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Crop Combination and Crop Diversification in Chandauli District, U.P.: A Geographical Analysis

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The concept of crops combination and diversification is a scientific device to study the existing relationship of crops in association with each other. The pattern of crop combination gives spatial predominance of specific crops or combination, resulting in the emergence of crop regions. However, it is evident that the higher the number of crops in a combination, the greater the Degree of diversification. Crops are diversified in the field due to the erratic nature of rainfall and insufficient irrigation. The study of crop combination and crop diversification thus forms an integral part of agricultural geography, and such study is exceedingly helpful for regional agricultural planning.

Keyword- Crop combination, Crop diversification,

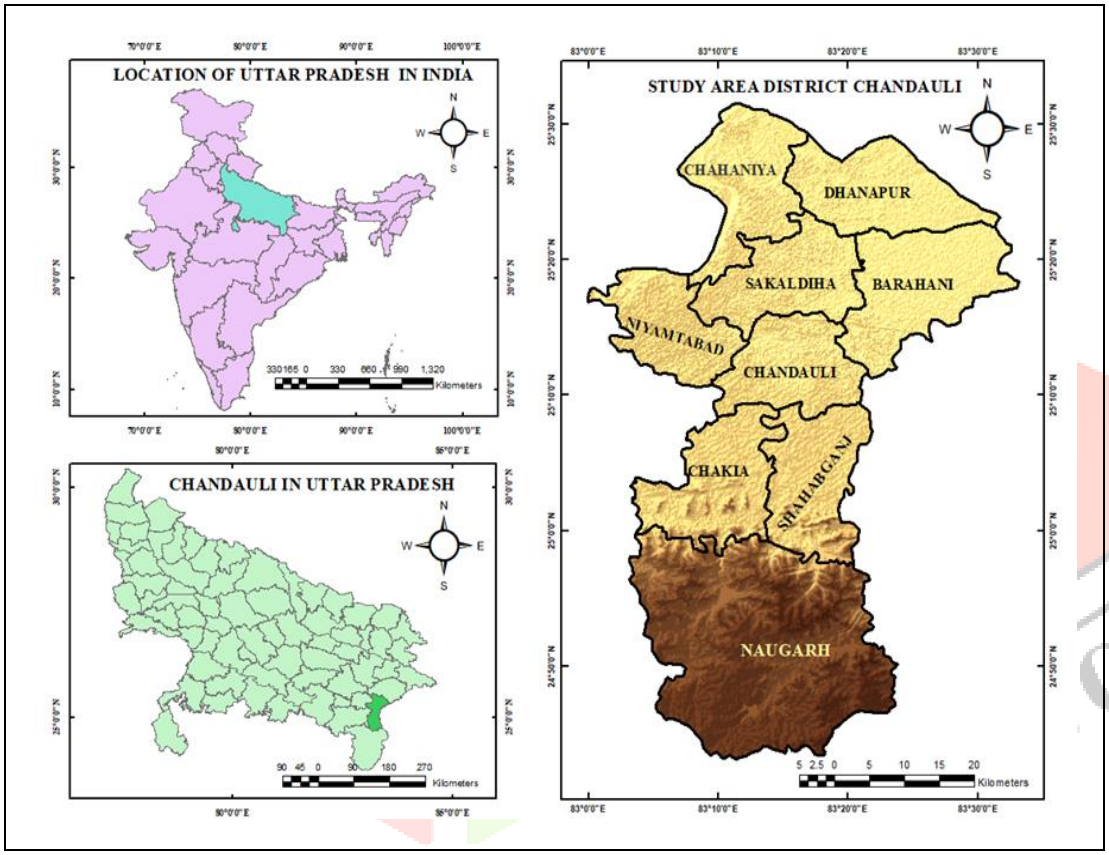
Introduction

Crops are generally grown in combinations (Weaver, 1954). The study of crop combination of any region has gained importance in the geographical study. It gives us the relative position of crops on the regional scale. The concept of crops combination is a scientific device to study the existing relationship of crops in association with each other and land utilization (Comred, 1979). Crops are commonly grown in combination and it is hardly that a specific crop occupies a position of the total isolation from other crops in a given area. The pattern of crop combination gives spatial prevalence of certain crops or combination resulting in the emergence of crop regions (Todkari 2012). Such an analysis would ultimately minimize the chances of oversimplified generalization. Crop combination study in geography is fruitful in several ways; firstly, it provides an ample understanding of an individual crop. Secondly, the combination is in itself an integrative reality and finally crop combination regions are essential for the construction of a more complex structure of vivid agricultural regions. The study of crop combination thus forms an integral part of agricultural geography and such study is significantly helpful for regional agricultural planning.

