CHAPTER – IV

SPATIO-TEMPORAL CHANGES IN AGRICULTURAL LAND USE PATTERN

4.1 Introduction

The present chapter aims to provide a homogeneous image of ALU with their trend and spatial distribution in the district. However, the previous chapter has given a detailed and systematic evaluation of the Spatio-temporal patterns of land use (general) of the study area. But it could not provide a combined scenario of ALU in the study area. So, special importance has been laid on the trend and growth of ALU, i.e., the area under major and some minor crops produced in this district with their spatial variation. Crops grown in the district are autumn rice (aus), winter rice (aman), summer rice (boro), wheat, maize, gram, lentil (masoor), urad (maskalai), khesari, rapeseed & mustard, jute, sugarcane, potato, vegetables, pea, arhar, sesame (til), ground nut, etc. Based on the area under cultivation in the district, the crops may be categorized into two groups, i.e., major crops (occupying land area >1% of the net sown area) and minor crops (occupying land area >1% of the net sown area). Thirteen crops have been selected for analysis in this study, considering significant crops in the district during the study period (1980-81 to 2020-21). As per cropping area sown in 2020-21, the major crops of the district are winter rice (aman), summer rice (boro), wheat, maize, lentil (masoor), urad (maskalai), rapeseed & mustard, jute and potato; while minor crops are autumn rice (aus), gram, khesari and sugarcane. Also, the trend and growth of production and productivity have been discussed in this chapter. Furthermore, the different ALU elements are closely associated with each other and give rise to a complex reality. Therefore, the study of agricultural regionalization is also essential. For this purpose, an attempt has also been made through the changes of crop ranking region, crop combination region, crop diversification region, crop concentration region and cropping intensity region. Such an exercise is exclusively helpful in regional planning and development.

4.2 Concept of agricultural land use

'Agricultural land use' (ALU) basically symbolizes the gross cropped area (GCA) computation under different crops during the agricultural year. It is a significant indicator of the appropriate and inappropriate use of land. The traditional cultivation technique has continued to dominate most of the provinces of India since we achieved independence. The knowledge about the cultivation technique was transferred from one generation to another. As expected, there was no change in the cultivation procedures or cropping pattern for a very long period. But, most parts of India have recently faced challenges about the increasing demand for food crops and the unequal development of agriculture. However, the nature or quality of the production procedures or techniques is related to the farmers' judgment. The district's agricultural land use pattern is typical due to dryland and irrigated culture, which is directly governed by some other geographical aspects and revised by favourable social and economic conditions. Moreover, lack of implementation of new technology, essential machinery, High Yielding Varieties (HYV) of seeds, pesticides, fertilizers, and availability of irrigation facilities prevails the agricultural land use pattern of the district.

4.3 Methodology

4.3.1 Autocorrelation function (ACF)

Autocorrelation is the most challenging problem when evaluating and identifying time series data. Due to autocorrelation or serial dependency, the variance of MK test statistic is increase. Additionally, the positive serial correlation in a data increases the Type I error i.e., false positive and shows a trend (significant) when there is no trend (Yue et al., 2002). As a result, the presence of serial correlation in a data has been investigated initially in this study using the lag-1 autocorrelation coefficient (r_k) at a 0.05 significant level for the two-tailed test.

$$r_k = \frac{\sum_{t=r+1}^{T} (x_{kt} - \bar{x}_k)(x_{k(t-r)} - \bar{x}_k)}{\sum_{t=1}^{T} (x_{kt} - \bar{x}_k)^2} \quad (1)$$

Where, r_k is the Autocorrelation function of kth time series at lag r, x_{kt} refers to the tth observation of the kth time series, $\overline{x}_k$ is the mean of the kth time series. The value of autocorrelation falls between -1 and $+1$.

The alternative hypothesis is that the true r_k must be other than zero, but it might be positive or negative, because the test is two-tailed. If r_k lies between the smaller and bigger confidence interval margins, the time series data are regarded as sequentially correlated; otherwise, the data are assumed to be serially independent (Anderson, 1954).

4.3.2 Mann-Kendall (MK) test

The MK test statistic (S) of the data series x_1, x_2, x_3 ..., and x_n are calculated as (Mann 1945; Kendall 1975):

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sign}\left(x_j - x_k\right) \quad (2)$$

Where n is the number points of the data, x_j and x_k symbolizes the data points of j and k time,

$$\text{Sign}\left(x_j - x_k\right) = \begin{cases} +1 \text{ if } x_j - x_k > 0 \\ 0 \text{ if } x_j - x_k = 0 \\ -1 \text{ if } x_j - x_k < 0 \end{cases} \quad (3)$$

The VAR(S) is calculated as:

$$\text{VAR}\,(S) = \frac{1}{18}\left\{n(n-1)(2n+5) - \sum_{i=1}^{g} t_i(t_i-1)(2t_i+5)\right\} \quad (4)$$

Where VAR (S) represents the variance, g is the no. of ties group, t_i reveals the range (i) of ties number. The ties groups are a set of sample data with a similar value.

The S is recognized with Kendall's τ (tau), that can be explained as follows:

$$\tau = \frac{S}{D} \quad (5)$$

$$D = \sqrt{\frac{1}{2}n(n-1) - \frac{1}{2}\sum_{i=1}^{g} t_i(t_i-1)}\sqrt{\frac{1}{2}n(n-1)}$$

The assessment of S and VAR(S) are required to construct the test measurement of Z in the given way when n>10 (Gilbert,1987)

$$Z = \begin{cases} \frac{S-1}{\sqrt{\text{VAR(S)}}} & \text{, if } S > 0 \\ 0 & \text{, if } S = 0 \\ \frac{S+1}{\sqrt{\text{VAR(S)}}} & \text{, if } S < 0 \end{cases} \quad (6)$$

The increasing and decreasing trend in the time series data are symbolized by the positive and negative value of Z. The null hypothesis (H_0) is rejected whether the obtained value of Z statistic is greater than 1.96 at 95% confidence level (Pearson and Hartley 1966).

4.3.3 Modified Mann-Kendall test

The modified VAR (S) can be assessed as follows (Hamed and Rao, 1998):

$$VAR(S) = \left(\frac{n(n-1)(2n+5)}{18}\right) \cdot \left(\frac{n}{n_e^*}\right) \quad (7)$$

At this juncture, the correction factor $\left(\frac{n}{n_e^*}\right)$ is adjusted to the auto-correlated data as follows:

$$\left(\frac{n}{n_e^*}\right) = 1 + \left(\frac{2}{n^3 - 3n^2 + 2n}\right)\sum_{f=1}^{n-1}(n-f)(n-f-1)(n-f-2)\,\rho_e(f) \quad (8)$$

$\rho_e(f)$ denotes the ACF between observation's rank which can be assessed as:

$$\rho(f) = 2\sin\left(\frac{\pi}{6}\,\rho_e(f)\right) \quad (9)$$

4.3.4 Sen's slope estimator

P. K. Sen proposed Sen's slope estimator in 1968 to detect the rate of change (slope Q) of the obtained trend (increasing or decreasing) as follows:

$$Q_i = \frac{x_k - x_j}{k - j}, \quad i = 1,2,\cdots\cdots N,\ k > j \quad (10)$$

Where, Q_i refers to the median slope; x_k and x_j signifies k and jth time's data value.

4.3.5 Innovative trend analysis

Z. Sen proposed the ITA method in 2012 to identify the trend in hydrometeorological data. This graphical trend detection method is more robust in detecting sub-trends in data series. This method also not required to satisfy the supposition of nonlinearities of data, serially autonomous of the data and the ideal number of data that is a pre-requisite for MK/mMK and Spearman row (SR) test (Mun et al. 2021). For this comparative advantage, the ITA gained the most popularity in time series analysis. In this technique, the data series is divided into two subsets having an equal number of data points. These two subsets are reorganized in ascending order and plotted into a Cartesian coordinate system where the 1st subset is plotted on the horizontal axis (X-axis) and the 2nd subset on the vertical axis (Y-axis) (Mandal et al., 2021). The straight line of 1:1 (45^0) represents no trend in the data series, and it divides the graph into two equal tringles (Alifujiang et al., 2021). If the data points are distributed above the 45° line, indicate an increasing trend; similarly, if the data point is distributed below the 1:1 line suggests a decreasing trend (Sen, 2012). However, the ITA slope (Sen, 2012) is computed using the following formula:

$$\beta = \frac{1}{n}\sum_{i=1}^{n}\frac{10(x_j - x_k)}{\bar{x}} \quad (11)$$

Where β represents the ITA slope, n represents the range of individual subset of the time series, x_j and x_k denotes the values of the successive sub-set, $\bar{x}$ is the mean of the 1st sub-set (X_j).

Moreover, the probability distribution function (PDF) determines the significance level of ITA. Hereafter, if the confidence limits (upper and lower) of PDF and standard deviation (σ_s) of the slope of ITA have a mean of zero at a significance level (α), the confidence limit of the trend will be -

$$CL_{(1-\alpha)} = 0 \pm S_{ITA^{\sigma_s}} \quad (12)$$

The null hypothesis (no trend) will be nullified if the calculated ITA slope (S_{ITA}) is found to be larger than the critical value. 95% confidence level has been considered in this work as confidence level.

4.4 Trend and spatial variation of the crops

The trend, growth and spatial variation of the major and minor crops' area, production, and productivity have been analyzed in this section. However, the crops of the study area are classified into four categories, i.e., A. Cereals B. Pulses C. Oil seeds and D. Cash crops.

4.4.1 Some exploratory statistics of cereals

Cereals are usually referred to as the crops that are grown to be eaten. The word 'cereal' has been derived from 'ceres,' the Roman goddess of harvest and agriculture. Rice (aus, aman and boro), wheat and maize are the important cereals of the district. Some of the exploratory statistics, such as minimum, maximum, mean, standard deviation (SD) and coefficient of variation (CV) of the area, production and yield of the cereals are presented in Table 4.1. During the study period (1980-81 to 2020-21), the minimum and maximum area used for the cultivation of different cereals crops varied from 1097 ha. for autumn rice (aus) to 73094 ha. for winter rice (aman) and 49264 ha. (maize) to 177200 ha. (Winter rice (aman)). However, the mean area varied from 10862.03 ha. ± 8829.79 (maize) to 140216.33 ha. ± 16457.51(autumn rice (aman)). Also, the CV of area of the crops varied from 11.74% (winter rice (aman)) to 94.14% (autumn rice), revealing the area used for winter rice (aman) was more consistent and the area used for autumn rice (aus) was less consistent during the study period in the district (Table 4.1). Similarly, the mean production of different cereal crops varied from 23078.42

tons± 17180.98 (autumn rice (aus)) to 348133.53 tons± 175314.20 (winter rice (aman)). At the same time, the CV of production of the crops varied from 36.21% (wheat) to 119.71% (maize), which depicts the more consistent of wheat and less consistent of maize production in the district. On the other hand, the mean yield varied from 1555.22 kg ± 842.60 (maize) to 3602.54kg ±716.23 (summer rice (boro)) and the CV of yield varied from 17.89% (wheat) to 54.18% (maize) (Table 4.1). From the CV of yield, it can be concluded that the yield of wheat was more consistent than other cereal crops.

4.4.2 The trend of cereals

4.4.2.1 Rice (*Oryza sativa*)

Rice is the staple food crop of Maldah district and West Bengal and is grown with several agricultural practices. However, sowing, growth and harvest of rice can be seen throughout the year. According to Sengupta (1969), there are three types of rice such as a) autumn rice (aus), b) winter rice (aman) and c) summer rice (boro) which cultivate in the district.

4.4.2.1.1 Autumn rice (aus)

Autumn rice, also called aus in West Bengal, is commonly sowed in the summer season (March-April) along with pre-monsoonal rains and harvested in autumn (August-September). The word 'aus' comes from the Sanskrit word 'Ashu,' meaning quick or early. The cultivation season of aus rice is designated as Kharif I and however, the quality of this rice is more or less unsmooth.

The results of the ITA clearly showed a decreasing trend in area and production of autumn rice (aus) at 95% confidence level in Maldah during the study period (1980-81 to 2020-21) (Table 4.2 and Fig. 4.1). The rate of decrease obtained from the ITA slope is $-1751.78\ ha./year$ and $-1333.80\ tons/year$ respectively. On the other hand, the yield shows an increasing trend at 95% confidence level and the rate of increase is 55.87 kg/ year. The MK/mMK shows more or less similar results to ITA, identifying a significant decreasing trend for area and production with a slope of $-1487.23\ ha/year$ and $-1303.12\ tons/year$ respectively. At the same time, the yield showed a significant increasing trend at the 95% confidence level, and the rate of increase is $+52.63\ kg/year$ (Table 4.1).

Table 4.1 Some exploratory statistics of area, production & yield of cereals of Maldah district (1981 to 2021)

Variable	Name of the Crops	Minimum	Maximum	Mean	SD	CV (%)
Area	Autumn Rice (Aus)	1097	60800	22899.44	21557.26	94.14
	Winter Rice (Aman)	73094	177200	140216.33	16457.51	11.74
	Summer Rice (Boro)	21700	72795	56613.85	14690.15	25.95
	Wheat	9486	55094	38351.15	12449.64	32.46
	Maize	3371	49264	10862.03	8829.79	81.29
Production	Autumn Rice (Aus)	2303	59000	23078.42	17180.98	74.45
	Winter Rice (Aman)	119800	718918	348133.53	175314.20	50.36
	Summer Rice (Boro)	57400	368175	217231.80	79162.33	36.44
	Wheat	26900	143989	97039.72	35135.61	36.21
	Maize	3200	167497	26093.91	31237.96	119.71
Yield	Autumn Rice (Aus)	433	3046	1626.50	702.13	43.17
	Winter Rice (Aman)	864	4600	2314.83	953.06	41.17
	Summer Rice (Boro)	2427	5850	3602.54	716.23	19.88
	Wheat	1570	3387	2548.08	455.91	17.89
	Maize	592	3400	1555.22	842.60	54.18

Source: District Statistical Handbook and PAO, Maldah

SD= Standard Deviation, CV= Co-efficient of Variation

4.4.2.1.2 Winter rice (aman)

The common name of winter rice in Maldah is aman, planted in the rainy season (July-Aug) and harvested in the winter season (Dec-Jan). The word 'aman' is basically is an Arabic word meaning peace. The cultivation season of aman rice is designated as Kharif II. The results of ITA showed a significant ($\alpha = 0.05$) decreasing trend in the area of winter rice (aman) with a magnitude of -451.30 ha/year. However, the production and the yield showed a significant($\alpha = 0.05$) increasing trend during the study period. The magnitude of increase of production and yield of winter rice (aman) is 11138.43 tons/year and 70.78 kg/year, respectively (Table 4.2). The Z statistics of MK and mMK also showed an increasing trend of production and yield of winter rice (aman); however, the area showed an insignificant decreasing trend at 0.05 significance level. The rate of increase of production and yield obtained from Sen's slope is 12000.73 tons/year($Q = +12000.73\ tons/year$) and 67.13 kg/year ($Q = +67.13\ tons/year$). On the other hand, the magnitude of the increasing (insignificant) area is 179.00 ha/year ($Q = +179.00\ ha/year$).

