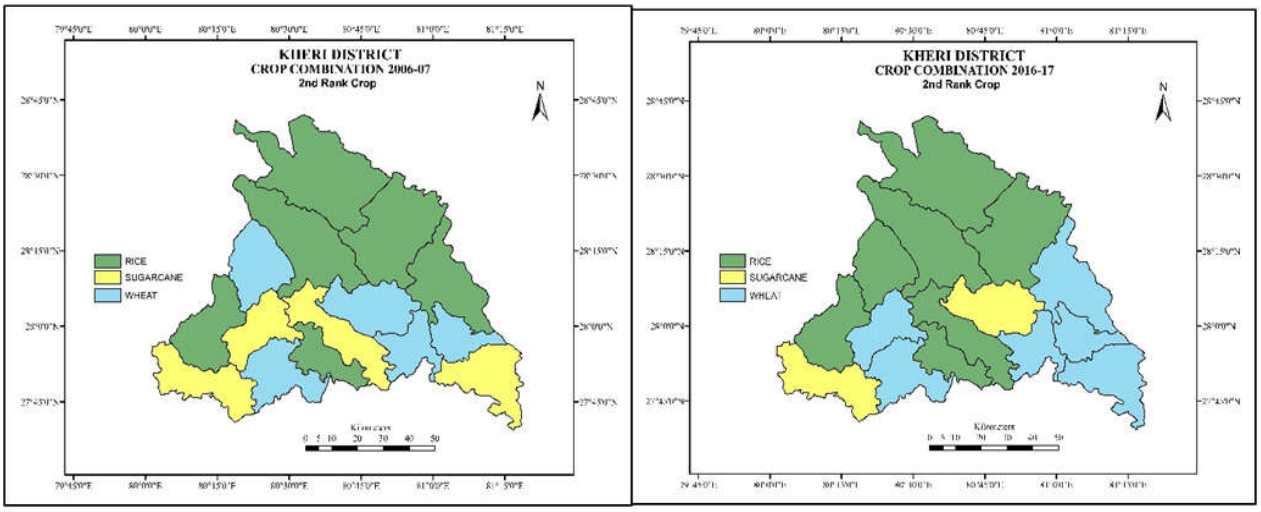


Figure 3. Second Rank Crops

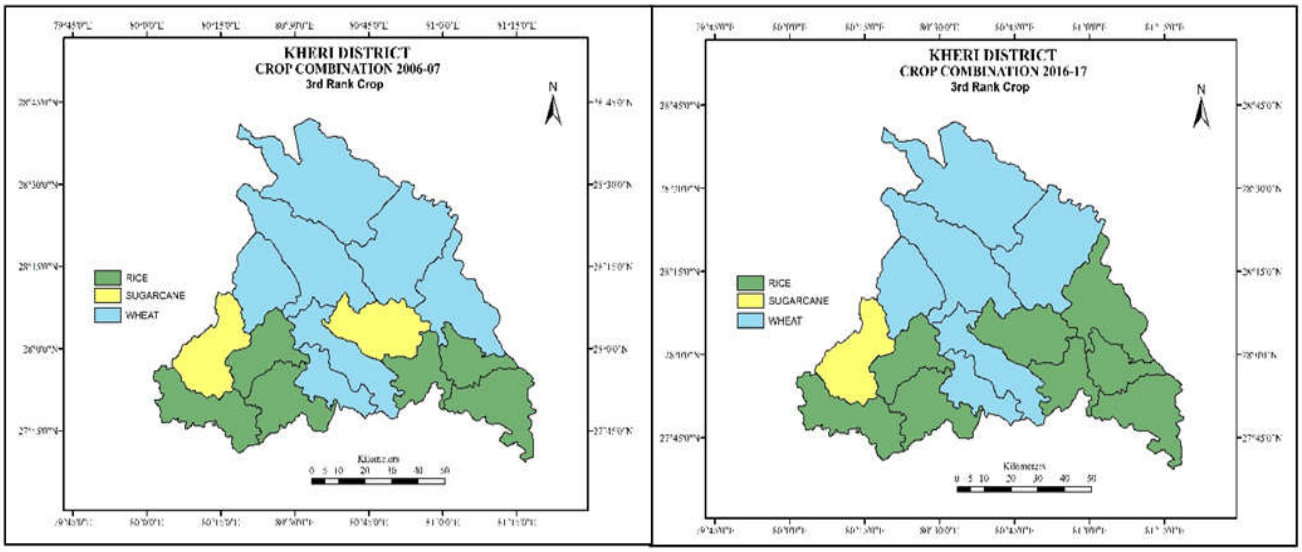


Figure 4. Third Rank Crops

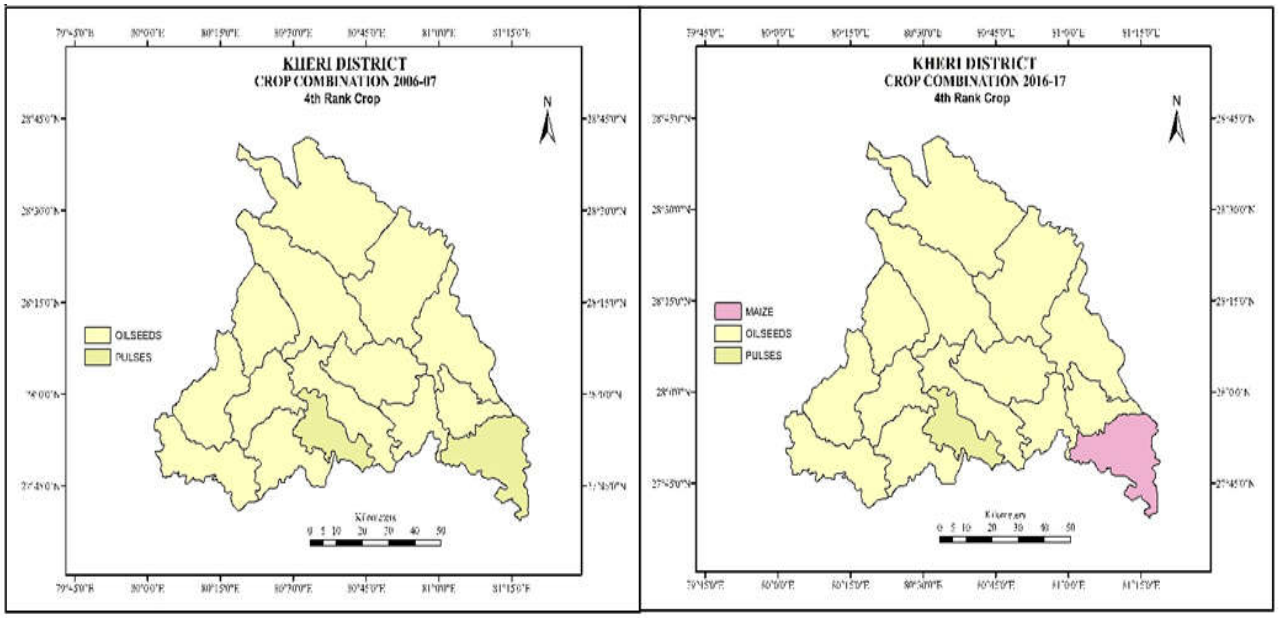


Figure 1. Fourth Rank Crops

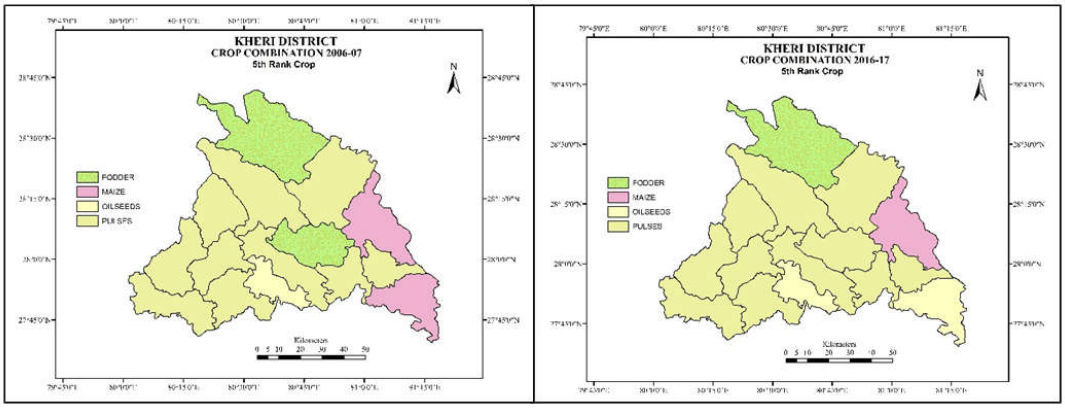


Figure 6. Fifth Rank Crops

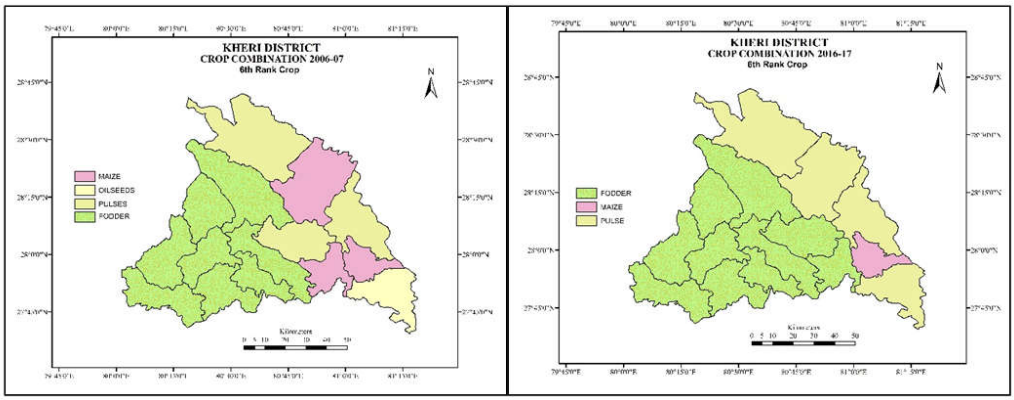


Figure 7. Sixth Rank Crops

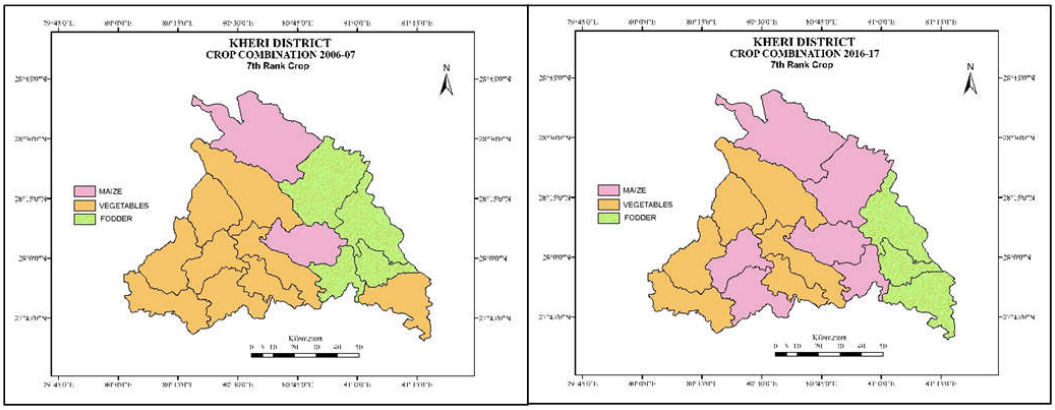


Figure 8. Seventh Rank Crops

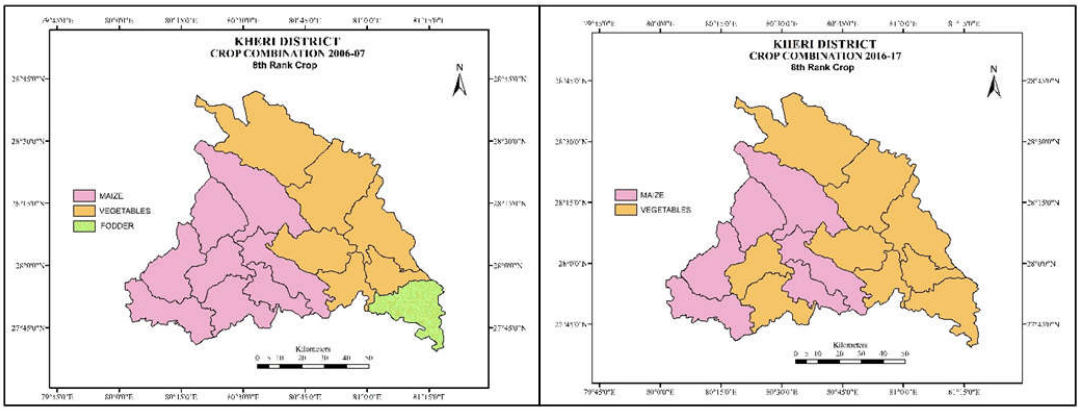


Figure 9. Eighth Rank Crops

Table 3. Crop Combination after Doi's Method

2006-07			2016-17		
Blocks	Crop Combination	Crops	Blocks	Crop Combination	Crops
Palia	3 crop Combination	SWR	Palia	2 crop Combination	SR