Study Area

District Chandauli is a part of middle Ganga plain, and it is situated in the eastern part of Uttar Pradesh lies between 24º 42' to 25º 35' north latitudes and 83.00' to 83º 24' east longitudes, the total area of the region is 2441 sq. Km. The study area bounded by both political and natural boundary in the north-west to north all boundary covered by river Ganga, in north-east to south-east cover by Bihar state, in southern by Sonbhadra district and the west by Mirzapur district. This region belongs a humid subtropical monsoon climate with mild winter and severe summer, characterize by cwg according to Koppen's climate classification. Where 85 per cent of annual rainfall received during June to September and remaining rainfall is received through western disturbance during the winter season. The District is dividing into four micro agro-climatic situations, low laying paddy land, hill area, irrigated upland, and rain-fed area.

LOCATION MAP OF CHANDAULI DISTRICT



(Fig. 1)

Methodology

The present research is based on secondary data collected from District statistical Patrika, Chandauli ranging between years 2000-01 to 2016-17 at the district and block level as District and block was the study unit. The crops are arranged and ranked in hierarchical order and then crop combinations, and diversification is obtained respectively with the help of Weaver and Bhatiya method. Using ArcGIS 10.5 software to prepare crop combination and crop diversification map.

Weaver's Crop Combination Method

Weaver was the first Geographer who used (1954) statistical technique to express the crop combination of the Middle West USA. In this process, Weaver attempt to the delineation of agricultural regions of the Middle West in the United States computed the percentage of total harvested cropland occupied by each crop that held as much as one per cent of the 184 total cultivated lands in each of the 1081 counties. In this work, Weaver calculated the deviation of the real percentage of crops (occupying one per cent of the cropped area) for all the possible combinations in the component areal units against a theoretical standard.

The theoretical curve for the standard measurement was employed as follow

Monoculture = 100 % of the total harvested cropland in one crop.

Two crop combination = 50 % in each of the two crops.

Three crop combination = 33.3 % in each of the three crops.

Four crop combination = 25 % in each of the four crops.

For the determination of the minimum deviation the standard deviation method was used: Where d is the difference between the actual crop percentages in a given areal unit and the appropriate percentage in the theoretical curve 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 extracted so, the actual formula used as follows

$$d = \Sigma d^2/n$$

RESULT AND DISCUSSION:

Table 1: Crop Combinations in Chandauli district 2000-01

Type of Crop combination	Monoculture	Two Crop		Three Crop			Four Crop			
Theoretical % (A)	100	50	50	33.33	33.33	33.33	25	25	25	25
% of the crop land occupy (B)	46.48	46.48	40.82	46.48	40.82	7.56	46.48	40.82	7.56	1.23
Deviation (A-B)	53.52	3.52	9.18	-13.15	-7.49	25.77	-21.48	-15.82	17.44	23.77
d^2	2864.39	12.41	84.34	172.84	56.05	664.12	461.26	250.16	304.17	564.87
Σd^2	2864.39	96.75		206.17			1580.46			
$d = \Sigma d^2/n$	2864.39	48.38		68.72			395.12			

Source- **Computed the data from district statistical Handbook, Chandauli District. 2001 and 2017**

Monoculture

Rice is the leading crop in the study area in both years. Showing highest coverage in the District (table no.1). It was grown 101655 ha. (46.48 %) in 2000-01 (table no.2). Whereas, in 2016-17 it is grown 114052 ha. (48.35 %) in the study area. It is the result of a fertile plain, irrigation facility, climate condition and Rice culture favours the cultivation of Rice. The 'd' of monoculture crop is much higher than other crops combination in both time frame (table no.1 & 2). Therefore, it is not a suitable combination for the study area.

Two crop Culture

Rice (the Kharif) and Wheat (the Rabi) is the main crop of this category of the study area in both years. Wheat is the second crop which is occupied the highest area after Rice in both years. Wheat covers 89247 ha. (40.8 %) and the total area under this category was 87.30 % of the total study area in 2000- 01. Whereas, in 2016-17 wheat cropped

area has been increased 99168 ha. (41.87%) and the total area under this category, 90.22% of the total study area. It is the lowest crop culture (d) in both times (Table 1 and 2). Therefore, two crop combination is the best suitable crop combination of this area.