Table 4.2 Trends and growth of area, production & yield of cereals of Maldah district (1981 to 2021)

Variable	Crops	Slope of ITA	Z statistics of MK/mMK	Sen's Slope (Ha, Tons & Kg/Year)
Area	Autumn Rice (Aus)	-1751.78	-7.93***	-1487.23
	Winter Rice (Aman)	-451.30	-1.18	-179.00
	Summer Rice (Boro)	713.30	3.16***	595.00
	Wheat	210.86	0.84	159.04
	Maize	311.69	4.40***	291.56
Production	Autumn Rice (Aus)	-1333.80	-6.94***	-1303.12
	Winter Rice (Aman)	11138.43	7.00***	12000.70
	Summer Rice (Boro)	5206.14	7.20***	5858.89
	Wheat	1490.38	3.85***	1966.68
	Maize	1328.04	6.00***	1163.08
Yield	Autumn Rice (Aus)	55.87	7.09***	52.63
	Winter Rice (Aman)	70.48	7.76***	67.13
	Summer Rice (Boro)	37.74	6.29***	32.93
	Wheat	30.26	5.99***	32.67
	Maize	42.46	3.34***	45.04

Source: District Statistical Handbook and PAO, Maldah

* Specifies significant at 0.1 level of significance, ** specifies significant at 0.05 level of significance, *** specifies significant at 0.01 level of significance

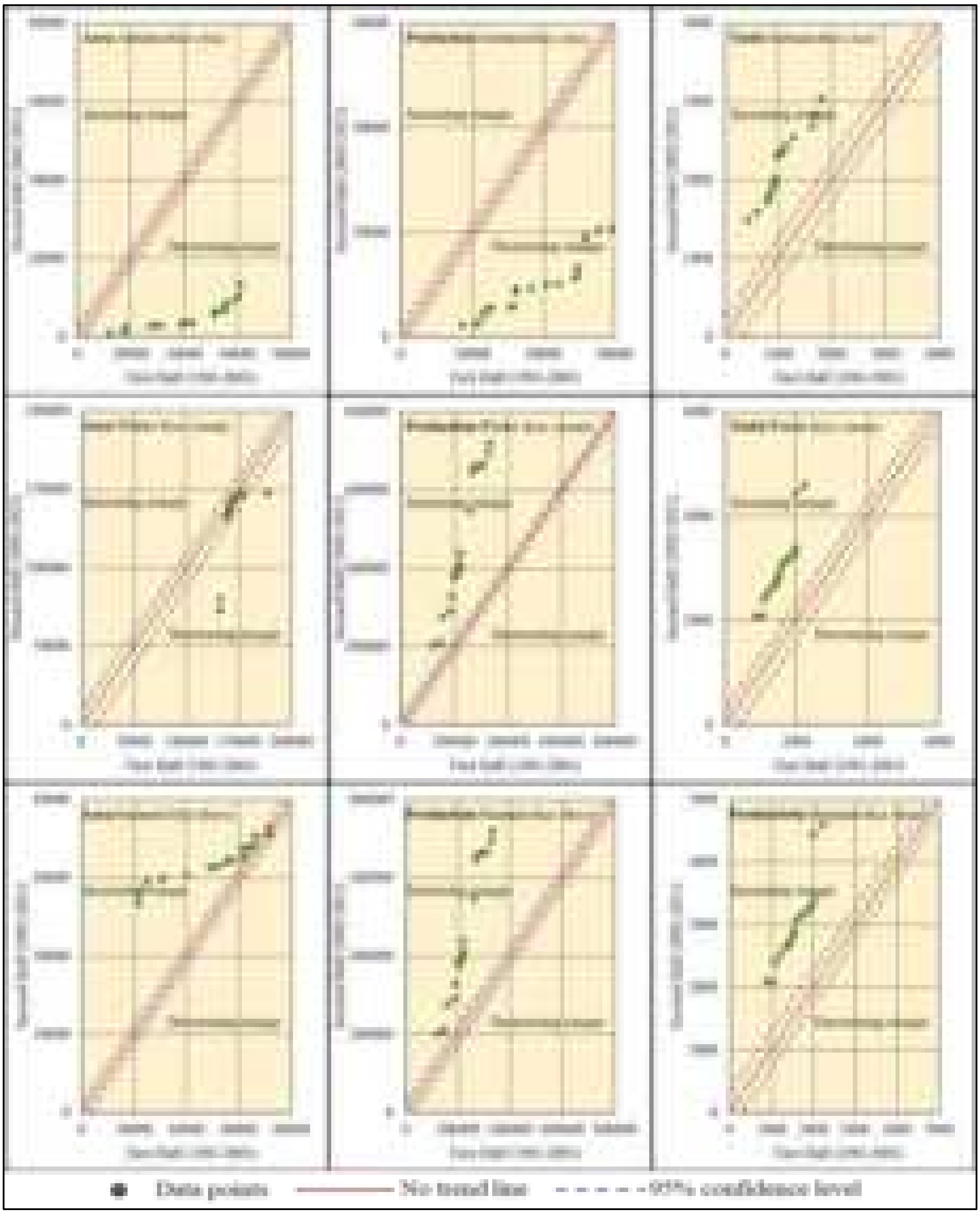
Trend was identified by a mMK test based on lag-1 autocorrelation

Plate 4.1 *Various stages of paddy cultivation in Barind region (Molladighi mouza, Gazole block)*

4.4.2.1.3 Summer rice (boro)

Summer rice is called boro in West Bengal, is usually sowing in the winter season (November-February) and harvested in the summer season from March-June. 'Boro' is basically a Bengali language that comes from the Sanskrit word 'Borob,' meaning a special type of rice cultivated in low-lying, waterlogged areas with the help of irrigation after the harvest of Kharif rice.

The ITA detected a significant ($\alpha = 0.05$) increasing trend in the area, production and yield of summer rice (boro) in Maldah during the study period (Table 4.2). The rate of increase (ITA) is 713.30 ha/year, 5206.14 tons/year and 37.74 kg/ha/year for the area, production and yield, respectively. The Z statistics of MK or mMK results also identified the significant increasing trend of the area, production and yield of summer rice (boro) at 95% confidence levels. The rate of increase of the area, production and yield obtained from Sen's slope is 595.00 ha/year($Q = +595.00\ ha/year$), 5858.89 tons/year($Q = +5858.89\ kg/\ ha/year$) and 32.93 kg/ha/year ($Q = +32.93\ kg/\ ha/year$) respectively (Table 4.2).



Source: District Statistical Handbook and PAO, Maldah

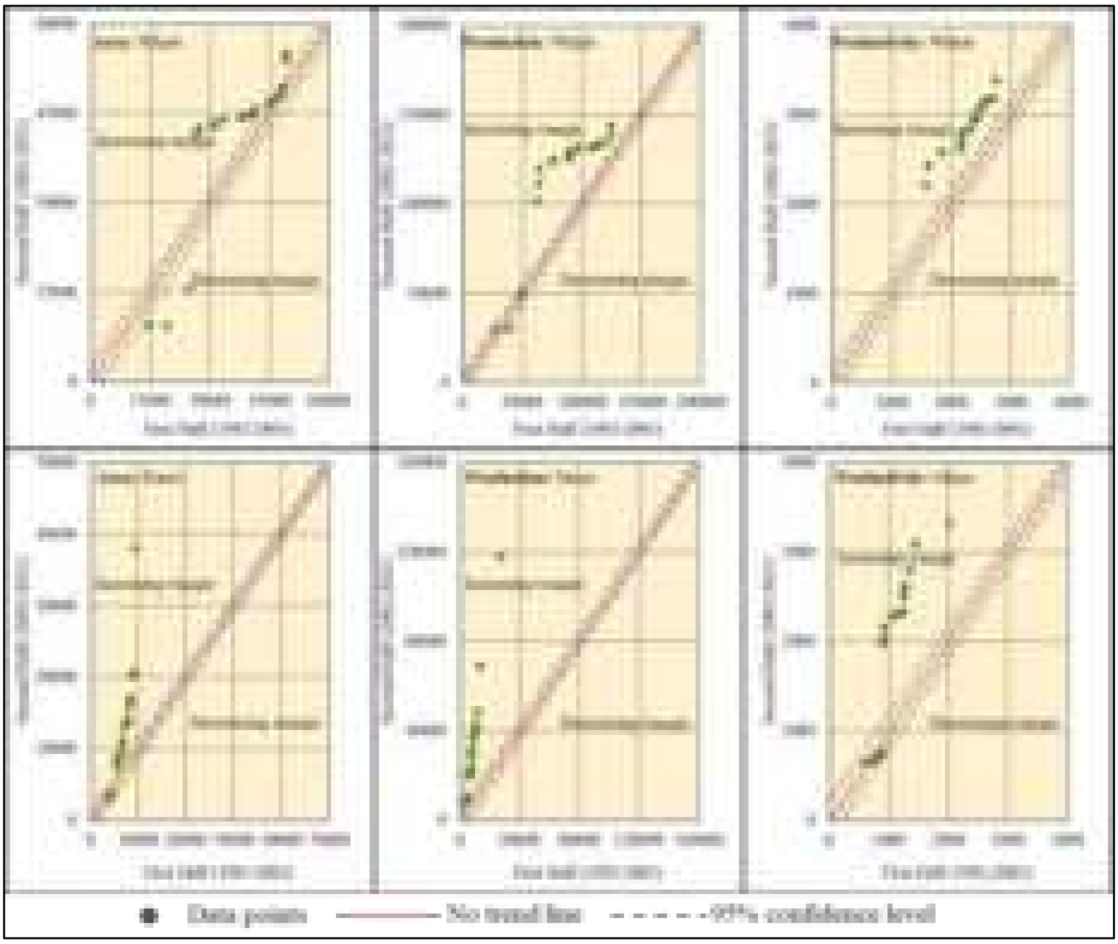
Fig. 4.1 ITA graph of area, production and yield of autumn rice (aus), winter rice (aman) and summer rice (boro).

Plate 4.2 *Wheat cultivation at Deotala mouza, Gazole block*

4.4.2.2 Wheat (*Triticum aestivum*)

Wheat is broadly grown cereal crop in the world and the second most important in the study area, which plays a significant role in food and nutritional security in the district. It also takes the second position in terms of area to the total crop area of the district. The crop is known as the Rabi crop or winter crop, sown from October to November and harvested in March and April.

The results of ITA, MK/mMK and Sen's slope estimator of area, production, and yield of wheat are also presented in Table 4.2 and Fig. 4.2. The ITA clearly revealed a significant increasing trend of area, production and yield from 1980-81 to 2020-21 with the rate of 210.86 ha/year, 1490.38 tons/year and 30.26 kg/ha/year, respectively. On the other hand, MK/mMK showed a significant increasing trend only for production and yield at 95% confidence level. The rate of increase (Sen's slope estimator) is 1966.68 tons/year ($Q = +1966.68\ tons/year$) and 32.67 kg/ha/year ($Q = +32.67\ kg/\ ha/\ year$) respectively (Table 4.2). At the same time, the area of wheat showed an insignificant increasing trend and the rate of increase is 159.04 ha/year ($Q = +159.04\ ha/year$).



Source: District Statistical Handbook and PAO, Maldah

Fig. 4.2 ITA graph of area, production and yield of wheat and maize

4.4.2.3 Maize (*Zea mays*)

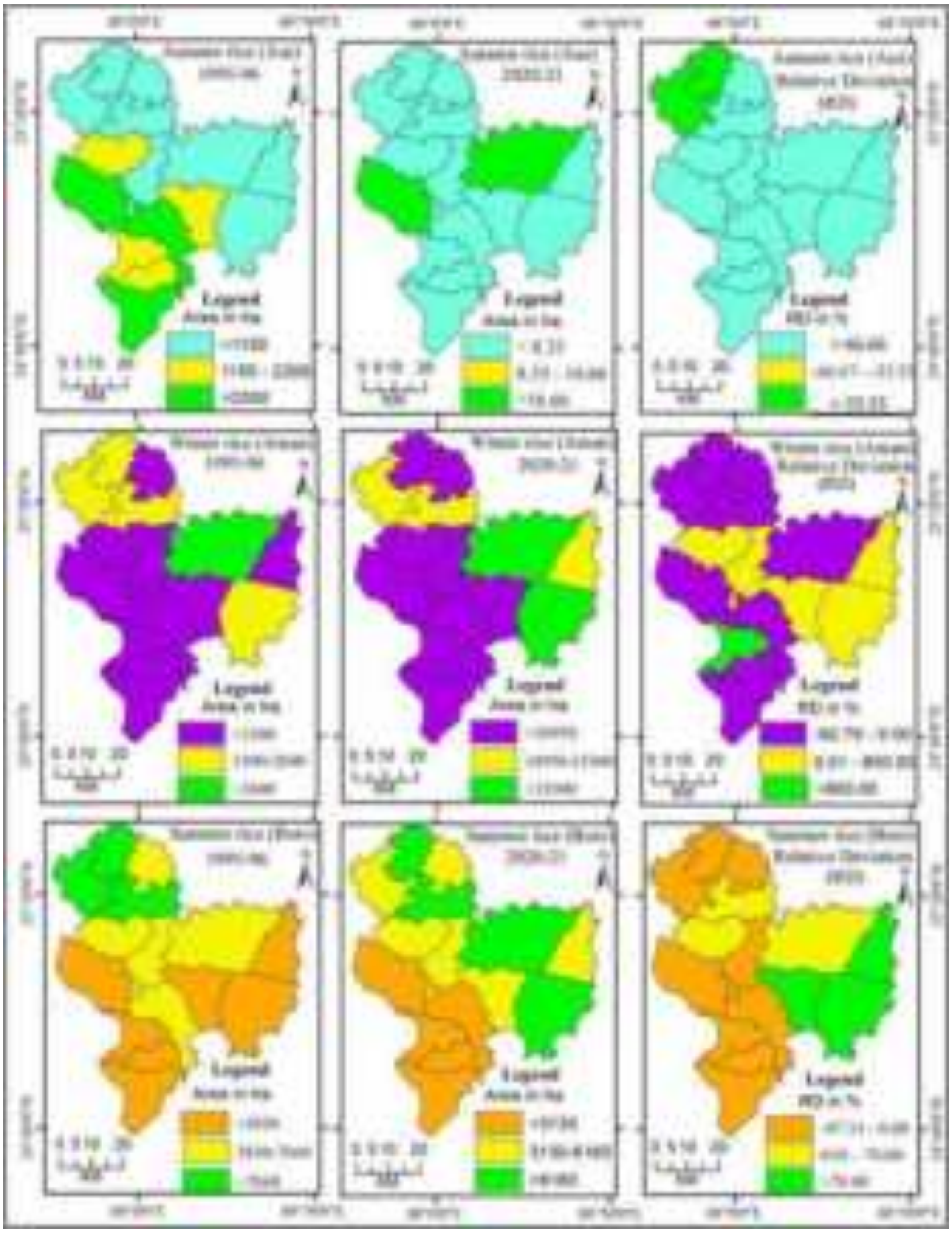
Maize is the third most significant cereal crop after rice and wheat in Maldah district. Due to its adaptability under the diverse agro-climatic condition, it is the greatest multipurpose emerging crop. It is sown in the month of March-April and harvested in the month of July. It is also called the queen of cereals because it has the maximum genetic yield prospective among the cereals.

The area, production and yield showed a significantly increasing trend during the study period with a 95% confidence level obtained from ITA and Z statistics (Table 4.2 and Fig. 4.2). The increasing amount of area, production and yield obtained from Sen's slope is 291.56 ha/year, 1163.08 tons/year and 45.04 Kg/ha/year. However, the growth rate obtained from ITA for the area, production and yield is 311.69 ha/year, 1328.04 tons/year and 42.46 kg/ha/year, respectively (Table 4.2). From the results of both methods, it can be concluded that the results of the Z statistic show a good match (about 90%) with the graphical ITA method.

4.4.3 Spatio-temporal changes of cereals

Rice, wheat and maize are the major cereals in the study area. Among these three, rice and wheat are the principal crops grown in highly fertile land of the district. The area under cereals in the district accounts for 78.26% of the total cropped area in 2020-21, which was 74.74% in 1980-81, showing significant change during the study period. The spatial variation of the cereals is evaluated using the data of 1995-96 and 2020-21 due to the unavailability of block-wise reliable data before 1995-96. The spatial variation of cereals with their relative change in percent in the different blocks is shown in Fig.4.3. The variation is categorized into three equal zones based on their areal coverage and relative deviation (RD). Figure 4.3 clearly indicates decrease in the area of autumn rice (aus) in all the blocks of the study area except Harishchandrapur I and Harishchandrapur II during 1995-96 to 2020-21 and the rate of decrease is quite high (RD=> -66.67%). While, Harishchandrapur I and Harishchandrapur II blocks showed comparatively low decreasing rate (RD= <-33.33%). In these blocks the cultivation of maize and summer rice (boro) has increased significantly. So, it may be concluded that the farmers switch their cultivation from autumn rice (aus) to maize and boro in these blocks. For winter rice (aman), both decreasing and increasing areas are observed. Decreasing area (RD = -92.79-0.00) is mainly observed in the Chanchal I, Chanchal II, English Bazar, Gazole, Harishchandrapur I, Harishchandrapur II, Manikchak, Kaliachak I and Kaliachak II blocks. In these blocks a tendency of land conversion from cropping field to mango orchard has been observed more. This is the main cause of decrease area under winter rice (aman) in these blocks. The increasing area of winter (aman) rice is observed in the rest of the blocks. Comparatively low rate (RD = 0.00-800%) of increase is noticed in the Bamangola, Habibpur, Old Malda, Ratua I and Ratua II blocks; and a high, increasing rate (800%) is found in the Kaliachak II block (Fig. 4.3). In these blocks the area of autumn rice (aus) has converted to the area under winter rice (aman). The area of the summer rice (Boro) also displayed negative and positive changes during the study period. Nine blocks (Chanchal I, Harishchandrapur I, Harishchandrapur II, English Bazar, Manikchak, Kaliachak I, Kaliachak II, Kaliachak III, and Ratua II) out of fifteen are caught with negative RD (-92.79 - 0.00%).

