Spatial-Temporal Variation in Cropping Intensity and Crop Combination Region in Upper Ganga-Yamuna Doab (U.P.) India

Dr Mohammad Zafar Iqbal*

Guest Faculty, Department of Geography, Kamla Rai College, Gopalganj, JP University Chapra Bihar, India.

*Corresponding Author: *Dr Mohammad Zafar Iqbal*, *Guest Faculty, Department of Geography, Kamla Rai College, Gopalganj, JP University Chapra Bihar, India.*

Abstract: *The present research work examines the pattern of cropping intensity and crop combination among the districts of Upper Ganga-Yamuna Doab. This study is a part of agricultural regionalization, a technique for dividing land into different fragments as well as facilitates our understanding of the existing agricultural patterns of the region. Thus, in this study the quantitative methods of crop combination and cropping intensity has been carried out. In general, five crops are found to be the cultivated in Upper Doab crops viz., Barley, Maize, Rice, Wheat and Sugarcane have the maximum share. During the period 2001-05, cropping intensity was low for two districts, moderate for three districts and high for two districts, while in the period 2006-10 the cropping intensity was high for three districts, moderate for three districts and low for one district. Crop combination regions considering all the districts of Upper Doab based on Weaver's method were worked out for three distinct periods 2000-01, 2005-06 and 2010-2011.*

Keywords: *Cropping Pattern, Agricultural Regionalization, Cropping Intensity and Crop Combination.*

1. INTRODUCTION

The study of crop combination and crop intensity is an important aspect of agricultural geography, as it provides a clear basis for agricultural regionalization. The definition of crop combination has drawn the attention of geographers and agricultural land-use planners in recent years. The research done so far ranges from topical to regional in this field and varies in scale from small areas of minor political units to the entire world. Cropping Intensity (CI), defined as the number of crops harvested annually vary widely from region to region in the Space as well as time (Siebert et al., 2010) [1]. The variation between water requirements, soil conditions, biogeochemical cycles, natural resources and agricultural production are expressed (Monfreda et al., 2008[2]; Portmann et al., 2010) [3]. In addition, unsustainable agricultural land-use activities in many parts of the country can have major adverse effects on the ecological environment and on food production (Yan et al., 2014) [4]. Weaver (1954) [5] was the first to use statistical techniques in the field of agricultural geography to develop the Middle West (USA) crop combination. In the demarcation of combinations of crops and live-stock (Scott, 1957[6]; Coppock, 1964) [7] others have adopted this strategy. Its weakness has been shown by others (Rafiullah, 1956) [8] or have attempted, after reasonable modifications, to present and use it (Doi, 1970[9]; Ahmad and Siddiqui, 1967[10]; Husain, 1976[11]; Jasbir Singh, 1976). [12]

*Guest Faculty, Department of Geography, Kamla Rai College, Gopalganj JP University, Chapra, Bihar (India).

The cropping patterns of crop concentration and diversification were introduced to India through Bhatia's studies in 1965[13].The pattern of crop concentration reveals the intensity of any crop in a given area at a point of time. It refers to the number of crops grown in the area during a year. It is the extent to which the net sown area is re cropped or re sown (Singh, 1999) [14]. Kenichi Tatsumi (2016) [15] detailed analyses of cropping intensity and crop seasonality parameters, such as the beginning and end of cropping intensity are given. For the period 1999–2010 across Mainland Asia, a season, the duration of a season, and the seasonal amplitude. A recent research on agricultural land use and crop trends was conducted by Shyju and Kumaraswamy (2017)[16] in Talappilli Taluk, Thrissur District in Kerala. Therefore, high cropping index value will be the higher the cropping index value will be the higher agricultural land use efficiency, and consequently, indicates a lower percentage of fallow land.