Nighasan	3 crop Combination	SWR	Nighasan	3 crop Combination	SWR
Ramiyabehar	3 crop Combination	SWR	Ramiyabehar	3 crop Combination	SWR
Kumbhi	3 crop Combination	SWR	Kumbhi	2 crop Combination	SW
Bijua	3 crop Combination	SWR	Bijua	3 crop Combination	SWR
Bankeyganj	3 crop Combination	SWR	Bankeyganj	3 crop Combination	SWR
Mohammadi	3 crop Combination	SWR	Mohammadi	3 crop Combination	SWR
Mitauli	3 crop Combination	SWR	Mitauli	3 crop Combination	SWR
Pasgawan	3 crop Combination	SWR	Pasgawan	3 crop Combination	SWR
Behjam	3 crop Combination	SWR	Behjam	3 crop Combination	SWR
Lakhimpur	3 crop Combination	SWR	Lakhimpur	3 crop Combination	SWR
Phoolbehar	3 crop Combination	SWR	Phoolbehar	3 crop Combination	SWR
Nakha	3 crop Combination	SWR	Nakha	3 crop Combination	SWR
Dhaurehra	3 crop Combination	SWR	Dhaurehra	Monoculture	S
Isanagar	3 crop Combination	SWR	Isanagar	3 crop Combination	SWR
Kheri	3 crop Combination	SWR	Kheri	3 crop Combination	SWR

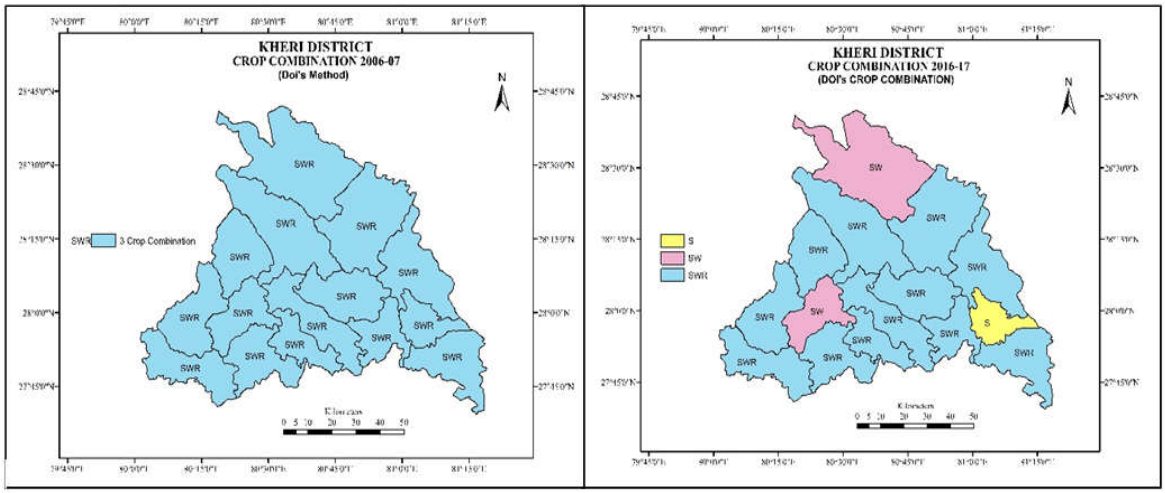


Figure 10. Crop Combination in Kheri District after Doi's Method

Seventh Rank Crops: Figure 8 reveals the spatial distribution of the seventh ranked crops in Kheri district in the year 2006-07 and 2016-17. In the year of 2006-07, Vegetables were predominant as seventh ranked crop in 9 blocks out of 15 blocks, i.e. Isanagar, Lakhimpur, Behjam, Mitauli, Kumbhi, pasgawan, Mohammadi, Bankeyganj, and Bijua. Hence, Fodder was seventh ranked crop in four blocks including Nakha, Dhaurehra, Ramiabehar, and Nighasan. Maize was occupied seventh place in Phoolbehar and Palia blocks. In the year 2016-17, vegetables were the seventh ranked crops in six blocks i.e. Bijua, Bankeyganj, Mohammadi, Pasgawan, Behjam, and Lakhimpur. Parallelly, Maize was sprawling in six blocks namely Palia, Nighasan, Phoolbehar, Nakha, Mitauli, and Kumbhi as the seventh ranked crop. However, fodder was reported in Isanagar, Dhaurehra, and Ramiabehar as the seventh ranked crop.