Three crop culture

Rice (Kharif) wheat (Rabi) and Pulses have entered in this combination in both years (table 1&2). The total area under this category was 94.89 %. Where pulses covered 16534 ha. (7.56%) in 2000-01 (Table 1). Whereas, in 2016-17, the total area under this category is 96.32%. Where pulses occupied only 14436 ha. 6.10% (Table 2). It is the second-best crop combination of the study area.

Table 2: Crop combination in Chandauli District 2016-17

Type of crop combination	Monoculture	Two Crops		Three Crops		
Theoretical % (A)	100	50	50	33.33	33.33	33.33
% of the crop land occupy (B)	48.35	48.35	41.87	48.35	41.87	6.10
Deviation (A-B)	51.65	1.65	8.13	-15.02	-8.54	27.23
d^2	2668.10	2.73	66.07	225.49	72.96	741.73
Σd^2	2668.10	68.80		1040.18		
$d= \Sigma d^2/n$	2668.10	34.40		346.73		

Source- Calculated by the researcher and adopted from District statistical Handbook Chandauli, 2001 and 2017.

Four crop culture

In four crop culture, only find in 2000-01 (Table 1). The total area under this category was 96.09 % of the study area. Where Maize and Pulses covered respectively 7.56% and 1.23% area in 2000-01.

Blockwise Crop combination analysis of Study area

Table 3 depicts that the crop combination in blocks of Chandauli for two separate years from three crop combination to seven crop combination. The details are as follows.

Three Crop Combinations

Sakaldiha, Chandauli, Barahani blocks identified as three crop combination in 2000-01 (Fig. 2). Whereas, in this category number of blocks has been increased, which has extended till Chakia and Shahabganj in 2016-17 (Fig. 2). However, the noticeable point is that Maize which has an identity in 2000-01, has substituted by the pulses in 2016-17 (Table 1). As Maize demand more protection from insect to till thief. On the other hand, zero participation in the daily diet; therefore, farmers reduce the cultivated area of Maize.

Four Crop Combinations

Niyamtabad, Chakia and Shahabganj blocks had four crop combinations in 2000-01. Whereas, in 2016-17 also as it is based on block number (Table 1). Nevertheless, in the place of Chakiya and Shahabganj blocks occupied by Dhanapur and Naugarh in 2016-17 (Fig. 2). In Niyamtabad block Maize replace by millet crop. Because millet is more suitable crop compare to Maize for animal feed. In these blocks, Wheat, Rice Pulses and Millet are conventional crops only Naugarh have Oilseeds in forth crop (Table 1) In these circles have found such type of crop combination because of irregularity in fertile soil as well as irregularity in irrigation facilities.

Table 3: Block wise study of Crop Combination in Chandauli district 2000-01 and 2016-17

Source- Calculated by the researcher and adopted from District statistical Handbook Chandauli District.