Plate 4.3 *Maize cultivation being one of the major crops of Maldah district (Babla mouza, Kaliachak II block)*



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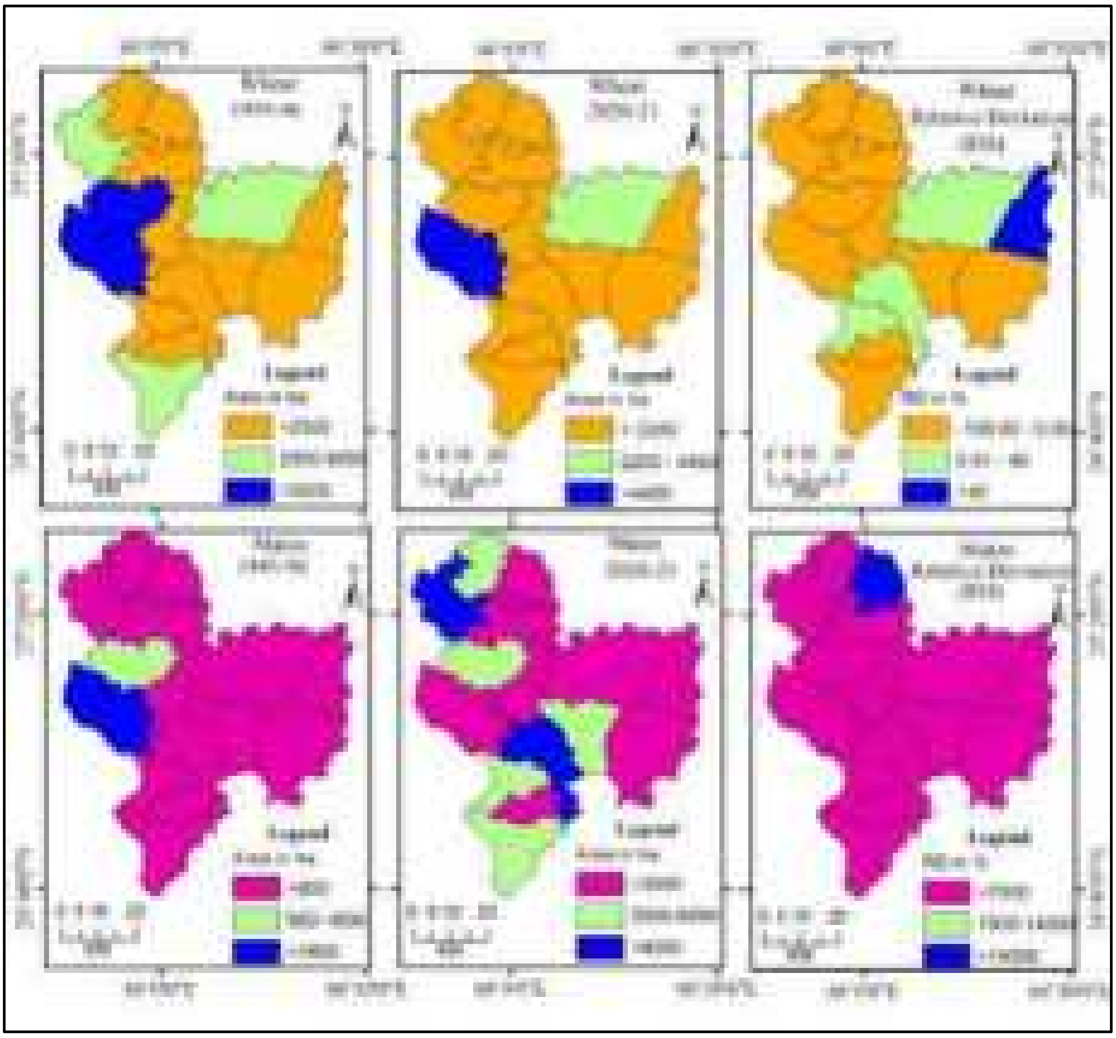


Source: District Statistical Handbook and PAO, Maldah

Fig. 4.3 Spatial variation and relative changes of area of Cereals during 1995-96 & 2020-21

In these blocks the cultivation of maize has been increased remarkably and the area of summer rice (boro) has converted to the maize. On the other hand, Chanchal II, Gazole, and Ratua I have low positive changes (RD= 0.00 -70.00%). At the same time, Bamangola, Habibpur, and Old Maldah are observed with high RD (>70.00%) in the district (Fig. 4.3).

Wheat cultivation area also showed a similar tendency to summer rice (boro). Eleven blocks (Chanchal I, Chanchal II, Habibpur, Harishchandrapur I, Harishchandrapur II, Manikchak, Kaliachak I, Kaliachak III, Old Maldah, Ratua I, and Ratua II) out of fifteen are caught with negative RD (-100 - 0.00%). In these blocks the farmers are mostly tend to cultivate rapeseed and mustard instead of wheat and therefore these decreasing area under wheat is converted to the rapeseed and mustard. While, Gazole, English Bazar, and Kaliachak II have positive RD of the area with 0.01 – 40%. At the same time, the Bamangola block has the maximum positive RD (>40.00%). The area under maize has also positively increased from 1995-96 to 2020-21, and the magnitude of increment is so high in all the blocks. All the blocks except Chanchal I showed an increase with a <7000; for Chanchal I, it was >14000 (Fig.4.3). So maize is the district's most significant crop, which increased its area at a higher rate in all the blocks.

4.4.4 Some exploratory statistics of pulses

Pulses are the most important food crops after cereals. The term 'Pulse' was first used by the Food and Agricultural Organization (FAO), allocated for legume crops. Sometimes pulses play a vital role in crop rotation since most have symbiotic nitrogen-fixing bacteria in root nodules. Primarily pulses are grown for human consumption, livestock silage and forage and soil-improving green fertilizer. These crops are mainly sown in September-November as *Rabi* crops and harvested in March-April. Gram, lentils, maskalai and khesari are the necessary pulses of the district.

Table 4.3 Some exploratory statistics of area, production & yield of pulses of Maldah district (1981 to 2021)

Variable	Name of the Crops	Minimum	Maximum	Mean	S. D	CV (%)
Area	Gram	327	18900	6216.89	5191.49	83.51
	Lentil (Masoor)	3217	9767	5902.27	1737.24	29.43
	Urad (Maskalai)	1020	21242	9960.95	4514.35	45.32
	Khesari	1253	6218	3085.88	1189.40	38.54
Production	Gram	1710	19300	6560.44	4991.73	76.09
	Lentil (Masoor)	1270	8399	3704.05	1775.23	47.93
	Urad (Maskalai)	4150	20392	9455.76	3502.37	37.04
	Khesari	770	4170	1761.39	862.50	48.97
Yield	Gram	543	6587	1285.34	1125.61	87.57
	Lentil (Masoor)	243	1073	660.07	267.11	40.47
	Urad (Maskalai)	347	5961	1289.16	1132.63	87.86
	Khesari	190	1447	701.65	359.29	51.21

Source: District Statistical Handbook and PAO, Maldah

SD= Standard Deviation, CV= Co-efficient of Variation

Some of the exploratory statistics, such as minimum, maximum, mean, standard deviation (SD) and coefficient of variation (CV) of area, production and yield of the pulses are presented in Table 4.4. During the study period (1980-81 to 2020-21), the minimum and maximum area used for different pulses crops varied from 327 ha. for gram to 3217 ha. for lentil (masoor) and 6218 ha. (khesari) to 21242 ha. (urad (maskalai)) respectively. The mean area varied from 3085.88 ha. $\pm$ 1189.40 (khesari) to 9960.95 ha. $\pm$ 4514.35(urad (maskalai)). However, the CV of the area varied from 29.43% (lentil (masoor)) to 83.51% (gram), clearly revealing the more consistent area under lentil (masoor) production. However, the CV of the area under gram was comparatively less consistent (Table 4.5). Similarly, the mean production varied from 1761.39 tons$\pm$ 862.50 (khesari) to 9455.76 tons$\pm$ 3502.37 (urad (maskalai)). Also, the CV of production of the crops varied from 37.04% (urad (maskalai) to 76.09% (gram), which depicts the more consistent (urad (maskalai)) and less consistent (gram) in production, respectively. On the other hand, the mean yield varied from 660.07 kg $\pm$ 267.11 (lentil (masoor)) to 1289.16 kg $\pm$1132.63 (urad (maskalai)). At the same time, the CV of the yield varied from 40.47% (lentil (masoor)) to 87.87% (urad (maskalai)), indicating that the yield of lentil (masoor) was more consistent than other crops under pulses in the district during the study period.

4.4.5 The trend of pulses

4.4.5.1 Gram (*Cicer arientium*)

Gram is one of the minor pulses of Maldah district, cultivated mainly for its seeds. It is also called Bengal gram or chickpea, or Chana, a significant and low-priced source of protein. Generally, it is an important *Rabi* crop sown mainly in September-November and harvested in February. Low to modest rainfall of 60-90 cm and a mild cold temperature is suitable for this crop. Too much rain after sowing or at the blossoming stage causes damage to the crop.

Results of ITA, MK/mMK and Sen's slope estimator of area, production and yield of pulses are presented in Table 4.6 and Fig. 4.3 & 4.4. The ITA clearly showed a significant (α = 0.05) decreasing trend of area and production of grams during the study period. However, the yield of gram showed a significant increasing trend at a 95% confidence level. The Z statistics of MK/mMK also revealed the significant decreasing trend of the area and production of a gram at a 5% significant level. At the same time, the yield of grams showed a significant ($\alpha = 0.05$) increasing trend. The rate of change of gram obtained from ITA is -239.08 ha. /Year, -182.99 tons/year and $+$ 30.43 kg/ ha for the area, production and yield, respectively (Table 4.6). On the other hand, the magnitude of change obtained from Sen's slope estimator showed -365.50ha/year for the area, -179.21tons/year for production, and $+15.42$ kg/ha for yield, respectively.

Table 4.4 Trend and growth of area, production & yield of pulses of Maldah district (1981 to 2021)

Variable	Name of the Crops	Slope of ITA	Z statistics of MK/mMK	Sen's Slope (Ha, Tons & Kg/Year)
Area	Gram	-239.08	-5.68***	-365.50
	Lentil (Masoor)	-31.56	-1.59	-65.33
	Urad (Maskalai)	197.91	4.08***	247.57
	Khesari	-34.50	-4.74***	-69.50
Production	Gram	-182.99	-3.17***	-179.21
	Lentil (Masoor)	38.32	3.23***	64.63
	Urad (Maskalai)	151.10	3.65***	122.47
	Khesari	38.32	1.65*	21.88
Yield	Gram	30.43	1.69*	15.42
	Lentil (Masoor)	25.16	4.86***	18.17
	Urad (Maskalai)	-35.97	-1.09	-12.21
	Khesari	25.16	5.34***	24.86

Source: District Statistical Handbook and PAO, Maldah

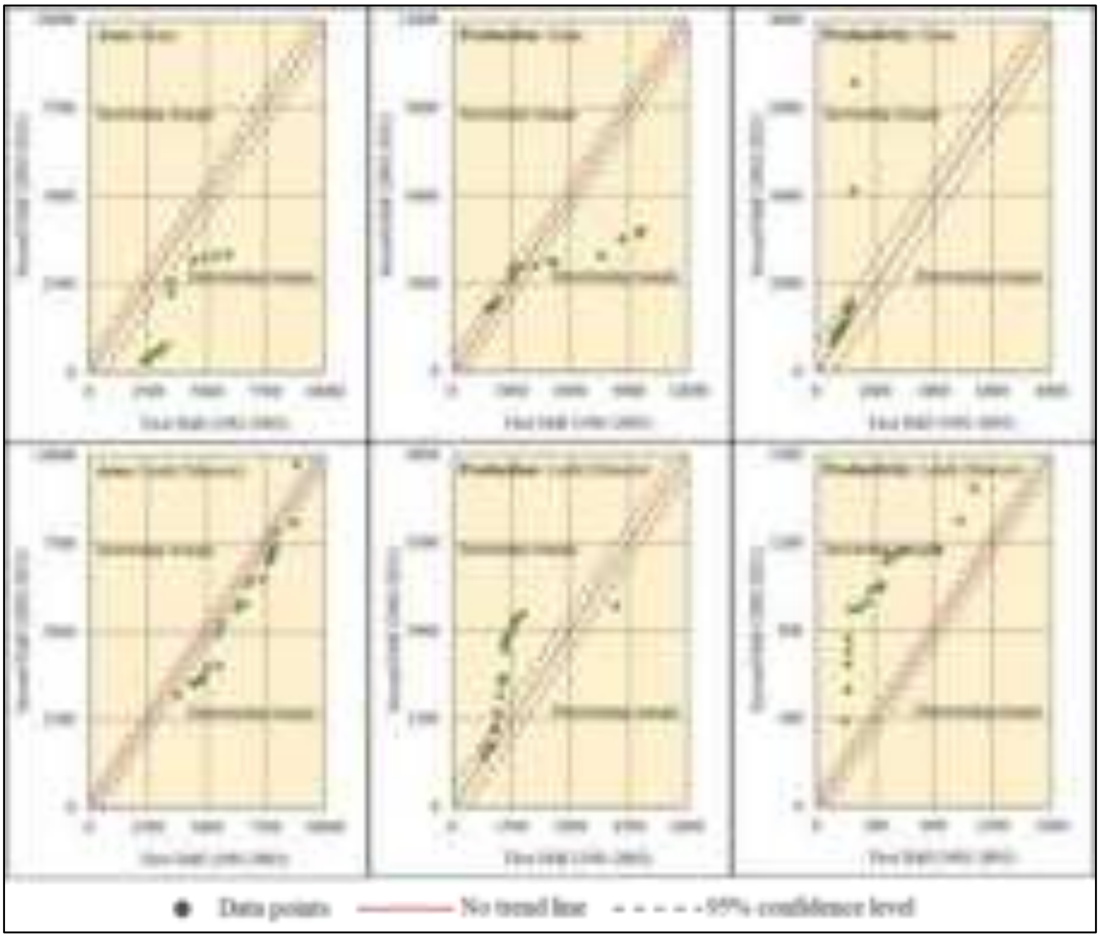
* Specifies significant at 0.1 level of significance, ** specifies significant at 0.05 level of significance, *** specifies significant at 0.01 level of significance,

Trend was detected by mMK test based on lag-1 autocorrelation

4.4.5.2 Lentil/masoor (*Lens culinaris*)

Lentil is another essential pulse crop of the Maldah. The word lentil comes from 'lens,' the Latin/Roman language and botanist Tourneford first used the word in the 16th century. Lentil is mainly sown at the beginning of February and harvested in April. The crop is basically hypogeal, meaning cotyledons of germinating seeds remain in the ground and inside the seed coat. Therefore, it is less vulnerable to insect attack, wind erosion or frost.

Results of the ITA identified a significant ($\alpha = 0.05$) decreasing trend of area and an increasing trend of production and yield of lentils in the study area during the study period. The quantity of change for the area is $-$ 31.56 ha/year. While the amount of change for the production and yield is 38.32 tons/year and 30.43 kg/year, respectively. The Z statistics of MK/mMK detected insignificant decreasing trends (90% confidence level) of the area and significant increasing trends of production and yield at 95% confidence level. The rate of decrease of the area obtained from Sen's slope is -65.33 ha/year($Q = -65.33\ ha/year$), while the magnitude of increase for production and yield is $+64.63$ tons/year ($Q = +83.80\ \text{tons}/year$) and $+18.17$ kg/ha/year($Q = +18.17\ kg/\ ha/year$) (Table 4.6).