2. OBJECTIVES

1. Show the spatial pattern of cropping intensity among the district of Upper Doab.

2. To calculate the weaver's minimum deviation method in the all district of Upper Doab

3. STUDY AREA

 The Upper Ganga-Yamuna Doab in Uttar Pradesh, which is relatively more advanced agriculturally region in the state. It comprises the seven districts of which namely, Saharanpur, Muzaffarnagar, Baghpat, Meerut, Ghaziabad, Gautama Buddha Nagar and Bulandshahar. It lies on the north western side of Uttar Pradesh, between the two master streams-the Ganga and the Yamuna and spreads between 28˚ 4' N to 30˚ 24' N latitudes and 72˚ 2' to 78˚ 29' E longitudes(Fig. 1).
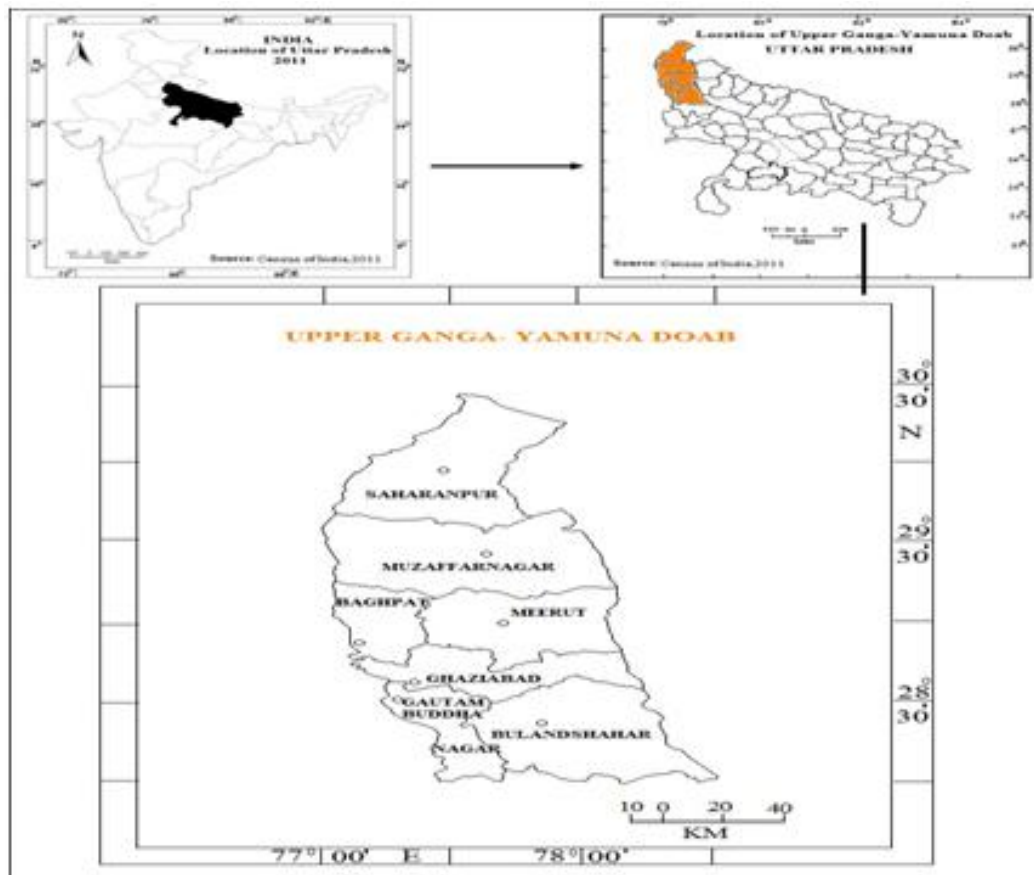

Fig. 1

4. DATA AND METHODOLOGY

The present research work is entirely based on secondary sources of data collected from District *Statistical Magazine,* Lucknow, Uttar Pradesh. In order to work out the cropping intensity following method has been used by the Directorate of Agriculture, Government of India is as follows:

$$\text{Cropping Intensity} = \frac{\Sigma ai_j}{\Sigma ai_0} \div \frac{N_j}{N_0} \times 100$$

Where

ai_j = area under the ith crop in the jth year

ai_0 = area under the ith crop in the base year

N_j = net area sown in the jth year

N_0 = net area sown in the base year

For the determination of the minimum deviation the standard deviation method was used:

$$\text{Standard Deviation (SD)} = \frac{\sum d^2}{n}$$

Where d = Difference between the actual crop percentage of a

block and equivalent theoretical value.