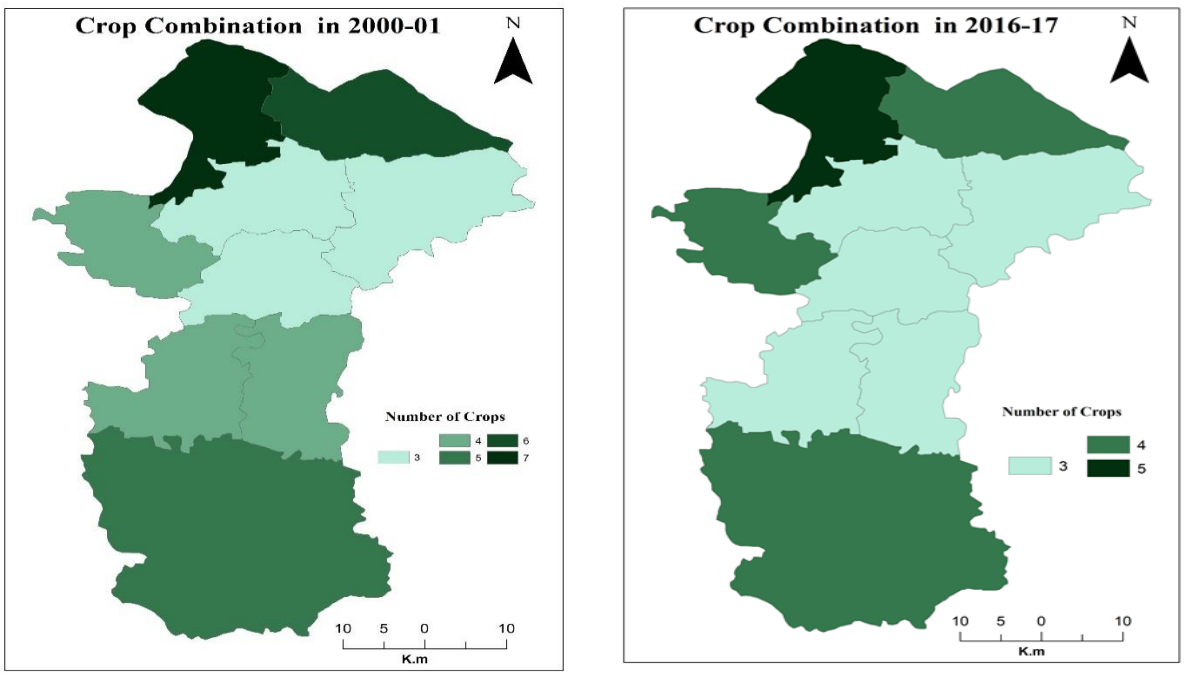
Five Crop Combinations

Name of the Block	No. of Crops	Crops Combination in 2000-01	No. of Crops	Crops Combination in 2016-17
Chahaniya	7	Wheat, Rice, Millet, Pulses, Jowar, Sugarcane, Barley	5	Wheat, Rice, Millet, pulses, Jowar
Dhanapur	6	Wheat, Rice, Pulses, Sugar cane, Millet, Maize	4	Wheat, Rice, Pulses, Millet
Sakaldiha	3	Wheat, Rice, Maize	3	Rice, Wheat, pulses
Niyamatabad	4	Rice, Wheat, Maize, Pulses	4	Wheat, Rice, Pulses, Millet
Chandauli	3	Rice, Wheat, Maize	3	Rice, Wheat, pulses
Barahani	3	Rice, Wheat, Maize	3	Rice, Wheat, pulses
Chakiya	4	Rice, Wheat, Maize, Pulses	3	Rice, Wheat, pulses
Sahabganj	4	Rice, Wheat, Maize, Pulses	3	Rice, Wheat, pulses
Naugarh	5	Rice, Wheat, Pulses, Maize, Millet	4	Rice, Wheat, Pulses, Oilseeds
District	4	Rice, Wheat, Maize, Pulses	3	Rice, Wheat, pulses

Only Naugarh block has identified five crop combinations in 2000-01 (Fig. 2). The crops are Rice, Wheat, Pulses, Maize and Millet (Table 1). Whereas, in 2016-17 also one block identified in this category (Fig. 2) Which is Chahaniya and the crops are Wheat, Rice, Millet, pulses and Jowar (Table1) Because these blocks have physical adversities like Naugarh is the hilly area and Chahaniya bounded by the Ganga River from south-west to north-east. These phenomena break the regularity of soil nature, the irrigation facility. Therefore, farmers interested in sown more crops at one point in time.

Six Crop Combinations

Only Dhanapur block has identified six crop combinations in 2000-01(Fig. 2), and the crops are Wheat, Rice, Pulses, Sugar cane, Millet and Maize (Table 3). Whereas, not any single blocks find in this category in 2016-17.



Source- **prepared by the author** **(Fig. 2)**

Seven Crop Combinations

Only Chahniya block has identified seven crop combinations in 2000-01(Fig. 2), and the crops are Wheat, Rice, Millet, Pulses, Jowar, Sugar cane and Barley (Table 3). Whereas not any single blocks find in this category in 2016-17.