Source: District Statistical Handbook and PAO, Maldah

Fig. 4.4 ITA graph of area, production, and yield of pulses (gram and lentil(masoor))

4.4.5.3 Urad (maskalai) (*Vigna mungo*)

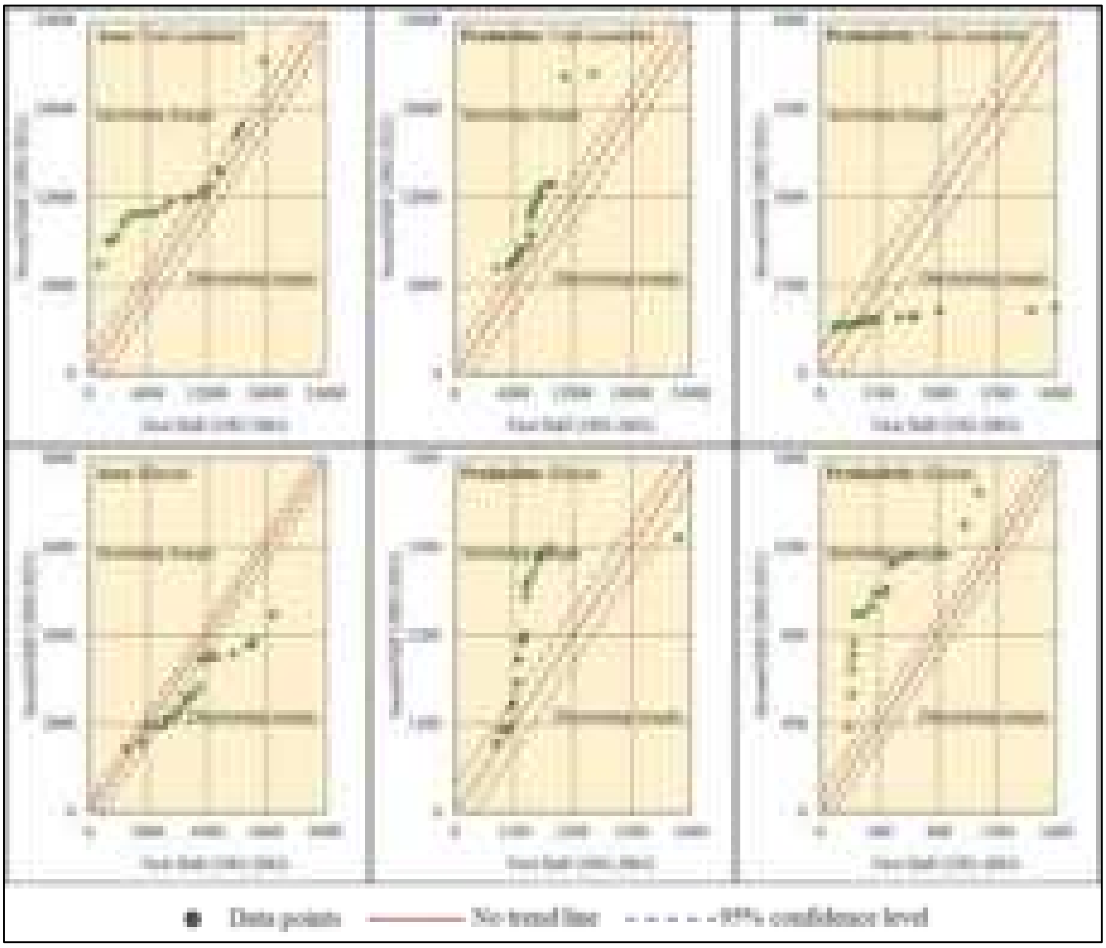
Maskalai is another vital pulse crop in the study area. It is usually grown in Kharif/during the rainy and summer season. The ideal temperature for maskalai is 25℃ to 35℃ and rainfall is 60 cm to 75 cm. Heavy rain is harmful to the crop during flowering. Generally, the crop is shown at the beginning of March and harvested at the beginning of June. Except for the saline and alkaline soils, all soil types are suitable for urad (maskalai) growing, from sandy loam to heavy clay.

From the results of ITA, it is found that the area and production of urad (maskalai) had a significant increasing trend and the yield had an insignificant decreasing trend at a 95% confidence level during the study period (Fig. 4.4). The Z statistics of MK/mMK also revealed a similar trend, showing significant increasing trend for the area and production and an insignificant decreasing trend for yield at the 95% confidence level. The rate of increase of area and production obtained from Sen's slope estimator is 247.57 ha/year ($Q = +247.57\ ha/year$) and 122.47 tons/year ($Q = +122.47\ tons/year$), while the rate of decrease of yield is 12.21 kg/ha/year ($Q = -12.21\ kg/ha/year$). At the same time, the rate of change obtained from ITA is +197.91 ha/year, +151.10 tons/year and −35.97 kg/ha/year for the area, production and yield, respectively (Table 4.6).

4.4.5.3 Khesari (*Lathyrus sativus*)

Khesari is another minor pulse crop in Maldah, commonly known as 'poor man's pulse.' This crop is also known as grass pea, white pea, sweet blue pea, etc. This crop contains up to 34% protein and some other essential micronutrients and is often the only alternative to food shortages when other crops fail. It ripens in a 4 to 6-month duration and is collected as soon as the leaves begin to turn yellow. Being a winter season crop requires 15℃ to 25℃ temperatures during sowing and harvesting. It is basically a crop of drought-prone areas and thus survives in a region with water deficiency.

Table 4.6 shows the results of ITA, MK/mMK and Sen's slope estimator of area, production and yield of Khesari in the study area. From the analysis of ITA, it is found that the production and yield had a significant positive trend during 1980-81 to 2020-21. However, the crop area showed a significantly decreasing trend at 5% significant level. The rate of decrease of the area obtained from ITA is −34.50 ha/year, while the rate of increase for production and yield is 38.32 tons/year and 25.16 kg/ha/year, respectively. On the contrary, Sen's slope estimator showed that the rate of decrease of area is −69.50 ha per year($Q = -69.50\ ha/year$), and the rate of increase of production and yield is 21.88 tons/year($Q = +21.88\ tons/year$) and 24.86 kg/ha/year($Q = +24.86\ kg/\ ha/year$) respectively (Table 4.6).

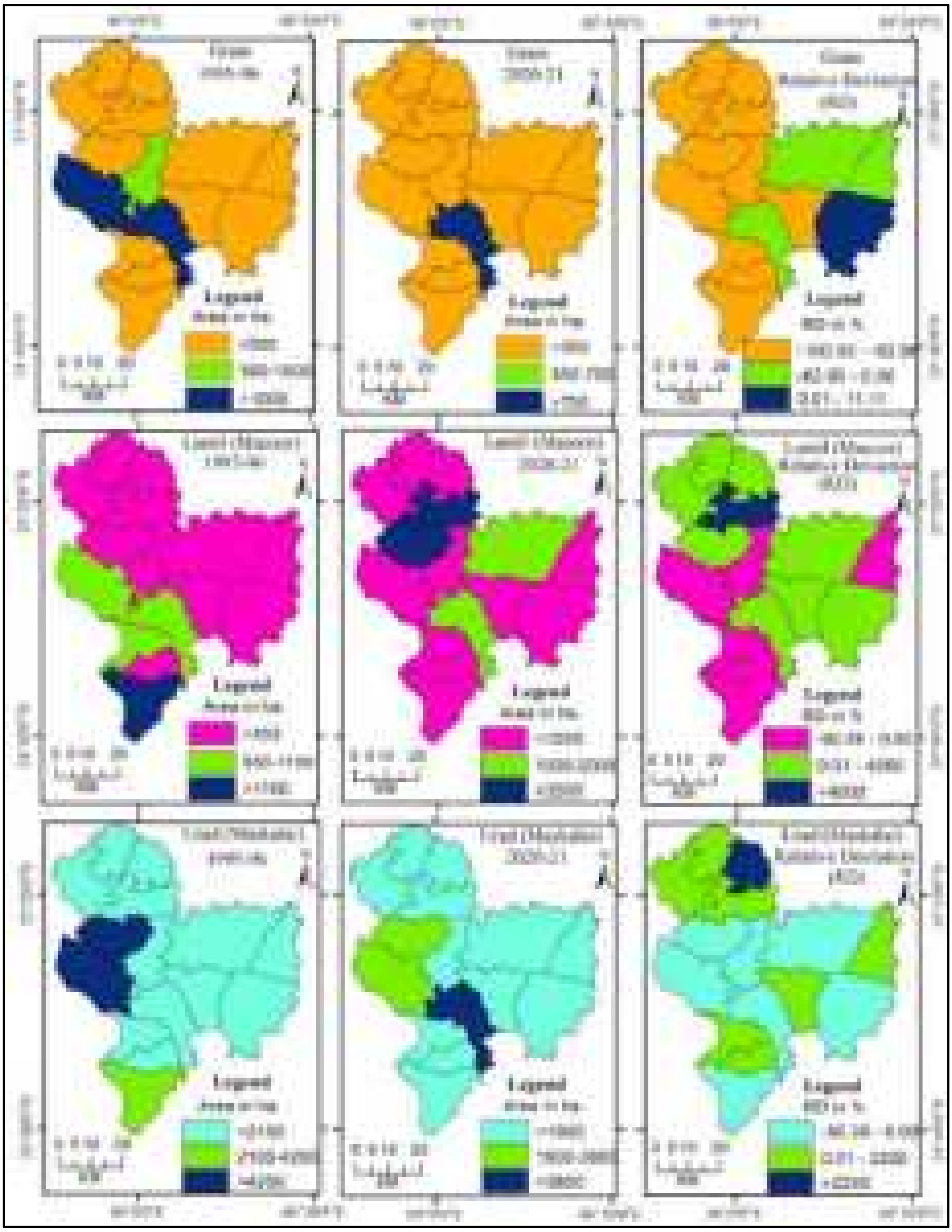


Source: District Statistical Handbook and PAO, Maldah

Fig. 4.5 ITA graph of area, production and yield of pulses (urad (maskalai) and khesari)

4.4.6 Spatio-temporal changes of pulses

Gram, lentils (masoor), urad (maskalai) and khesari are the pulses of the study area. The area under pulses in the district accounts for 6.76% of the total cropped area in 2020-21, which was 11.42% in 1980-81, showing significant change during the study period. The spatial variation of pulses with their relative change in percent in different blocks is shown in Fig.4.6. Figure 4.6 shows a decrease in the area of a gram in all the blocks except Bamangola during 1995-96 to 2020-21. High negative changes (RD=-



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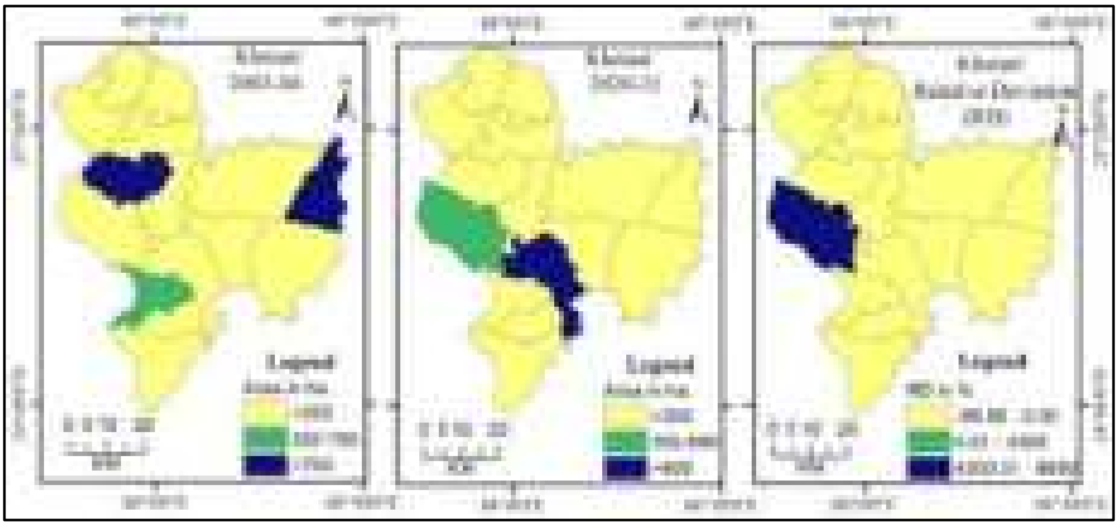


Source: District Statistical Handbook and PAO, Maldah

Fig. 4.6 Spatial variation and relative changes of area of pulses during 1995-96 & 2020-21 (for khesari 2003-04 & 2020-21)

100.00-62.96%) are observed in Chanchal I, Chanchal II, Harishchandrapur I, Harishchandrapur II, Manikchak, Kaliachak I, Kaliachak II, Kaliachak III, Old Malda, Ratua I and Ratua II. Comparatively, low decrease is noticed in the Bamangola, English Bazar and Gazole blocks. The farmers switched their land from gram to urad (maskalai) in these blocks. However, Bamangola showed positive RD from 1995-96 to 2020-21, and the increase rate is 0.01-11.11%. The area of lentils (masoor) showed both decreasing and increasing trend during the study period, though the increasing area dominated the decreasing area. In nine blocks, the area of lentils (masoor) has increased; however, the rate of increase is very high (RD=>4000%) in the Chanchal II block.

Comparatively high (0.01-4000%) increase are observed in the Chanchal I, English Bazar, Habibpur, Harishchandrapur I, Harishchandrapur II, Gazole, Old Maldah and Ratua I block. While negative changes (RD= -92.59-0.00%) are observed in Bamangola, Manikchak, Kaliachak I, Kaliachak II, Kaliachak III and Ratua II blocks (Fig. 4.6). The area of urad (maskalai) also displayed negative and positive changes during the study period. Seven blocks (English Bazar, Gazole, Habibpur, Manikchak, Kaliachak III, Ratua I, and Ratua II) are caught with negative changes (RD=-95.39 - 0.00%) from 1995-96 to 2020-21. On the other hand, Bamangola, Chanchal II, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Kaliachak II and Old Maldah had high positive changes (RD= 0.01 -2200.00%). At the same time, Chanchal I is observed with very high RD (>2200.00%) of the area of urad (maskalai) cultivation (Fig. 4.6). The cultivation of khesari showed decreasing RD in all the blocks except Manikchak. The RD of the area decreasing blocks is -99.06-0.00%. In comparison, the RD rate of the Manikchak block is very high (RD=4300.01-8650%). So, the khesari cultivation in the district has declined continuously. The farmers have changed their ALU from khesari to urad (maskalai) and lentil (masoor) in the study area.

4.4.7 Some exploratory statistics of oilseeds and cash crops

Oilseeds are grown primarily for the oil contained in the seeds. It is an essential supplier of higher quality and domain vegetable oils to nutritional products, premium snack food and even natural food. Due to their high protein value, oilseeds are very useful for animal feed. Rapeseeds & mustard is the only major oilseeds grown in Maldah district. On the other hand, cash crops are planted to sell on the market or for export to make a profit. It is typically purchased by parties separate from a farm. The cash crops produced in the district are jute, sugarcane and potato.

Table 4.5 Some exploratory statistics of area, production & yield of oilseeds & cash crops of Maldah district (1981 to 2021)

Variable	Name of the Crops	Minimum	Maximum	Mean	S. D	CV (%)
Area	Rapeseed & Mustard	6000	46463	26032.81	10313.06	39.62
	Jute	9400	44300	24293.42	5528.98	22.76
	Sugarcane	200	7026	2712.83	1552.68	57.23
	Potato	1100	12078	3900.21	3431.95	87.99
Production	Rapeseed & Mustard	3300	54594	23732.93	12422.60	52.34
	Jute	6462	71298	49809.56	13438.10	26.98
	Sugarcane	3500	540840	160693.93	144754.02	90.08
	Potato	6000	386012	95858.64	109404.81	114.13
Yield	Rapeseed & Mustard	431	1193	874.50	211.83	24.22
	Jute	687	3297	2088.82	614.96	29.44
	Sugarcane	3217	121353	58864.08	43365.23	73.67
	Potato	5455	38048	19577.60	10104.37	51.61

Source: District Statistical Handbook and PAO, Maldah

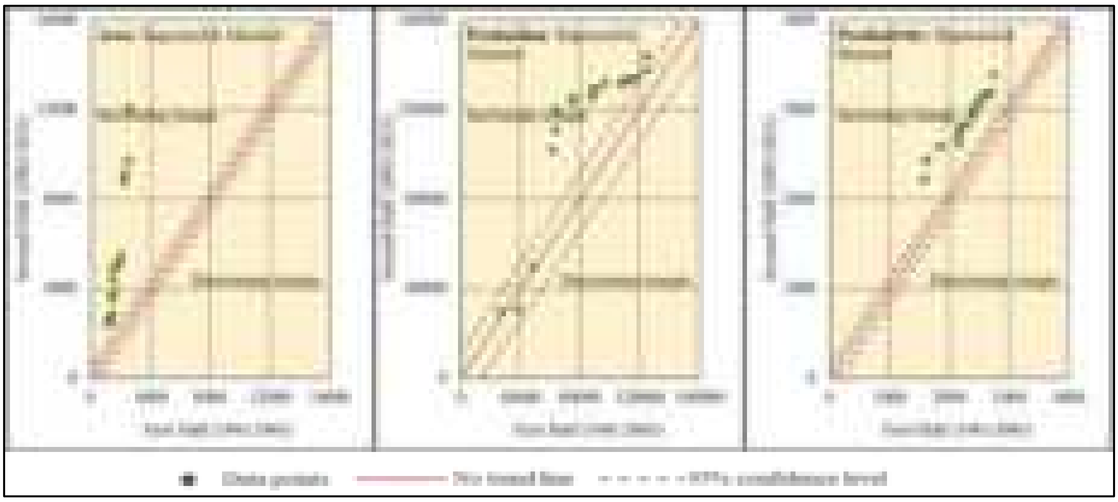
SD= Standard Deviation, CV= Co-efficient of Variation

The exploratory statistics of the oilseeds and cash crops are presented in Table 4.7. During the study period (1980-81 to 2020-21), the minimum and maximum area used for oilseeds (rapeseeds and mustard) was 6000 ha. and 46463 ha, respectively (Table 4.7). The mean area used for rapeseed and mustard is 26032.81 ha. with an SD of 10313.06. However, the CV of the rapeseed and mustard is medium (39.62%). The district's mean production of rapeseed and mustard was 23732.93± 12422.60, with a CV of 52.34%. The minimum and maximum area for cash crops varied from 200 ha. to 9400 ha. and 7026 ha. to 44300 ha. Sugarcane and jute occupied the lowest and highest positions for both minimum and maximum statistics. The mean area varied from 2712.83 ha. ± 1552.68 (sugarcane) to 24293.42 ha. ± 5528.98 (jute). However, the CV of the crop area ranged from 22.76% (jute) to 87.99% (potato), clearly revealing the more consistent area under jute production and the area under potato was comparatively less consistent (Table 4.7). Similarly, the mean production varied from 49809.56 tons± 13438.10 (jute) to 160693.93 tons± 144754.02 (sugarcane). Also, the CV of production of the crops varied from 26.98% (jute) to 114.13% (potato), which depicts the more consistent (jute) and less consistent (potato) production, respectively. On the other hand, the mean yield varied from 2088.82 kg ± 614.96 (jute) to 58864.08 kg ±43365.23 (sugarcane). At the same time, the CV of the yield ranged from 29.44% (jute) to 73.67% (sugarcane), indicating that the yield of jute is more consistent than other cash crops produced in the district during the study period.