n = the number of crops in a given combination

5. RESULTS AND DISCUSSION

Main advantage of the study lies in the fact that, it enables to understand the specialization of different crops grown in a region at a given point of time. Cultivation of specific crops in unit or region, however, leads to progressive reduction in yield, and therefore, rotation of crops with diverse choice, permissible under the environmental conditions; need to be grown for profitable from crop cultivation returns. In upper Ganga-Yamuna *doab*, cropping intensity has been computed for the period from 2001-10, by dividing the entire period of 10 years into two different points of time, i.e. 2001-05 and 2006-10. In order to determine the cropping intensity the total cropped area was divided by the net sown area and the result obtained was multiplied by a value of 100. The district wise cropping intensity indices computed for upper Ganga-Yamuna Doab shows that during 2001-05, the highest intensity is found in the district of Bulandshahar (168.94), followed by Ghaziabad (159.19), Baghpat (158.42), Saharanpur (154.35), (Meerut 153.29), Muzaffarnagar (146.66). The cropping intensity values the districts of the region are given Table 1. The districts have been grouped into three distinct categories: high, medium and low. It can be seen from Fig. 2 that, during the period of 2001-05 high cropping intensity (159.19 and above) was in two districts of Bulandshahar and Ghaziabad, whereas medium intensity (153.29 -159.19) was in three districts in three of Baghpat, Saharanpur and Meerut. Whereas, low crop intensity (below 153.29) was found in two districts of Muzaffarnagar and Gautam Buddha Nagar.

Table1. *Districtwise Cropping Intensity in the Upper Ganga Yamuna Doab*

Name of the District	2001-05	2006-10
Saharanpur	154.35	149.68
Muzaffarnagar	146.66	148.27
Meerut	153.29	153.38
Baghpat	158.42	159.57
Gautama Buddha Nagar	110.76	154.45
Ghaziabad	159.19	159.27
Bulandshahar	168.94	171.77

Source: *Calculations are based on data obtained from District Statistical Magazine, Lucknow, Uttar Prades.*

Fig. 2

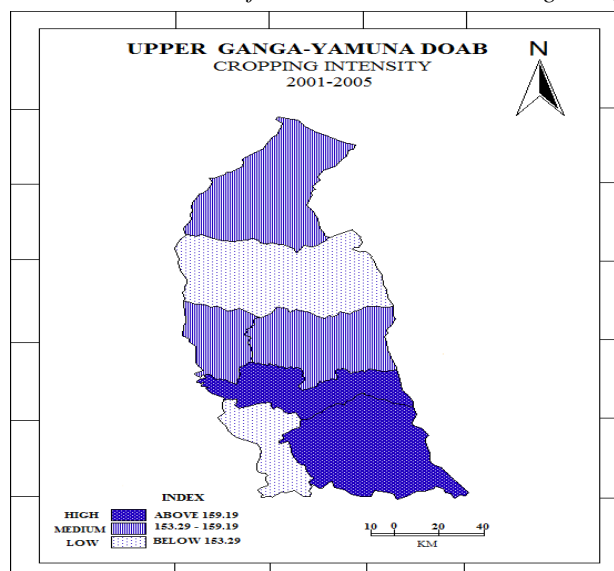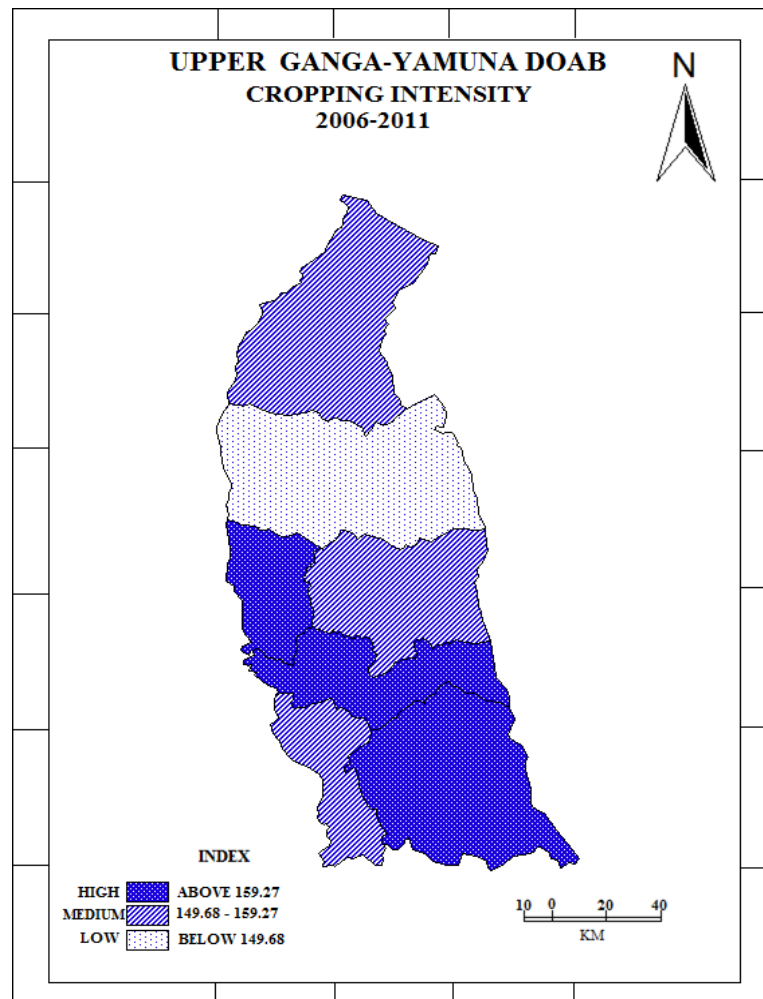**Fig.** 3