Eighth Rank Crops: Figure 9 shows the comparative analysis of the least sprawled crops in the Kheri district in two different years. In the year 2006-07, Maize was the least dominated crop in 8 blocks of Bijua, bankeyganj, Mohammadi, Pasgawan, Mitauli, Kumbhi, Behjam and Lakhimpur. While, vegetables were occupying the smallest area in the blocks of Palia, Nighasan, Ramiabehar, Dhaurehra, Nakha and Phoolbehar. Fodder was reported as least crop only in Isanagar block. In the year 2016-17, vegetables were the eight ranked crops in 9 blocks namely, Mitauli, Kumbhi, Nakha, Phoolbehar, isanagar, Dhaurehra, Nighasan, Ramiabehar, and Palia. However, all other 6 blocks of Bijua, Bankeyganj, Mohammadi, Pasgawan, Behjam and Lakhimpur have registered vegetables as the least sprawled crops.

Crop Combination after Doi's Method: By using Doi's technique, the crop combination of Kheri district has been analysed. The results suggested that there was three crop combination in all the blocks of Kheri district in the year 2006-07. While in the year 2016-17, three types of crop systems were identified in the Kheri district. Crop combinations of the district are discussed following:

Monoculture: In Doi's crop ranking technique, monoculture suggests the cultivation of a single crop over half of the cultivated area. Dhaurehra block was the only to experience monoculture in the whole district in the year 2016-17. Sugarcane was occupying more than half of cultivated area in this block. The reason for high sugarcane cultivation in this region was a good market due to sugarmills and good payment system. This block lies at the confluence of Ghaghara and Sharda river, experienced heavy flooding in the rainy season.There is not such crop which can survive in the flood condition in this block, therefore the farmers go for sugarcane cultivation. The plant of sugarcane is longer so it can survive in the floods.

Two Crop Combination: There were only two blocks, Palia, and Kumbhi which registered two crop combinations in the

year 2016-17. Paliahada combination of sugarcane and rice crops, sugarcane accounting for the highest area under acreage followed by rice. While, Kumbhi block had a combination of sugarcane and wheat crops, sugarcane sharing the highest area under cultivation followed by wheat. The acreage of the leading crop i.e. sugarcane was reported less than 50 percent, therefore, another crop has been included in this combination in this technique. Thus, it is evident from this result that these blocks are most suitable for the cultivation of these crops.

Three Crop Combination: In the year 2006-07, all the blocks were reported to have three crop combinations. The crops consisted of this combination were sugarcane, wheat, and rice. In the year 2016-17, 12 blocks out of 15 were registered three crop that combination in the district, these blocks include Nighasan, Ramiabehar, Phoolbehar, Nakha, Isanagar, Lakhimpur, Behjam, Mitauli, Pasgawan, Mohammadi, Bankeyganj and Bijua. The result suggests that sugarcane, wheat, and rice are the significant crops of the district. In most of the blocks these three crops surpass 90 percent of the acreage. The conditions are favorable for these crops. The blocks in the swampy area had generally sugarcane as the main crop. While wheat is cultivated in almost all the blocks indiscriminately. As well as, rice is dominant in the swampy area and well irrigated area.

Conclusion

Kheri district is an agriculturally rich district in Uttar Pradesh and accounts for the highest sugarcane production in the whole state. The results suggest that the district is predominantly inclined towards the sugarcane cultivation. Wheat and rice are the second and third leading crops in the district. The ranking of the crop represents two clusters of the crops i.e. a) sugarcane, rice, and wheat and, b)oilseed, pulses and maize. While vegetables and fodder are the other trace crops which area found negligible in all the blocks sprawling over small cultivated area. In Doi's method of crop combination, it has been found out that there is a dominancy of three crop combinations in all the blocks in both agricultural years of study having a combination of sugarcane, wheat, and rice crops. Only two blocks Palia and Kumbhi in 2016-17 had two crop combinations having a combination of sugarcane with rice and wheat. Only one block Dhaurehra was experiencing monoculture where sugarcane was the predominant crop accounting for more than half of the acreage.

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