4.4.8 The trend of oilseeds and cash crops

4.4.8.1 Rapeseed (Brassica napus) & mustard (Brassica nigra)

Rapeseed, also known as oilseed rape, is a bright yellow flowering member of the Brassicaceae family, cultivated mainly for its oil-rich seed, which naturally comprises considerable amounts of erucic acid. The results of ITA, MK/mMK, and Sen's slope estimator of area, production, and yield of rapeseed & mustard are presented in Table 4.8 and Fig. 4.5. The significant ($\alpha = 0.05$) increasing trends are identified by the ITA for the area, production, and yield. The increase is 153.74 ha/year for the area, 886.49 tons/year for production, and 30.26 kg/ha/year for yield. The Z statistics also revealed the significant increasing trend of area, production and yield of rapeseed & mustard at



Source: District Statistical Handbook and PAO, Maldah

Fig. 4.7 ITA graph of area, production and yield of oilseeds (rapeseed and mustard)

Table 4.6 Trend and growth of area, production & yield of oil seeds & cash crops of Maldah district (1981 to 2021)

Variable	Name of the Crops	Slope of ITA	Z statistics of MK/mMK	Sen's Slope (Ha, Tons & Kg/Year)
Area	Rapeseed & Mustard	153.74	3.43***	585.15
	Jute	-152.12	-3.66***	-170.82
	Sugarcane	-10.45	-0.03	-0.48
	Potato	159.84	7.78***	138.75
Production	Rapeseed & Mustard	886.49	4.17***	179.21
	Jute	835.03	3.61***	761.47
	Sugarcane	5259.59	2.01**	589.5
	Potato	6624.37	8.35***	3370.19
Yield	Rapeseed & Mustard	30.26	5.38***	14.00
	Jute	48.25	5.85***	46.58
	Sugarcane	3519.11	5.22***	2817.2
	Potato	767.61	6.77***	731.83

Source: District Statistical Handbook and PAO, Maldah

* Specifies significant at 0.1 level of significance, ** specifies significant at 0.05 level of significance, *** specifies significant at 0.01 level of significance,

The trend was detected by mMK test based on lag-1 autocorrelation

95% and 99 % confidence levels during 1980-81 to 2020-21. The rate of increase of the area, production, and yield obtained from Sen's slope is 585.15 ha per year($Q = +585.15\ ha/year$), 179.21 tons/year, and 14.00 kg/ha/year, respectively (Table 4.8).

Plate 4.4 *Mustard cultivation being one of the major crops of Maldah district at the late flowering phase (Sripur mouza, Ratua II block).*

4.4.8.2 Jute (Corchorus)

Jute is one of the utmost essential cash crops of the Maldah district. It is a rainy crop, sown mainly from March to May depending upon rainfall and land quality, and harvesting between June and September, according to the early or late sowing. It needs a warm and humid climate with temperatures varying between 24℃ and 37℃. Continuous rain or waterlogged conditions are harmful for jute cultivation, especially in the seedling period. The innovative grey soil with good depth, receiving sediment from the annual inundations, is best for jute. The results of the ITA identified a

Plate 4.5 *Jute cultivation and preparation of jute fibre under pondage at Mathurapur mouza, Manikchak block.*

significant ($\alpha = 0.05$) decreasing trend in the area and an increasing trend in the production and yield of jute in the study area during 1980-81 to 2020-21 (Fig.4.8). The ITA also revealed the amount of change for the area $-$ 152.12 ha/year. However, the production and yield magnitude change are 835.03 tons/year and 48.25 kg/year. The Z statistics of MK/mMK also detected decreasing trends for the area and increasing trends for production and yield at a 95% confidence level. The rate of decrease of the area obtained from Sen's slope is -170.82 ha per year($Q = -170.82\ ha/year$), and the magnitude of increase for production and yield is 761.47 tons/year ($Q = +761.47\ \text{tons}/year$) and 46.58 kg/ha/year($Q = +46.58\ kg/\ ha/year$) (Table 4.8).

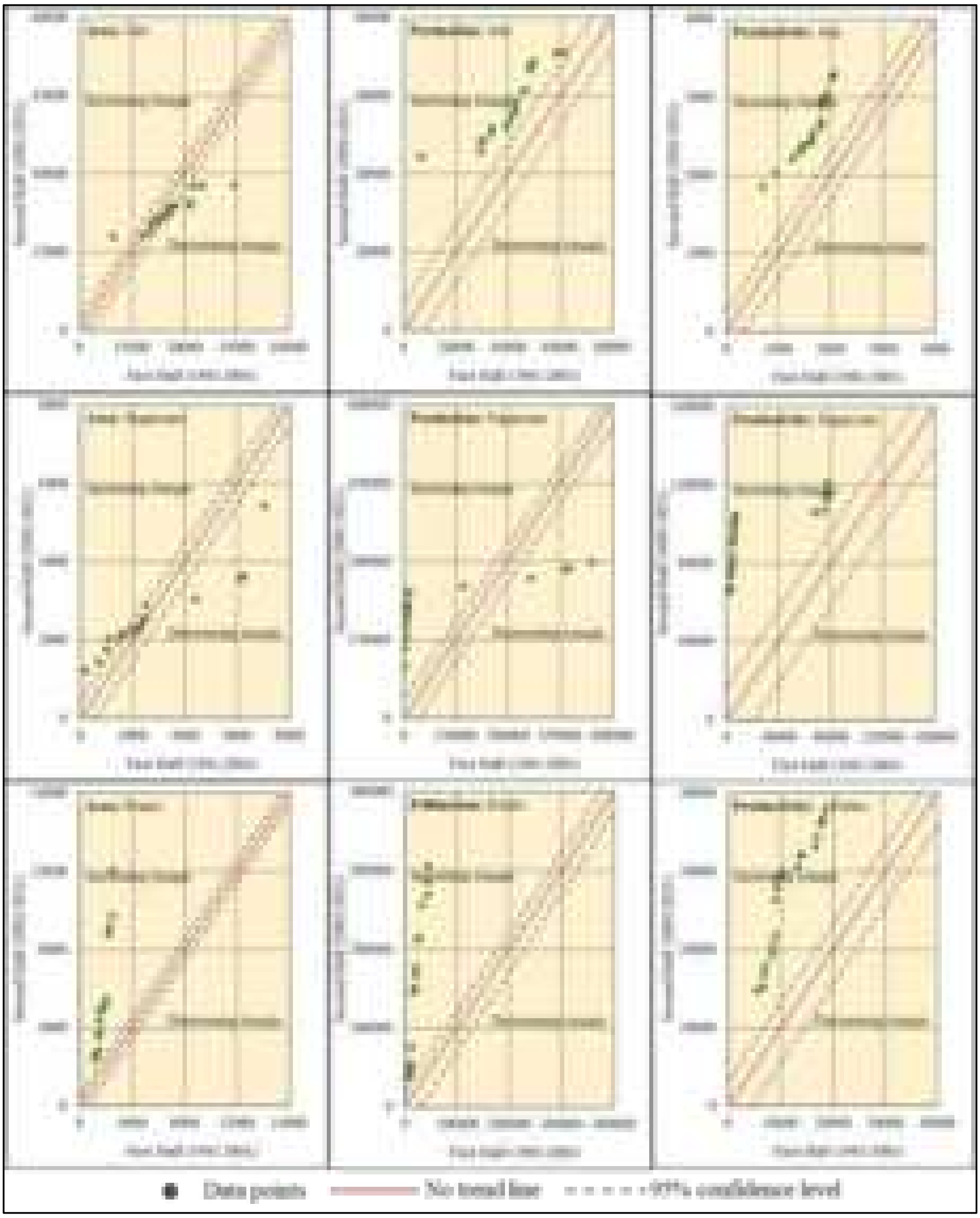
4.4.8.3 Sugarcane (Saccharum officinarum)

Sugarcane is another important cash crop in the district. It is a high water-demanding crop and the primary source of sugar. It requires 750mm to 1200 mm of rainfall during its growth period and temperatures below 20°C and above 50°C are not suitable for its growth. Abundant drained alluvial to medium black cotton soils with neutral pH and optimum depth is ideal for its growth. The trend analysis results of sugarcane using ITA showed a significant increasing trend in production and yield and decreasing trend of the area at 5% significant level (Fig.4.6). The quantity of increase obtained from ITA is 5259.59 tons/year for production and 3519.11 kg/ha/year for yield. On the other hand, the decrease rate of the area is 10.45 ha/year. The MK/mMK also showed more or less similar results to ITA, showing an increasing trend for production and yield at the rate of 589.50 tons/year ($Q = +589.50\ \text{tons}/year$) and 2817.20 kg/ha/year($Q = +2817.20\ kg/\ ha/year$) respectively (Table 4.8).

4.4.8.4 Potato (Solanum tuberosum)

Potato is another cash crop of the Maldah district and is commonly known as 'the king of vegetables.' It grows under varied climatic conditions; however, the temperature is moderately cool during the growing season. It can be produced more or less on any soil type except alkaline and saline. More precisely, loamy and sandy loam soil, rich in organic substance with well drainage and aeration, is most favourable for its cultivation. It is commonly sowing in October-November along with irrigation water and harvested in December-January. Table 4.8 shows the results of ITA, MK/mMK and Sen's slope estimator of area, production and yield of potatoes in the study area. From the analysis of ITA, it is found that the area, production and yield have a significant positive trend at 5% significant level during 1980-81 to 2020-21 (Fig. 4.6). The Z statistics of MK/mMK identified similar trends to ITA, although their magnitude is different. The increased area, production, and yield obtained from ITA are 159.84 ha/year, 6624.37 tons/year, and 767.61 kg/ha/year, respectively. On the contrary, Sen's slope estimator showed the rate of decrease for the area is −69.50 ha per year($Q = -69.50\ ha/year$), and the rate of increase for production and yield is 21.88 tons per year($Q = +21.88\ tons/year$) and 24.86 kg/ha/year($Q = +24.86\ kg/\ ha/year$) respectively (Table 4.8).

Plate 4.6 *Sugarcane cultivation being one of the minor crops (cash crop) in Maldah district (Rashikpur mouza, Gazole block).*



Source: District Statistical Handbook and PAO, Maldah

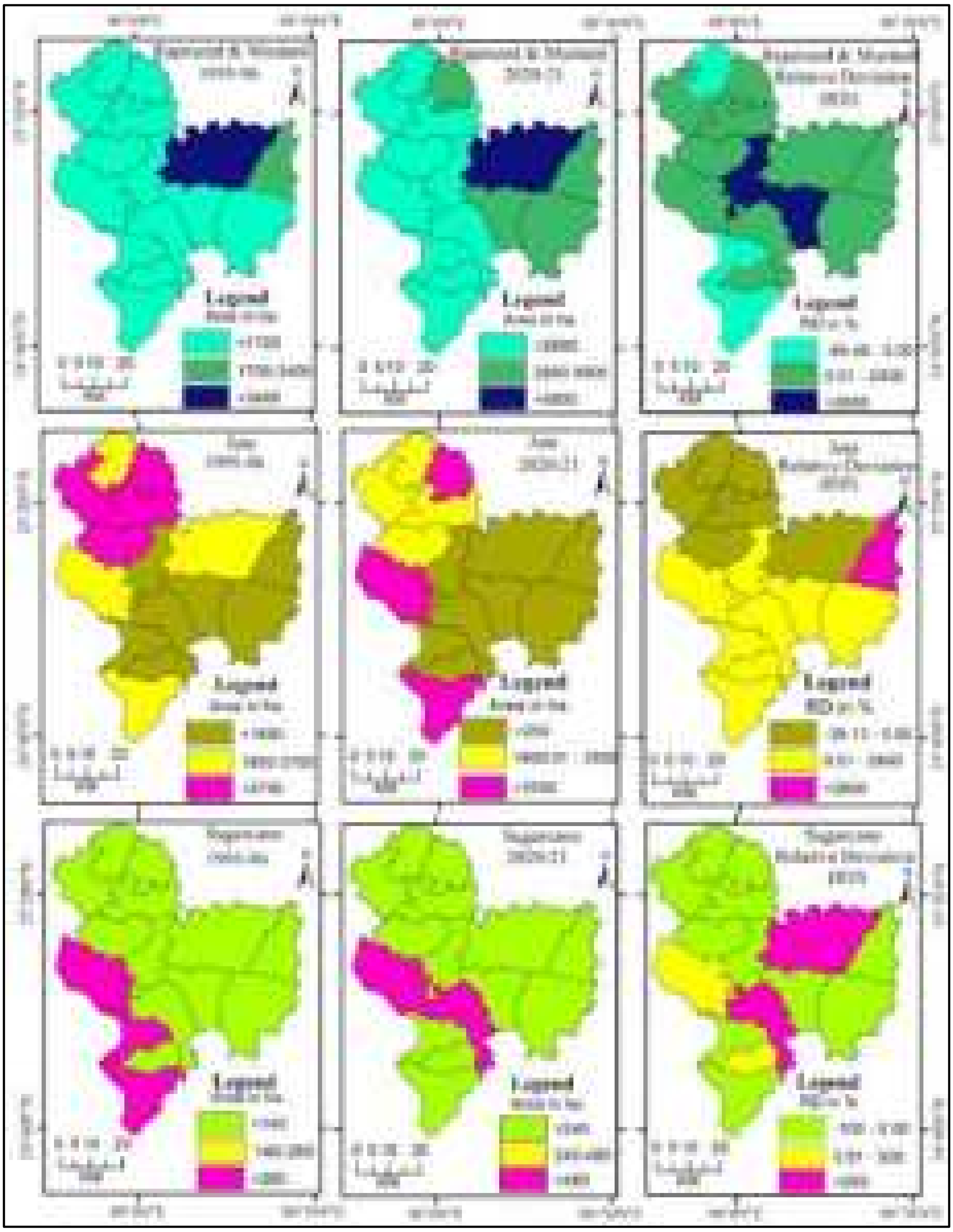
Fig. 4.8 ITA graph of area, production and yield of cash crops (jute, sugarcane and potato)

4.4.9 Spatio-temporal changes of oilseeds and cash crops

Rapeseed & mustard is the only oilseed, and jute, sugarcane and potato are important cash crops in the study area. The area under rapeseed & mustard in the district accounts for 4.95% of the total cropped area in 2020-21, which was 3.17% in 1980-81, showing change during the study period. The area under cash crops is 10.02% of the total cropped area in 2020-21, and 10.66% in 1980-81. The spatial variation of oilseed and cash crops with their relative change in the different blocks is shown in Fig.4.9. From Fig. 4.9, it is found that the area under rapeseed & mustard has decreased in three blocks (Harishchandrapur I, Kaliachak I, and Kaliachak III) and increased in twelve blocks (Bamangola, Chanchal I, Chanchal II, English Bazar, Gazole, Habibpur, Harishchandrapur II, Manikchak, Kaliachak I, Old Maldah, Ratua I and Ratua II). The increasing rate is maximum (>2000%) in Old Maldah and Ratua II blocks (Fig. 4.9). Medium to High positive changes (RD= 0.01-2000%) are observed in the Bamangola, Chanchal I, Chanchal II, English Bazar, Gazole, Habibpur, Harishchandrapur II, Manikchak, Kaliachak I and Ratua I. While decreasing amount is -64.48-0.00% in the Harishchandrapur I, Kaliachak I and Kaliachak III blocks. The farmers are switched their cropland from rapeseed & mustard to maize cultivation in Harishchandrapur I, Kaliachak I, and Kaliachak III. The area under jute showed only positive changes from 1995-96 to 2020-21, and the magnitude of the increase is high in all the blocks. Comparatively low high (<2950%) increasing rate of the area is observed in the Chanchal I, Chanchal II, Gazole, Harishchandrapur I, Harishchandrapur II, and Ratua I blocks. Medium-high (2950-5900%) increasing rate is observed in the English Bazar, Habibpur, Manikchak, Kaliachak I, Kaliachak II, Kaliachak III, Old Maldah, and Ratua II blocks. In contrast, a very high increasing rate (>5900%) is observed only in the Bamangola block. So, jute is another significant crop in the district, which increased its area at a higher rate in all the blocks.