During 2006-10 highest cropping intensity was in the district of Bulandshahar (171.77) followed by Baghpat (159.57), Ghaziabad (159.27), Gautam Buddha Nagar (154.45), Meerut (153.38), Saharanpur (149.68), and Muzaffarnagar (148.27). It is clear from Fig.3 that, during this period high cropping intensity (159.27 and above) was in three districts namely, Bulandshahar, Baghpat, Ghaziabad. Medium cropping intensity (149.68-159.27) was computed for three districts of Gautam Buddha Nagar, Meerut and Saharanpur. Only one district namely, Muzaffarnagar belonged to the category of low intensity (below 149.68).

The study of crop-combination constitutes an important aspect in agricultural regionalization. Crops are generally grown in combinations, and it is rarely that a particular crop occupies a position in total isolation from other crops in a given aerial unit at a given point of time. In recent years the concept of crop combination has engaged the attention of many of the geographers and agricultural planners. For a comprehensive and batter understanding of the agricultural mosaic in an agro-climatic region, the study of crop-combinations is of great significance.

For the first time, Weaver (1954) [17]. attempted to demarcate agricultural regions of the Middle West in the United States on the basis of his crop analysis on crop acreage statistics. Weaver, computed the percentage of total harvested cropland occupied by each crop that held as much as one per cent of the total cultivated land in each region. With the exception of the few regions in which the crop-combination was easy to ascertain, other areas were having a complex picture of the percentages occupied by different crops. It was, therefore, necessary to devise a rigorous approach that would provide objective constant and precisely repeatable procedure and would yield comparable results for different years and localities. In his work Weaver, calculated deviation of the aerial percentages of crops (occupying over 1 per cent of the cropped area) for all the possible combinations of the component areal units against a theoretical standard. For a theoretical expression a standard measurement was employed which reads as follows:

Monoculture = 100 per cent of the total harvested crop land under one crop
Two crop-combination = 50 per cent in each of two crops
Three crop-combination = 33.3 per cent in each of three crops
Four crop-combination = 25 per cent in each of four crops
Five crop-combination = 20 per cent in each of five crops
Ten crop-combination = 10 per cent in each of ten crops

For the determination of the minimum deviation the standard deviation method was used :

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

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.

To illustrate the Weaver's method for calculating the crop-combination an illustration can be given from Saharanpur district in which the percentage share of crops in the cropped area during 2000-01 was as follows:

Wheat	28.18 per cent
Rice	16.64 per cent
Maize	1.91 per cent
Barley	0.03 per cent

1. Monoculture

$$= \frac{(100 - 28.56)^2}{1} = 5103.67$$

2-Crop combination

$$= \frac{(50 - 28.56)^2 + (50 - 28.18)^2}{2} = 467.89$$

3-Crop combination

$$= \frac{(33.33 - 28.56)^2 + (33.33 - 28.18)^2 + (33.33 - 16.64)^2}{3} = 105.91$$

4-Crop combination

$$= \frac{(25 - 28.56)^2 + (25 - 28.18)^2 + (25 - 16.64)^2 + (25 - 1.19)^2}{4} = 164.89$$

5-Crop combination

$$= \frac{(20 - 28.56)^2 + (20 - 28.18)^2 + (20 - 16.64)^2 + (20 - 1.19)^2 + (20 - 0.03)^2}{5} = 180.81$$