Crop Diversification

Diversification means raising a variety of crops. Crops are diversified in the field due to the erratic nature of rainfall and insufficient irrigation (Singh and Dhillon, 1984). The more significant number of crops led to greater competition, and the higher is the magnitude of diversification (Bhatiya, 1960). In Indian conditions, the diversification is a common phenomenon because the farmers try to satisfy most of the family demands from its own land resulted in crop diversification. The cultivation of crops depends on physical and socio-economic factors (Murgan et al. 2018), and the crops are the result of contemporary competition. It is evident that the greater the number of crops in a combination, the greater the degree of diversification (Mehta, 2010). Bhatia's (1965) formulated the following formula to find out the diversification of crops in a particular area.

$$\text{Index of crop Diversification} = \frac{\text{Percentage of shown Area under X crop}}{\text{Number of X crop}}$$

The Areas of Low Magnitude of Crop Diversification 25 < :--

In 2000-01, three blocks belonged to this category, namely Sakaldiha, Chanduli and Barahani (Fig. no.3) and the total area of under this group was 43.57% (Table 5). Whereas, in 2016-17, five blocks came under this category, namely Sakaldiha, Chandauli, Barahani, Chakiya and Shahabganj (Fig. 3) which that covered 63% of the total study area (Table 5). Because all these areas which are falling in this group have a homogeneous nature based on soil, slope, irrigation facilities, developed transport network and market. These amenities never allowed farmers for sown other crops on the big scale. Thus, their choice had fallen on Wheat, Rice and pulses, which lead to a low magnitude of crop diversification. Chakiya and shahabganj are new blocks in 2016-17 to come under this classification after removing Maize crop (Table 3).

Table 4: Block wise Degree of diversification in Chandauli District between 2000-01 and 2016-17.

Source: District Statistical Hand Book, Chandauli District, 2001 and 2017, Computed by Researcher

Name of the Block	No. of Crops	Diversification index 2000-01	No. of Crops	Diversification index 2016-17
Chahaniya	7	14.02	5	19.58
Dhanapur	6	19.49	4	24.49
Sakaldiha	3	32.61	3	32.85
Niyamatabad	4	24.56	4	24.49
Chandauli	3	32.79	3	32.83
Barahani	3	32.90	3	32.92
Chakiya	4	24.56	3	32.84
Sahabganj	4	24.75	3	32.87
Naugarh	5	19.83	4	24.62
District	4	24.02	3	24.08

Area of Medium Magnitude of Crop Diversification (21-25)

Area of medium crop diversification covers 30.49 per cent of the study area in 2000-01 (Table 5). It appeared in three blocks, namely Niyamtabad, Chakiya and Shahabganj. Whereas in 2016-17 also spread in three blocks, but the blocks have changed. The block falls in moderate diversification, namely, Dhanapur, Niyamtabad and Naugarh, which covered 25.47% of the study area (table 5). Niyamtabad is the common block in both given years for this category (fig. 3). Chakiya and Shahabganj, these blocks are having some physical adversities (see location map) therefore farmers grew various crops in 2000-01, but with the help of adequate irrigation facilities and sufficient agricultural infrastructure, farmers grow limited crops in this block, and now these blocks came under the low magnitude of crop diversification (Table 4). Dhanapur and Naugarh have newly entered blocks in this category because farmers want to grow those crops which that use in daily life (Fig. 3)