The area of sugarcane showed both decrease and increase during the study period; however, the number of blocks with decreasing rates dominated the district. The sugarcane area has decreased in eleven blocks in the district, which are Bamangola, Chanchal I, Chanchal II, Habibpur, Harishchandrapur I, Harishchandrapur II, Kaliachak II, Kaliachak III, Old Maldah, Ratua I and Ratua II. In these eleven blocks, the decreasing amount is -100-0.00%. the farmers switched their cropland from sugarcane to maize and jute cultivation in these blocks. On the other hand, two blocks (English Bazar and Gazole) showed a very high increasing amount (RD =>500%), and two blocks (Manikchak and Kaliachak I) showed a comparatively low increasing amount (RD=0.01-500%) during the study period (Fig. 4.9). The area of potato also

Plate 4.7 *Different stages of Potato cultivation, one of the major crops of Maldah district (Pandua mouza, Gazole block).*



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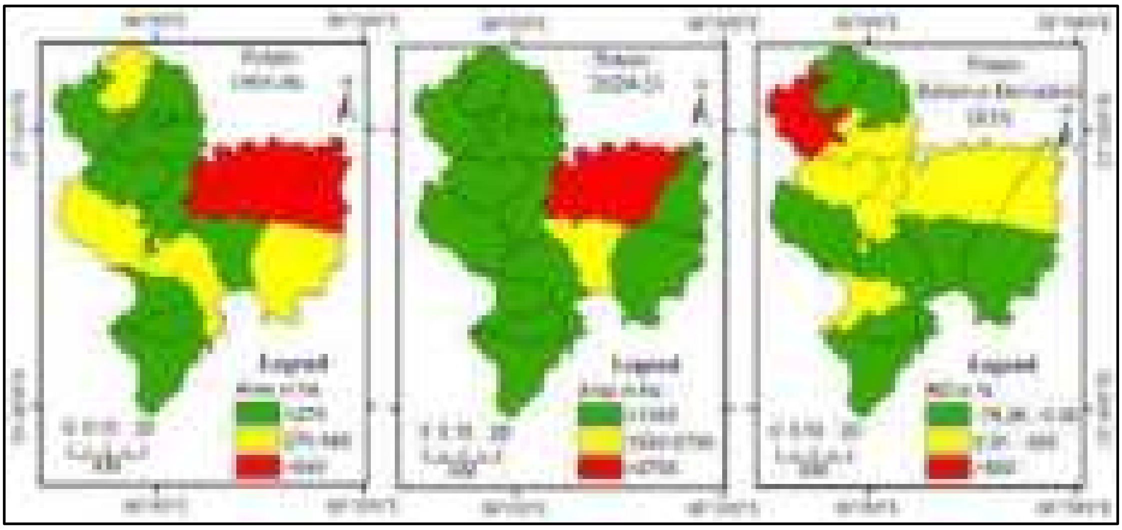


Source: District Statistical Handbook and PAO, Maldah

Fig. 4.9 Spatial variation and relative changes of area of oilseeds & cash crops (1995-96 to 2020-21)

displayed negative and positive changes during the study period. Eight blocks (English Bazar, Chanchal I, Habibpur, Harishchandrapur I, Manikchak, Kaliachak I, Kaliachak III, and Old Maldah) out of fifteen are caught with negative changes (RD=-78.26 - 0.00%) from 1995-96 to 2020-21. In these blocks the farmers changed their cropland from potato to rapeseed & mustard and maize cultivation. On the other hand, Bamangola, Chanchal II, Gazole, Kaliachak II, Ratua I, and Ratua II blocks area observed high positive changes (RD= 0.01 -500%). At the same time, Harishchandrapur II is observed with very high positive changes (RD = >500%) in the area of potato cultivation (Fig. 4.9). The patterns of agriculture within the blocks have been changed over time and place to place because of the socio-economic conditions of the farmers.

Hypothesis I: *There is a significant decreasing trend in the area under major crops.*

In the context of hypothesis I, the non-parametric Mann-Kendall (MK)/modified Mann-Kendall (mMK) test has been performed. First of all, autocorrelation function (ACF) of the data sets have been checked using lag-1 at 0.05 significant level if there any autocorrelation in the datasets. Because autocorrelation in a dataset may increases the variance of MK test statistic. In addition, positive autocorrelation in a dataset increases type I error which about false positive and show trend while there is no actual trend. From the Fig. 4.10, it is found that the ACF of the dataset is not significant at 0.05 significant level using lag-1. So, only MK test is enough here to find out the significant increasing or decreasing trend and no need to use modified mMK test results against

MK. However, mMK is required when there is significant correlation in the datasets using lag-1at 0.05 significant level.

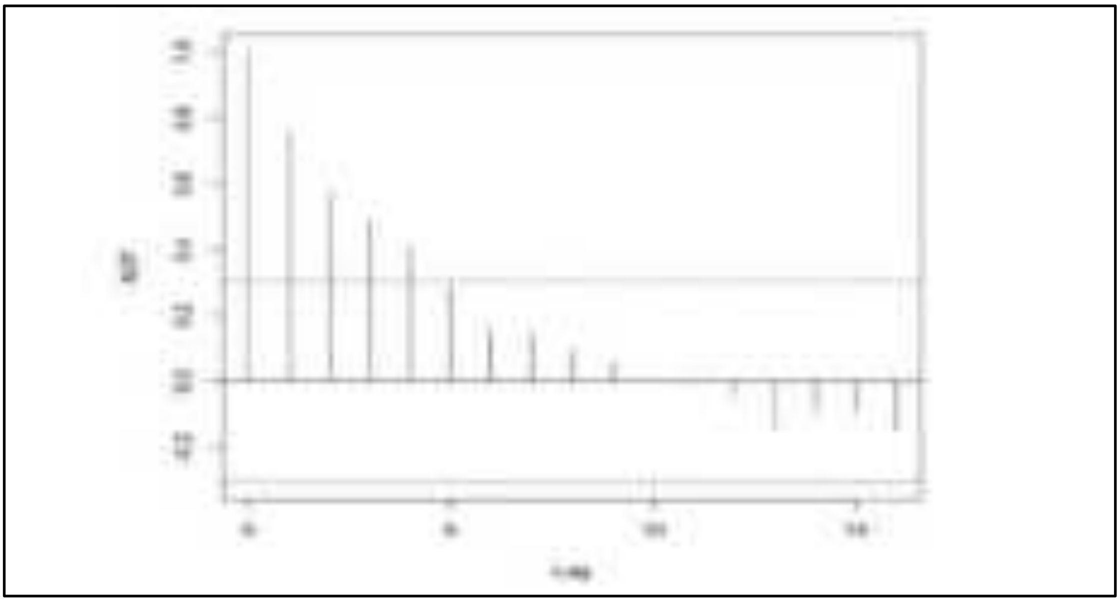


Fig. 4.10 ACF of the time series data of major crops of Maldah district

Table 4.7 Trend and growth of area of the major crops of Maldah district

Variable	ACF	Z Statistic of the MK/mMK	Sen Slope (ha/year)	Significant value at 0.05 level	Status
Area of the major crops	0.76	4.32	1565.08	≥ 1.96	Significant increasing trend

The Table 4.7 also showed that the value of ACF is greater than 0.05; so, the data of the time series is not significantly autocorrelated at 95% confidence level. On the other hand, the obtained value of Z statistic of the MK is 4.32 which is larger than the value of 1.96. So, it is significant at 0.05 significant level. So, it may be concluded that there is a significant increasing trend in the area of the major crops in Maldah district. So, hypothesis I is not accepted.

4.5 Agricultural regionalization and its changes

The agricultural region is a continuous area having uniformity with precisely defined external boundaries. It is basically the procedure of dividing a region into local units of homogeneous centers, which are the outcomes of a set of actions. According to Singh and Dhillon (1984), regionalization is not just a function of dividing an area into provincial units but also a technique of understanding the pattern of agriculture, labeled in such a manner to get supremacy over the study process. It is dynamic in nature, and its concept changes with time and space. Buchanan (1959) simply defined the agricultural region as an area of a uniform agricultural character. R. L. Singh (1966) revealed that regionalization contains a systematic study of regional assimilation and differentiation of interconnected occurrences in regional synthesis. The interrelated phenomena having some homogeneity and heterogeneity can be assembled. The area with some uniformity noteworthy in some respect from the adjacent area is delimited. So, an agricultural region, usually, is an area having homogeneity of crops and livestock (Husain, 2013). The agricultural regionalization and their changing pattern have been discussed based on crop ranking, crop combination, crop diversification, crop concentration and cropping intensity.

4.5.1 Crop Ranking

The ranking of crops provides the most accepted measure of the areal strength of specific crops. It mainly provided a vision into the geographical actuality of cropping structure. The areal potentialities of the crops have given employment opportunities to the farmers and their family members. Also, the nature of the economy, whether it is subsistence or commercial or market-oriented farming, is influenced by the ranking of crops. It is usually done by ranking the leading crops of a region according to the relative importance of each crop. By identifying the relative significance of different crops in an areal unit, the planning technique can be more logically accepted for the ideal use on the existing land for cultivation.

4.5.1.1 Methodology

The crop ranking for detecting the relative significance of a specific crop in cropping pattern nine major and four minor crops have been considered in the district. For calculating the crop ranking regions, the relative importance of percentage share to the gross cropped area, production, or productivity of the district and all blocks for each crop is considered. A combined rank of each crop is considered by calculating the rank of net sown area, production, and productivity individually. It is more fruitful and objective than calculating crop ranking based on only the percentage share of the net sown area to the gross cropped area. However, the ranking of crops of the study area has been examined for the two different periods, i.e., 1980-81 and 2020-21 for the district as a unit and 1995-96 and 2020-21 for the block level variation due to lack of block-level data before 1995-96.

4.5.1.2 Crop ranking region and its changing pattern

The ranking of crops delivers a healthy perception of the geographical actuality of the cropping structure of an area. Sensible land use with sufficient inputs can assist in growing agricultural production, even in the regions with less fertile. In the study area, the winter rice (aman), autumn rice (aus), and jute were ranked 1^{st}, 2^{nd}, and 3^{rd} in respect of net sown area during 1980-81 (Table 4.8). Based on production, winter rice (aman) ranked 1^{st}, summer rice (boro) ranked $2^{nd,}$ and wheat ranked 3^{rd}. However, on the basis of productivity sugarcane, potato, and summer rice (boro) ranked 1^{st}, $2^{nd,}$ and 3^{rd}. After making the final rank, it is observed that the 1^{st}, 2^{nd}, and 3^{rd} positions were occupied by winter rice (aman), summer rice (boro), and wheat. The final rank of the other crops is also displayed in Table 4.8.

During 2020-21, winter rice (aman), summer rice (boro) and maize ranked 1^{st}, 2^{nd} and 3^{rd} in the study area in respect of net sown area (Table 4.9). Based on production winter rice (aman), potato, and summer rice (boro) ranked 1^{st}, $2^{nd,}$ and 3^{rd}. While, sugarcane ranked 1^{st}, potato ranked $2^{nd,}$ and summer rice (boro) ranked 3^{rd} on the basis of productivity. At the same time, the results obtained from the final rank reveals that the 1^{st}, 2^{nd}, and 3^{rd} positions were occupied by winter rice (aman), summer rice (boro), and potato (Table 4.9).

During the study period (1980-81 to 2020-21), some remarkable changes are observed in crop ranking; however, the rank of the winter rice (aman), summer rice (boro), and khesari have remained the same in both period (Table 4.8 and 4.9). These three crops took place $1^{st,}$ $2^{nd,}$ and 13^{th} in both the year (1980-81 and 2020-21); however, their sown area has changed from 43.75% to 42.63% for winter rice (aman), from 7.01% to 17.50% for summer rice (boro) and from 1.97% to 0.45% for khesari. During 1980-81 the 3^{rd} position crop was wheat which is replaced by potato in 2020-21. Similarly, the 4^{th} and 5^{th} position crops were jute and autumn rice (aus) in 1980-81, which replaced by maize and sugarcane in 2020-21 (Table 4.8 and 4.9). So, the crops were grown in 1980-81 in Maldah district, also grown in 2020-21, but their rankings have changed significantly.

Table 4.8 Ranking of the crops of Maldah district in 1981

Name of the crops	% to net sown area	Rank	% to total production	Rank	Av. Yield in kg/ha	Rank	Compound rank	Final rank
Autumn rice (Aus)	13.61	2	6.21	5	590	10	5.67	5
Winter rice (Aman)	43.75	1	50.09	1	1180	6	2.67	1
Summer rice (Boro)	7.01	5	14.27	2	2629	3	3.33	2
Wheat	7.80	4	9.48	3	1570	4	3.67	3
Maize	2.57	8	1.74	7	877	9	8.00	10
Gram	6.00	6	4.4	6	945	7	6.33	6
Masoor	2.00	9	0.79	12	511	11	10.67	12
Maskalai	1.45	11	1.62	8	1436	5	8.00	8
Khesari	1.97	10	0.32	13	212	13	12.00	13
Rapeseed & Mustard	3.17	7	1.06	11	431	12	10.00	11
Jute	9.99	3	7.21	4	932	8	5.00	4
Sugarcane	0.32	13	1.35	10	5657	1	8.00	9
Potato	0.35	12	1.47	9	5455	2	7.67	7

(Calculated by the researcher)

4.5.1.3 Spatial pattern of crop ranking region

The spatial pattern of crop ranking regions for 1995-96 and 2020-21 have shown in Table 4.10 and Table 4.11.

4.5.1.3.1 First ranking crops

Autumn rice (aus), winter rice (aman), and wheat were the three significant crops that enlisted as the 1st ranking crop in different blocks during 1995-96 (Table 4.10). In contrast, winter rice (aman), wheat, maize, and jute are enlisted as 1st ranking crops during 2020-21 (Table 4.11). Autumn rice (aus) ranked 1st in Kaliachak II; winter rice (aman) ranked 1st in all the blocks in the district except Kaliachak II, Kaliachak III, Manikchak, and Ratua I, whereas wheat positioned 1st in Kaliachak III, Manikchak, and Ratua I blocks during 1995-96. During 2020-21, winter rice (aman) positioned 1st

in 10 blocks, namely Bamangola, Chanchal I, Chanchal II, Gazole, Habibpur, Harishchandrapur I, Harishchandrapur II, Old Maldah, Ratua I and Ratua II. Wheat ranked 1st in Manikchak block, and maize ranked 1st in English Bazar, Kaliachak I, and Kaliachak II blocks. At the same time, jute ranked 1st in Kaliachak III block. In the extent of more than two decades, there has been a change in the ranking order of some crops. The change showed that autumn rice (aus) is replaced by maize in Kaliachak II, winter rice (aman) is replaced by maize in English Bazar and Kaliachak I, wheat is replaced by winter rice (aman) in Ratua I, and jute in Kaliachak III. However, Manikchak block remained unchanged and positioned 1st in both periods for wheat production. These crops can also be cultivated as the 1st ranking crop in these blocks in the current environmental conditions. However, maize and jute are more commercial and profitable crops than rice and wheat (subsistence crops) in the district.