The deviation of the actual percentage from the theoretical curve is seen to be the lowest for a three crop-combination. Thus, the Saharanpur district is sugarcane wheat, rice region. Crop combination regions considering all the districts of Upper Ganga- Yamuna Doab based on Weaver's method were worked out for three distinct periods 2000-01, 2005-06 and 2010-2011. It is seen from Table 2 that during the period of 2000- 2001 crop-combination ranges, from 2 to 5 crops in all the districts. The lowest combination consisting of two crops predominated in only one district of Baghpat. Three crop-combinations were determined for the district of Saharanpur, Muzaffarnagar and Meerut. In all the districts wheat, rice and sugarcane were the common crops. Five crop combinations were determined in the districts of Ghaziabad, Gautam Buddha Nagar and Bulandshahar. Table 2 again depicts that during the period of 2005-2006 crop- combinations ranged from 2 to 5 crops in the region. Two crop-combinations existed in two districts of namely, Meerut and Baghpat. The crop-combinations were predominant in three districts of namely, Saharapur, Muzaffarnagar and Ghaziabad. Four crop-combinations persisted only in the district of Bulandshahar. Five crop- combinations was only in one

district of Gautam Buddha Nagar. During the period of 2010-2011, crop-combinations ranged from 2 crops to 5 crops, whole of the upper Ganga-Yamuna Doab.

It is seen from Table 2 that during the period of 2010- 2011 crop-combination ranges, from 2 to 5 crops in all the districts. Lowest combination consisting of two crops predominated in only one district of Baghpat. Three crop-combinations were determined for the district of Saharanpur, Muzaffarnagar and Meerut. In all the districts wheat, rice and sugarcane were the common crops. Five crop combinations were determined in the districts of Ghaziabad, Gautam Buddha Nagar and Bulandshahar..

Table2. *Crop-Combination Regions in Upper Ganga-Yamuna Doab Based on Weaver's Method*

District	2000-01	2005-06	2010-11
Saharanpur	3 crop- combination Sugarcane-wheat- rice	3 crop-combination Sugarcane- wheat- rice	3 crop-combination Sugarcane-wheat- rice
Muzaffarnagar	3 crop- combination Sugarcane-wheat- rice	3 crop-combination Sugarcane- wheat- rice	2crop-combination Sugarcane-wheat wheat
Meerut	3 crop- combination Sugarcane-wheat- rice	2 crop-combination Sugarcane-wheat	3 crop-combination Sugarcane-wheat- rice
Baghpat	2 crop- combination Sugarcane-wheat	2 crop-combination Sugarcane-wheat	2 crop-combination Sugarcane-wheat
Ghaziabad	5 crop-combination Wheat-sugarcane- rice-Maize-barley	3 crop-combination Wheat-sugarcane- rice	3 crop-combination Wheat-sugarcane- rice
Gautam Buddha Nagar	5 crop- combination Wheat-rice-maize- millet-barley	5 crop-combination Wheat-rice-millet- barley-sugarcane	2 crop comb. Wheat-rice
Bulandshahar	5 crop- combination Wheat-maize-rice- Sugarcane-barley	4 crop-combination Wheat-rice -sugarcane-millet	5 crop-combination Wheat-rice- sugarcane-millet- barley

Source: *Calculations are based on data obtained from District Statistical Magazine, Lucknow, Uttar Pradesh.*

It is seen from fig 4 two crop-combinations existed in three districts of Muzaffarnagar, Baghpat and Gautam Buddha Nagar. Three crop-combinations were seen in three districts of Saharanpur, Meerut and Ghazaiabad. Five crop-combinations was confined only one district of Bulandshahar .
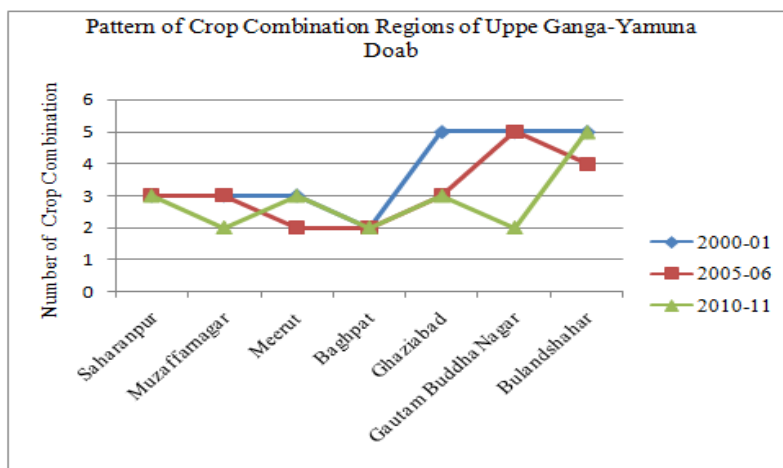