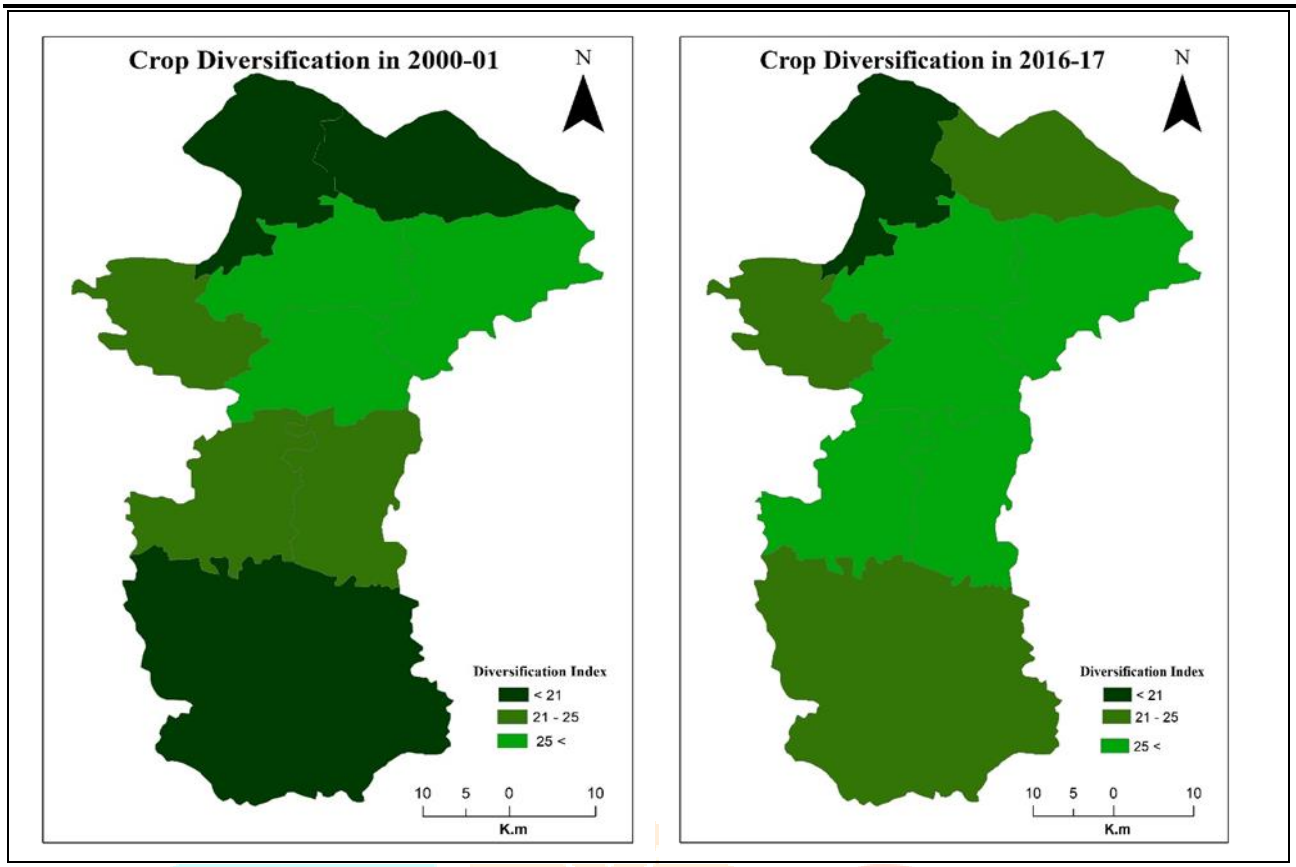
Table 5: Category of Crop Diversification in Chandauli District between 2000-01 and 2016-17.

Category	**blocks in 2000-01**	**Area (%) 2000-01**	**blocks in 2016-17**	**Area (%) 2016-17**
High< 21	3	25.92	1	11.72
Medium 21-25	3	30.49	3	25.47
Low 25 <	3	43.57	5	63.00
Total	9	100	9	100

Source: District Statistical Hand Book, Chandauli District, 2001 and 2017, Computed by Researcher

Areas of High Magnitude of Crop Diversification 25<

Areas under High Magnitude of Crop Diversification covered three blocks, namely chahaniya, Naugarh and Dhanapur (fig. 3) which has been occupied 25.92 % in 2000-01 of the total study area (Table 5). Because these blocks have some adverse physical site, therefore farmers interested in more crop at one point of time. Whereas, in 2016-17 only one block came under this category which is Chahaniya (Fig. 3) chahaniya located an edge of the Ganga River and its severely affected by receiving river effects, therefore farmer compulsion to sown more dryland crops like millet, pulses and Jowar (Table 3).



Source- **Prepared by Authors** **(Fig. 3)**

Conclusion

The detailed analysis of crop combination of them both given time in the study area reveals that Rice, Wheat and Pulses are the main crops in Chandauli district. Because most of the part have alluvial (fertile) soil, adequate irrigational facilities and developed agricultural infrastructure. At the block level analysis Chahaniya, Dhanapur and Naugarh blocks have some adverse physical site. Therefore, farmers of these blocks sown more than four crops in both given times. However, In the case of other blocks which has fertile plain. Therefore, farmers have no more choice except Rice, Wheat and pulses. However, the noticeable point is that the crop combination which was 3-7 in 2000-01. It has been reduced in 2016-17 and came 3-5. As increase irrigation facilities, awareness about modern technology and changes in food style. Low magnitude crop diversification finds in the middle part of the study area. Where, fertile plain, gradual slope, irrigation facilities and proper market, promote to Rice, Wheat and pulses culture. While farmers struggling with either the adverse physical environment or less developed agricultural infrastructure or both had witnessed moderate to the high magnitude of crop diversification.

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