Table 4.9 Ranking of the crops of Maldah district in 2021

Name of the crops	% to net sown area	Rank	% to total production	Rank	Av. Yield in kg/ha	Rank	Compound rank	Final rank
Autumn rice (Aus)	0.4	13	0.2	12	2650	8	11	12
Winter rice (Aman)	42.63	1	37.21	1	4570	4	2	1
Summer rice (Boro)	17.5	2	18.96	3	5670	3	2.67	2
Wheat	4.27	6	2.52	6	3090	7	6.33	6
Maize	14.12	3	9.17	4	3400	6	4.33	4
Gram	0.45	12	0.36	10	4270	5	9	10
Masoor	1.93	9	0.33	11	900	12	10.67	11
Maskalai	3.73	7	0.82	9	1150	10	8.67	9
Khesari	0.45	10	0.07	13	810	13	12	13
Rapeseed & Mustard	4.8	5	1.02	8	1110	11	8	8
Jute	5.96	4	2.48	7	2179	9	6.67	7
Sugarcane	0.45	11	6.24	5	72320	1	5.67	5
Potato	3.31	8	20.62	2	32580	2	4	3

(Calculated by the researcher)

4.5.1.3.2 Second ranking crops

Five crops, which are summer rice (boro), wheat, maize, urad (maskalai), and rapeseed & mustard, ranked 2nd in different blocks in the study area during 1995-96; whereas six crops, namely summer rice (boro), wheat, maize, urad (maskalai), rapeseed & mustard, and jute are ranked 2nd during 2020-21 (Table 4.10 and 4.11). During 1995-96, summer rice (boro) ranked 2nd in most of the blocks except Bamangola, Kaliachak I, Kaliachak II, Kaliachak III, Manikchak, and Ratua I; wheat ranked 2nd in Kaliachak I, maize in Kaliachak II, urad (maskalai) in Manikchak and Kaliachak III; while rapeseed & mustard ranked 2nd in Bamangola block. During 2020-21, summer rice (boro) ranked 2nd in Chanchal II, Gazole, Habibpur, Harishchandrapur I, Old Maldah, Ratua I, and Ratua II blocks; wheat ranked 2nd in Kaliachak I; maize ranked 2nd in Harishchandrapur II and Kaliachak III. While urad (maskalai) ranked 2nd in English Bazar block; however, rapeseed & mustard ranked 2nd in Bamangola block. At the same time, jute ranked 2nd in Chanchal I, Kaliachak II and Manikchak block. From the changes of crop ranking, it is found that summer rice (boro) is replaced by maize in Harishchandrapur II, urad (maskalai) in English Bazar, and jute in Chanchal I block. At the same time, urad (maskalai) is replaced by jute in Manikchak and maize in Kaliachak III block during 1995-96 to 2020-21.

4.5.1.3.3 Third ranking crops

During 1995-96, six crops, namely autumn rice (aus), summer rice (boro), lentil (masoor), urad (maskalai), rapeseed & mustard and jute were ranked 3rd in different blocks of the district (Table 4.10). The autumn rice (aus) was found as 3rd ranking crop in English Bazar, Kaliachak I, Kaliachak III, Manikchak, and Old Maldah block; summer rice (boro) in Bamangola and Ratua I; lentil (masoor) in Kaliachak II; urad (maskalai) in Ratua II; and rapeseed & mustard in Gazole and Habibpur block. Jute ranked 3rd in Chanchal I, Chanchal II, Harishchandrapur I and Harishchandrapur II block. During 2020-21, seven crops were ranked 3rd in different blocks and the crops are winter rice (aman), summer rice (boro), wheat, maize, maskalai, rapeseed & mustard, and jute. Winter rice (aman) ranked 3rd in English Bazar, Kaliachak I and Kaliachak III; summer rice (boro) in Bamangola, Chanchal I and Harishchandrapur II; wheat in Kaliachak II; maize in Harishchandrapur I and Ratua I; urad (maskalai) in Manikchak; rapeseed & mustard in Gazole and Habibpur; and jute in Chanchal II and

Ratua II blocks (Table 4.11). From the changes of crop ranking between the two periods (1995-96 to 2020-21), it is found that autumn rice is replaced by winter rice (aman) in English Bazar, Kaliachak I and Kaliachak III; summer rice (boro) is replaced by maize in the Ratua I; lentil (masoor) is replaced by wheat in Kaliachak II; urad (maskalai) is replaced by jute in Ratua II. Jute is replaced by summer rice (boro) in Chanchal I and Harishchandrapur II and maize in Harishchandrapur I block. However, rapeseed & mustard has kept its rank the same in both years.

4.5.1.3.4 Fourth ranking crops

Summer rice (boro), wheat, maize, gram, and jute were the five major crops that enlisted as 4th ranking crops in different blocks of the district during 1995-96 (Table 4.10). This year, summer rice ranked 4th in Kaliachak I, wheat in all the blocks except English Bazar, Kaliachak I, Kaliachak III, Manikchak and Ratua I, maize in Manikchak, gram in English Bazar, and jute in Kaliachak III and Ratua I. On the other hand, summer rice (boro), wheat, maize, lentil (masoor), urad (maskalai), rapeseed & mustard, jute, and potato are enlisted as 4th ranking crops during 2020-21 (Table 4.11). This year, summer rice (boro) ranked 4th in English Bazar, wheat in Bamangola, maize in Habibpur, Manikchak, Old Maldah, and Ratua II, lentil (masoor) in Chanchal II and Ratua I, urad (maskalai) in Kaliachak II and Kaliachak III, rapeseed & mustard in Chanchal I and Kaliachak I, jute in Harishchandrapur I and Harishchandrapur II, and potato in Gazole. However, the changes showed that summer rice (boro) is replaced by rapeseed & mustard in Kaliachak I, wheat is replaced by rapeseed & mustard in Chanchal I; also, wheat is replaced by maize in Habibpur, Old Maldah and Ratua II, by jute in Harishchandrapur I and Harishchandrapur II and by potato in Gazole. Gram is replaced by summer rice (boro) in English Bazar; jute is replaced by urad (maskalai) in Kaliachak III and by lentil (masoor) in Ratua I during 1995-96 to 2020-21.

4.5.1.3.5 Fifth ranking crops

There were eight crops in Maldah district during 1995-96 and seven crops during 2020-21, which ranked 5th in different blocks. The crops which ranked 5th during 1995-96 were autumn rice (aus) in Chanchal I; winter rice in Ratua I; summer rice (boro) in Kaliachak III; wheat in English Bazar; gram in Kaliachak I and Ratua II; rapeseed & mustard in Chanchal II, Harishchandrapur I, Harishchandrapur II and Kaliachak II; jute

Table 4.10 Block wise crop rank frequency of Maldah district (1995-96)

Name of the crops	Crop ranks and the number of blocks													Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
Autumn Rice (Aus)	1	-	5	-	1	4	1	1	-	-	1		1	15
Winter Rice (Aman)	11	-	-	-	1	-	1	-	1	-	1	-	-	15
Summer Rice (Boro)	-	9	2	1	1	1	1	-	-	-	-	-	-	15
Wheat	3	1	-	10	1	-	-	-	-	-	-	-	-	15
Maize	-	1	-	1	-	2	3	2	1	2	2	1	-	15
Gram	-	-	-	1	2	1	2	1	4	4	-	-	-	15
Masoor	-	-	1	-	-	4	2	3	1	3	1	-	-	15
Maskalai	-	3	1	-	-	-	3	1	3	1	2	-	1	15
Khesari	-	-	-	-	-	-	-	-	-	-	-	-	-	00
Rapeseed & Mustard	-	1	2	-	4	2	-	-	4	-	1	1	-	15
Jute	-	-	4	2	3	-	1	2	1	2	-	-	-	15
Sugarcane	-	-	-	-	-	-	-	2	-	1	4	6	2	15
Potato	-	-	-	-	2	1	1	3	-	2	3	3	-	15
Total	15	15	15	15	15	15	15	15	15	15	15	11	4	

(Calculated by the researcher)

in Gazole, Manikchak and Old Maldah; and potato in Bamangola and Habibpur blocks (Table 4.10). During 2020-21, winter rice (aman) ranked 4th in Kaliachak II; wheat in Gazole; maize in Bamangola; Chanchal I and Chanchal II; urad (maskalai) in Kaliachak I, Ratua I, and Ratua II; rapeseed and mustard in English Bazar, Harishchandrapur I, Harishchandrapur II, Kaliachak III, and Manikchak; jute in Habibpur and potato in Old Maldah (Table 4.11). From the changes, it is found that autumn rice (aus) is replaced by maize in Chanchal I, winter rice (aman) is replaced by urad (maskalai) in Ratua I, summer rice (boro) is replaced by rapeseed & mustard in Kaliachak III. On the other hand, wheat is replaced by rapeseed & mustard in English Bazar; gram is replaced by urad (maskalai) in Kaliachak I and Ratua II; rapeseed & mustard is replaced by maize in Chanchal II and by winter rice (aman) in Kaliachak II; jute is replaced by wheat in Gazole, by rapeseed & mustard in Manikchak and by potato in Old Maldah. Finally, potato is replaced by maize in Bamangola and by jute in Habibpur block in the district.

4.5.1.3.6 Sixth ranking crops

There were seven crops, i.e., autumn rice (aus), summer rice (boro), maize, gram, lentil (masoor), rapeseed & mustard, and potato, which ranked 6th during 1995-96 (Table 4.10). During 2020-21, also seven crops ranked 6th in different blocks in the district (Table 4.11). From the changes between these two periods, it is found that the autumn rice (aus) is replaced by potato in Bamangola, rapeseed & mustard in Chanchal II and Ratua II and by maize in Gazole; summer rice (boro) is replaced by lentil (masoor) in Kaliachak II; maize is replaced by potato in Harishchandrapur II and by jute in Ratua I; gram is replaced by summer rice (boro) in Manikchak; lentil (masoor) is replaced by wheat in English Bazar, by potato in Habibpur, by jute in Kaliachak I and by wheat in Kaliachak III block. At the same time, rapeseed & mustard is replaced by lentil (masoor) in Chanchal I and by jute in Old Maldah block; finally, potato is replaced by lentil (masoor) in Harishchandrapur I block in the district.

Table 4.11 Block wise crop rank frequency of Maldah district (2020-21)

Name of the crops	Crop ranks and the number of blocks													Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
Autumn Rice (Aus)	-	-	-	-	-	-	-	-	-	-	1	3	11	15
Winter Rice (Aman)	10	-	3	-	1	-	1	-	-	-	-	-	-	15
Summer Rice (Boro)	-	7	3	1	-	1	-	3	-	-	-	-	-	15
Wheat	1	1	1	1	1	2	2	-	5	1	-	-	-	15
Maize	3	2	2	4	3	1	-	-	-	-	-	-	-	15
Gram	-	-	-	-	-	-	-	1	-	-	8	4	2	15
Masoor	-	-	-	2	-	3	3	5	1	1	-	-	-	15
Maskalai	-	1	1	2	3	-	1	3	4	-	-	-	-	15
Khesari	-	-	-	-	-	-	-	-	4	10	-	-	1	15
Rapeseed & Mustard	-	1	3	2	5	2	2	-	-	-	-	-	-	15
Jute	1	3	2	2	1	3	2	-	-	1	-	-	-	15
Sugarcane	-	-	-	-	-	-	1	1	1	1	3	6	1	15
Potato	-	-	-	1	1	3	3	2	-	1	2	2	-	15
Total	15	15	15	15	15	15	15	15	15	15	15	15	15	

(Calculated by the researcher)

4.5.2 Crop combination

The analysis of crop combination of any region plays a significant role in agricultural geography as it offers a suitable basis for agricultural regionalization. It signifies the group of essential crops in the constituent region. Additionally, it gives a scientific solution to geographical problems. So, geographers pay massive attention to classifying the areas into different combinations of leading activities, viz., agricultural production and land use. According to Husain (2013), crop combination is a logical tool to analyze the existing spatial association of crops in land utilization and agricultural geography. While Todkari (2012) revealed that the analysis of crop combination and relative position of the crops are the pre-requisite condition for a regional level crop study. Thus, crop combination analysis is crucial for agricultural planning and development due to its appropriateness for separating the agricultural region (Ghar & Sonwane, 2011). It is also helpful to find out the leading crop in a region.

Several qualitative and quantitative techniques have been formulated to identify the crop combination region worldwide. In a quantitative approach, crops are organized in hierarchical order, and the crop combination region is identified. These methods are more accurate, precise and logical than qualitative methods. However, the concept of crop combination was first propounded by Weaver in 1954 for delineating the crop combination region of the middle-west in the U.S.A based on the minimum deviation. Despite its scientific base, this method delivers a much-generalized figure as it only considers those crops which occupy more than 1% area. To overcome this weakness, Scott (1957), Doi (1959), Coppock (1964), Rafiullah (1965) and Dayal (1967) appropriately modified Weaver's crop combination method. Scott modified Weaver's Crop combination technique in 1957 and applied his modified version to a study of crop and livestock association in Tasmania of Australia, where he revealed both the ranked combination and grouped combinations are significant. Doi later modified weaver's method in 1959, where he provided only one sheet of a table that only needed the summing up of actual percentage under diverse crops instead of discovering the differences between actual percentage and theoretical distribution. Whereas Coppock (1964) modified Weaver's technique and made not only crop and livestock association, but also the association of enterprises in Wales and England. He took rank into account in identifying the most significant crops. Still, his main objectives were to include both crops and livestock on one farm, facing the unequal unit problem in the comparison.

Subsequently, Rafiullah (1965) modified the crop combination technique of Weaver and applied this upgraded version to analyze the functional classification of towns which is more scientific and famous to the researcher.

4.5.2.1 Methodology

In this study, Rafiullah's (1965) maximum positive deviation method of crop combination has been implemented. He first used this method in his work "*A New Approach to the Functional Classification of Towns*." In this technique, the differences in actual values are computed from the median value of the theoretical value. Thus, this technique delivers the expected critical combination, unlike the standard deviation method. Moreover, this technique comprises a smaller number of crops in combination and therefore rejects the inclusion of irrelevant crops from the combination. Additionally, this statistical method is quite famous for demarcating crop combination regions as it is more objective, precise, and scientific. It is also able to handle extremely diversified cropping structures. Likewise, analysis of crop combination region using statistical technique arranges for a sound base for agricultural planning, its implication and development.

The present method keeps amused navigable economic and agricultural planning over inefficient cropping systems in the Maldah district as most of the population has been involved in agriculture. The maximum positive deviation method put forward by Rafiullah is given as follows:

$$d = \sqrt{\frac{\sum D_p^2 - D_n^2}{N^2}}$$

Where,

d denotes the deviation

D_p denotes the positive difference

D_n denotes the negative difference

N denotes the number of crops

The under-root symbol may be overlooked for the generalization of the whole calculation since the technique is the relative rank of the value of deviation, which is necessary. So, the formula may be written as follows:

$$d = \frac{\sum D_p^2 - D_n^2}{N^2}$$

Thus, at first, the block-wise percentage of every single crop area to the gross cropped area has been calculated. After that, the value of every crop has arranged in descending order and then applied to the formula mentioned earlier. The crops having an area less than 4 % were omitted from the calculation, and the maximum positive deviation of variance was calculated. The highest value of the variance is denoted as crop combination and the number of crops in the combination. The theoretical curve obtained by Rafiullah for the standard crop combination measurement is as follows:

Monoculture = 50% of the gross cropped area in one crop

Two crop combination = 25% in each of two crops

Three crop combination = 16.7% in each of the three crops

Four crop combination = 12.5% in each of the four crops

Five crop combination = 10% in each of the five crops

Ten crop combination = 5% in each of the ten crops

4.5.2.2 Spatial pattern of crop combination region

The spatial pattern of crop combination regions, obtained from Rafiullah's method for 1995-96 and 2020-21, revealed that most of the blocks of the study area are dominated by two crop combinations in both the period; however, mono crop, three crop and five crop combination are also observed which have been discussed in the following section:

4.5.2.2.1 Mono crop combination

The crop combination results of both the period (1995-96 and 2020-21) using Rafiullah's method are displayed in Table 4.12 and Fig. 4.11. The result shows that the study area was dominated by mono-crop combination in the year 1995-96. Eight blocks (English Bazar, Habibpur, Kaliachak II, Kaliachak III, Manikchak, Old Maldah, Ratua I and Ratua II) were found with mono-crop combination. The people of these blocks mainly preferred to cultivate winter rice (aman) during 1995-96, principally relying on monsoon rainfall. However, the area under monoculture (27.68%) was less compared to the two-crop combination (61.18%) in the study area. During 2020-21, seven blocks are under mono-crop combinations, which are English Bazar, Harishchandrapur I, Manikchak, Kaliachak I, Old Maldah, Ratua I and Ratua II (Table 4.12 and Fig 4.11).