Fig.4

6. CONCLUSION

For agriculture, crop combination and crop intensity are very significant. Because of the combination of crops, attention is paid to farmers with feasible options for growing various types of crops on their land. The crop combination makes cropping intensity. The combination of high crops produces a very high crop intensity zone. Agriculture is the most significant in the case of crop intensity. Crop intensity plays a key role in cultivation, in agricultural practices and in agricultural development. Upper Ganga-Yamuna Doab in Uttar Pradesh, which is relatively more advanced agriculturally region in the state. In spite of that, Sustainable irrigation practices, fertilizer use, crop rotation practices,

mixed methods of cropping, relay cropping and selective mechanization are some of the suggestions to boost crop intensity and increase the agricultural potential of the Upper Ganga-Yamuna Doab.

REFERENCES

[1] Siebert, S., Portmann, F. T., and Döll, P., 2010, Global patterns of cropland use intensity. Remote Sensing, 2, 1625–1643

[2] Monfreda, C., Ramankutty, N., and Foley, J. A., 2008: Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. Global Biogeochemical Cycles, 22, GB1022.

[3] Portmann, F. T., Siebert, S., and Döll, P., 2010, MIRCA2000— Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution dataset for agricultural and hydrological modelling. Global Biogeochemical Cycles, 24, GB1011.

[4] Yan, H., Xiao, X., Huang, H., Liu, J., Chen, J., and Bai, X., 2014, Multiple cropping intensity in China derived from agro meteorological observations and MODIS data. Chinese Geographical Science, 24, 205–219.

[5] Weaver, J.C., 1954,"Crop Combination Regions in Middle West", *Geographical Review,* XLIV*,* pp.176- 181.

[6] Scott, P., 1957, "The Agriculture Region of Tasmania" Economic Geography, 33, pp.109-131.

[7] Coppock ,J.T., 1964, "Crop Livestock and Enterprises Combination in England and Wales", Economic Geography,40,pp. 65-81

[8] Rafiullah, S.M., 1956, "A New Approach to Functional Classification of Towns" Geographer, 8, pp.40-53.

[9] Doi Kikukazu. 1970, "The re-examination of Weaver's method of combinations analysis", Jimbun Chiri 22, 485-502.

[10] Ahmad A., Siddiqi M.F. 1967, "Crop-association patterns in the Luni Basin" Geographer 14, 69-80.

[11] Hussain, M. 1976, "A New Approach to Agricultural Productivity Regions of the Sutluj-Ganga Plains-India", *Geographical Review of India*, 36, pp. 230-236.

[12] Singh, J. 1976, *An Agricultural Geography of Haryana*, Kurushetra, p.254.

[13] Bhatia S.S 1965, Patterns of Crop Concentration and Diversification in India, Economic Geography, 41, pp. 39-56.

[14] Singh, J. 1999, *Agricultural Development in South Asia,* New Delhi, p.300.

[15] Kenichi Tatsumi, 2016, "Cropping intensity and seasonality parameters across Asia extracted by multitemporal SPOT vegetation data" Journal of Agricultural Meteorology 72 (3-4): 142-150.

[16] Shyju K and Kumaraswamy K.A, 2017, "Study on Agricultural Landuse and Cropping Pattern in Talappilli Taluk, Thrissur District, Kerala". *Research Expo International Multidisciplinary Research Journal.*2017; 7(6): 40-53.

[17] Hussain, M. 1996, *Systematic Agricultural Geography*, New Delhi, pp. 229-240

AUTHOR'S BIOGRAPHY

Mohammad Zafar Iqbal, is an Assistant Professor (Guest) in the Department of Geography, Kamla Rai College Gopalganj, Jai Prakash University, Chapra, Bihar. I have completed an M.A. and Ph.D. degree in Geography from Aligarh Muslim University. I have also qualified National Eligibility Test (NET) conducted by UGC. My fields of specialization are Energy /Sustainable Environment, and Agricultural Geography. I have published more than five research papers on different themes of geography. Moreover, I have attended many international and national conferences/seminars and presented papers on the different aspects of geography. I have also participated in several workshops related to research methodology. I hold the membership of two academic bodies KGA, Maharashtra and International society for Asia & Pacific Studies, Tirupati. AP., India.