Table 4.12 Block wise crop combination and name of the crops of Maldah district (1995-96 & 2020-21)

Name of the Blocks	1995-96		2020-21	
	Types of crop combination	Name of the crops	Types of crop combination	Name of the crops
Bamangola	Two	Winter rice (aman) and rapeseed & mustard	Two	Winter rice (aman) and rapeseed & mustard
Chanchal-I	Three	Winter rice (aman), summer rice (boro), and Jute	Three	Winter rice (aman), Jute, and summer rice (boro)
Chanchal-II	Two	Winter rice (aman) and summer rice (boro)	Five	Winter rice (aman), summer rice, jute, masoor, and maize
English Bazar	Mono	Winter rice (aman)	Mono	Maize
Gazole	Two	Winter rice (aman) and summer rice (boro)	Two	Winter rice (aman) and summer rice
Habibpur	Mono	Winter rice (aman)	Two	Winter rice (aman) and summer rice
Harishchandrapur-I	Two	Winter rice (aman) and summer rice (boro)	Mono	Winter rice
Harishchandrapur-II	Two	Winter rice (aman) and summer rice (boro)	Three	Winter rice (aman), maize, and summer rice (boro)
Kaliachak-I	Two	Winter rice (aman) and wheat	Mono	Maize
Kaliachak-II	Mono	Autumn rice (aus)	Three	Maize, jute, and wheat
Kaliachak-III	Mono	Wheat	Three	Jute, maize, and winter rice (aman)
Manikchak	Mono	Wheat	Mono	Wheat
Old Maldah	Mono	Winter rice (aman)	Mono	Winter rice (aman)
Ratua-I	Mono	Wheat	Mono	Winter rice (aman)
Ratua-II	Mono	Winter rice (aman)	Mono	Winter rice (aman)

(Calculated by the researcher)

The area under mono-crop cultivation is 20.92% of the total crop combination region in the district in 2020-21. Rice is also a dominant crop this year. However, negative changes are observed in terms of coverage blocks (Table 4.13). Habibpur block is converted to two crop combinations from monoculture. Kaliachak II and Kaliachak II blocks are converted to three crop combinations from monoculture. However, the other two blocks, namely Harishchandrapur I and Kaliachak II have been converted to monoculture from two crop combination regions. Also, the area under mono-culture is reduced by 6.76% from 1995-96 to 2020-21(Table 4.13).

4.5.2.2.2 Two crop combinations

Six blocks, i.e., Bamangola (winter rice (aman) + rapeseed & mustard), Chanchal II (winter rice (aman) + summer rice (boro)), Gazole (winter rice (aman) + summer rice (boro)), Harishchandrapur I (winter rice (aman) + summer rice (boro)), Harishchandrapur II (winter rice + summer rice (boro)), and Kaliachak I (winter rice (aman) + wheat) were identified as two crop combination regions during 1995-96; however, most of the blocks were dominated by winter rice (aman) and summer rice (boro) (Table 4.12). About 61% of the total crop combination area is covered by two crop combinations this year. During 2020-21, only three blocks are identified as two crop combinations, and the blocks are Bamangola (winter rice (aman) + rapeseed & mustard), Gazole (winter rice (aman) + summer rice (boro)), and Habibpur (winter rice (aman) + summer rice (boro)) (Table 4.12 and Fig. 4.11). These blocks covered 40.81% of the total crop combination region in 2020-21. Among these three blocks, two are dominated by winter rice (aman) and summer rice (boro). The changes in the crop combination region clearly depicted that the negative changes from 1995-96 to 2020-21 (Table 4.13). Three blocks are found with two crop combinations in 2020-21, it was six blocks in 1995-96; however, the reducing area is 20.37% during the period. The analysis also found that the Chanchal II block has transformed into a five-crop combination region from two crop combination region. Harishchandrapur I and Kaliachak I are transformed into monoculture and Harishchandrapur II is transformed into three crop combination regions from two crop combination during 1995-96 to 2020-21 (Table 4.12). At the same time, the Habibpur block is transformed into two crop combination regions in 2020-21, which was in mono-crop combination in 1995-96.

4.5.2.2.3 Three crop combinations

During 1995-96, only one block (Chanchal I) was found with three crop combinations, and the crops were winter rice (aman), rapeseed & mustard and summer rice (boro) (Table 4.12). Together, these three crops occupied 11.14% of the total crop combination region in the district (Table 4.13). During 2020-21, a total no of four blocks is identified as three crop combination regions. The blocks are Chanchal I (winter rice (aman) + jute

+ summer rice (boro)), Harishchandrapur II (winter rice (aman) + maize + summer rice (boro)), Kaliachak II (maize + jute + wheat) and Kaliachak III (jute + maize +winter rice (aman)). These four blocks together covered 25.94% of the total crop combination region in the district. The positive changes have been observed clearly in the study area in terms of three crop combination regions from 1995-96 to 2020-21 (Table 4.13). The analysis also found that the Harishchandrapur II block is transformed into three crop combinations from two crop combinations. On the contrary, Kaliachak II and Kaliachak III blocks are transformed into three crop combination regions in 2020-21, which was in mono-crop combination in 1995-96 (Table 4.12 and Fig.4.11).

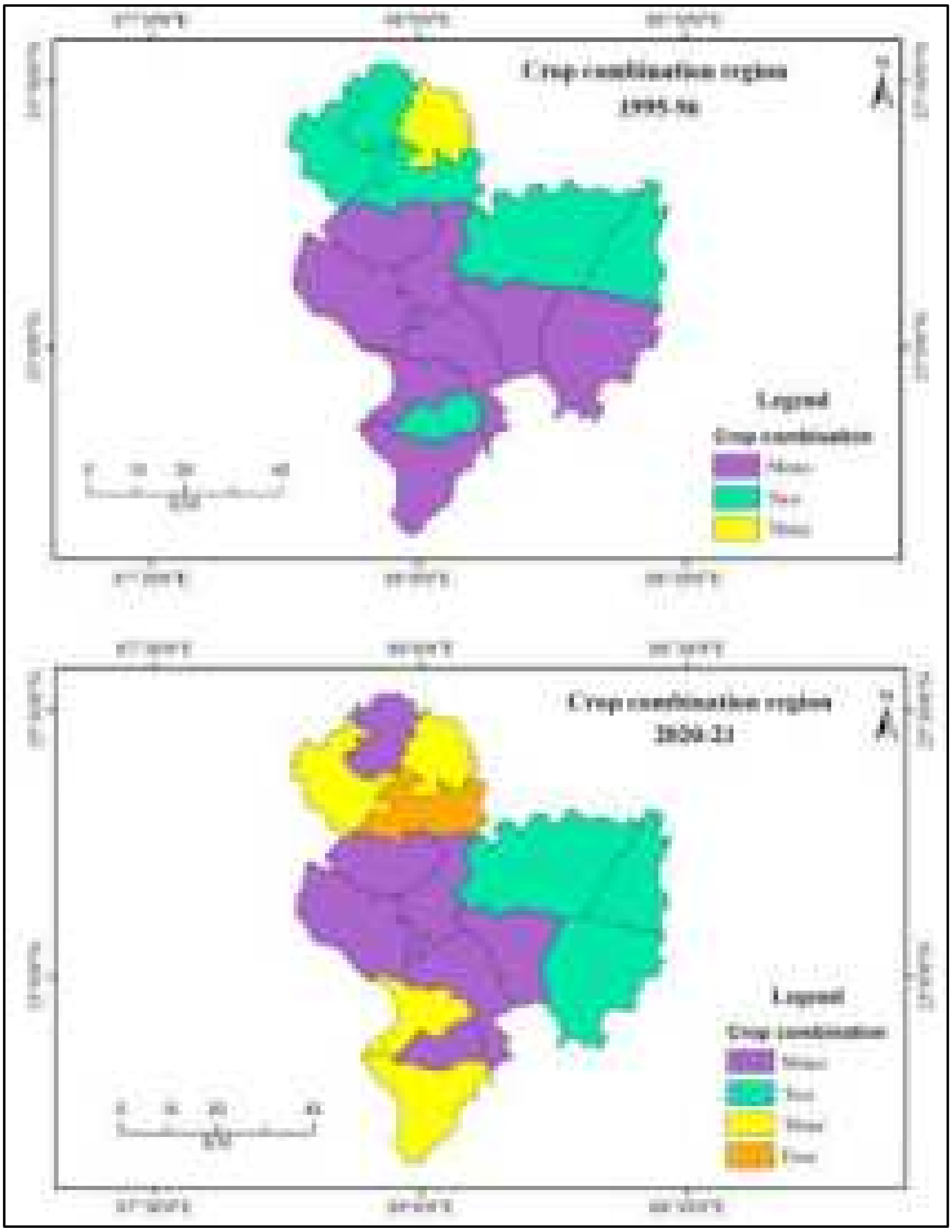
Table 4.13 Changes in crop combination region of Maldah district (1995-96 to 2020-21)

Crop Combination	1995-96		2020-21		Changes	
	No. of blocks	Area in %	No. of blocks	Area in %	In number	In %
Monoculture	8	27.68	7	20.92	-1	-6.76
Two Crops	6	61.18	3	40.81	-3	-20.37
Three Crops	1	11.14	4	25.94	3	14.8
Four Crops	0	0	0	0	0	0
Five Crop	0	0	1	12.33	1	12.33

(Calculated by the researcher)

4.5.2.2.4 Five crop combinations

Table 4.12 and Fig. 4.11 clearly show that there was no any block of the study area with five crop combinations during 1995-96. However, one block, i.e., Chanchal II, is identified as a five-crop combinations region in 2020-21. The dominant crops in this category are winter rice (aman), summer rice (boro), jute, lentil (masoor) and maize. These five crops together covered 12.33% of the total crop combination region in the district. Therefore, the changes depicted a positive growth during the study period. It is also found that the Chanchal II block is transformed into five crop combination regions from two crop combination regions (Fig.4.11).



Source: Agricultural Census, 1995-96; District Statistical Handbook, 1997 and PAO, Maldah (2021)

Fig. 4.11 Crop combination region of Maldah district

4.5.3 Crop diversification

Crop diversification is commonly used to calculate the divergence of cropping patterns in a region, generally opposite to the concept of crop specialization. It is basically the indicator of agricultural enterprises which evidently involved in robust competition among numerous activities for space (Singh and Sindhu, 2004). The farmers of developing countries mainly try to grow numerous crops in their cropland in an agricultural year to improve soil nitrogen and increase soil fertility. Therefore, it plays a significant role in improving the soil's health and preserving the agricultural ecosystem. The region has uncertain weather, erratic rainfall, subsistence farming, small land holding, scarcity of irrigation and inadequate technological development appropriate for crop diversification (Bodnar et al., 1997; Denis et al., 2002). The poor and subsistence farmers of any region mainly prefer the diversification of crops; conversely, the wealthy farmers are interested in specialized agricultural enterprises. According to Salunke (2004), crop diversification diminishes the menace involved in farming; therefore, farmers are usually motivated to grow more crops, leading to crop diversification in a region. Bhatia (1965) has used diversification for crop analysis purposes in India using a suitable formula. However, the technique of crop diversification of Bhatia has been modified by Ayyer (1969) and Singh (1978). According to Bhatia, the actual meaning of crop diversification is the occupying of land for a variety of crops having at least 10% of the gross cropped area.

4.5.3.1 Methodology

In the present study, Bhatia's crop diversification technique has been applied to determine crop diversification in the 15 community development blocks of Maldah district. The formula of Bhatia has been expressed as:

$$\text{Index of crop diversification} = \frac{\text{Percent of the sown area under x crops}}{\text{Number of x crops}}$$

X crops are such crops that individually hold 10% or more of the gross cropped area under study.

4.5.3.2 Spatial pattern of crop diversification region

Tables 4.14 & 4.15 presented the crop diversification index with the name of the crops that are in competition. Also, the category-wise areal coverage of high, medium and low diversification class and changes are displayed in the tables. The pattern of crop diversification in the study area has been divided into three different categories, i.e., high (<25), medium (25-35) and low (>35), depending on the index value of crop diversification acquired from Bhatia's method. From the results, it is found that a significant portion of the district was under medium (44.46%) and high (36.42%) crop diversification category during 1995-96 and is under high (48.32%) diversification class during 2020-21 (Table 4.15). Following are the three-crop diversification region identified during the study period.

4.5.3.2.1 High crop diversification

High crop diversification (<25) regions have been identified in six blocks during 1995-96 based on the value of the crop diversification index. The name of the blocks with high crop diversification are Harishchandrapur II (winter rice, summer rice, jute and wheat), Kaliachak II (autumn rice, maize and lentil (masoor)), Kaliachak III (wheat, urad (maskalai), autumn rice and jute), Manikchak (wheat, urad (maskalai), autumn rice and maize), Old Maldah (winter rice (aman), summer rice (boro), autumn rice (aus) and wheat) and Ratua I (wheat, urad (maskalai), summer rice (boro) and jute) (Fig. 4.12). The area covered by this high diversification during 1995-96 was 36.42% of the total diversification region. All the blocks in this category except Kaliachak II are found with four significant crops. During 2020-21, eight blocks showed a high degree of crop diversification (Fig. 4.12). The crops with a high degree of diversification are winter rice (aman), jute, summer rice (boro), rapeseed & mustard, and wheat in Chanchal I; maize, urad (maskalai) and winter rice (aman) in English Bazar; winter rice (aman), summer rice (boro), maize and jute in Harishchandrapur I and Harishchandrapur II; maize, wheat, winter rice (aman) and rapeseed & mustard in Kaliachak I; wheat, jute, urad (maskalai) and maize in Manikchak; winter rice (aman), summer rice (boro), rapeseed & mustard and maize in Old Maldah; and winter rice (aman), summer rice (boro), maize, lentil (masoor) and urad (maskalai) in Ratua I. However, the area covered by this high degree of diversification during 2020-21 is 48.32% of the total diversification area. Table 4.15 also shows the positive changes (+11.90%) in the area under high crop diversification region from 1995-96 to 2020-21. Kaliachak II and Kaliachak III block was in low crop diversification regions during 1995-96 and transformed into high crop diversification regions in 2020-21 (Table 4.15).

4.5.3.2.2 Medium crop diversification

During 1995-96, the medium crop diversification (25-35) regions were identified in seven blocks based on the value of the crop diversification index. The name of the crops with medium degree of diversification are winter rice (aman), rapeseed & mustard, and summer rice (boro) in Bamangola; winter rice (aman), summer rice (boro) and jute in Chanchal I, Chanchal II and Harishchandrapur I; winter rice (aman), summer rice

Table 4.14 Block wise index of crop diversification and name of the crops of Maldah district (1995-96 & 2020-21)

Name of the blocks	Index of crop diversification with crops name (1995-96)	Index of crop diversification with crops name (2020-21)
Bamangola	28.95 (winter rice + rapeseed & mustard + summer rice)	28.13 (winter rice + rapeseed & mustard + summer rice)
Chanchal-I	29.83 (winter rice + summer rice + jute)	22.52 (winter rice +jute+ summer rice + rapeseed & mustard + wheat)
Chanchal-II	28.46 (winter rice + summer rice + jute)	35.13 (winter rice + summer rice)
English Bazar	25.36 (winter rice + summer rice + autumn rice)	20.13 (maize + maskalai + winter rice)
Gazole	38.20 (winter rice + summer rice)	26.12 (winter rice + summer rice + rapeseed & mustard)
Habibpur	45.25 (winter rice + summer rice)	42.03 (winter rice + summer rice)
Harishchandrapur-I	28.58 (winter rice + summer rice + jute)	23.17 (winter rice + summer rice + maize + jute)
Harishchandrapur-II	24.47 (winter rice + summer rice +jute+ wheat)	23.50 (winter rice + summer rice + maize + jute)
Kaliachak-I	28.59 (winter rice + wheat +autumn rice)	17.38 (maize + wheat + winter rice + rapeseed & mustard)
Kaliachak-II	18.23 (autumn rice + maize + masoor)	35.46 (maize + jute)
Kaliachak-III	17.53 (wheat + maskalai + autumn rice+ jute)	42.98 (jute +maize)
Manikchak	18.33 (wheat + maskalai + autumn rice + maize)	19.49 (wheat + jute +maskalai + maize)
Old Maldah	22.83 (winter rice + summer rice+ autumn rice + wheat)	20.82 (winter rice + summer rice rapeseed & mustard + maize)
Ratua-I	19.17 (wheat + maskalai +summer rice jute)	16.81 (winter rice + summer rice + maize +masoor + maskalai)
Ratua-II	34.58 (winter rice + summer rice)	26.37 (winter rice + summer rice + jute)

(Calculated by the researcher)

(boro) and autumn rice (aus) in English Bazar; winter rice (aman), wheat and autumn rice (aus) in Kaliachak I; and winter rice (aman) and summer rice (boro) in Ratua II. The area covered by the medium crop diversification region is 44.46% of the total diversification region during 1995-96. During 2020-21 three blocks, Bamangola (winter rice (aman), rapeseed & mustard and summer rice (boro)), Gazole (winter rice (aman), summer rice (boro) and rapeseed & mustard), and Ratua II (winter rice (aman), summer rice (boro) and jute) showed a medium degree of crop diversification in the district (Table 4.14 and Fig. 4.12). However, the area covered by this medium degree of diversification during 2020-21 is 28.38% of the total crop diversification area. The magnitude of crop diversification area changes from 1995-96 to 2020-21 is -16.08% (Table 4.15). Four blocks i.e., English Bazar, Chanchal I, Harishchandrapur I and Ratua II were found with medium crop diversification region during 1995-96, and transformed into a high crop diversification region in 2020-21. At the same time, Chanchal II was in the medium crop diversification category during 1995-96, and transformed into a low crop diversification region in 2020-21 (Table 4.15).

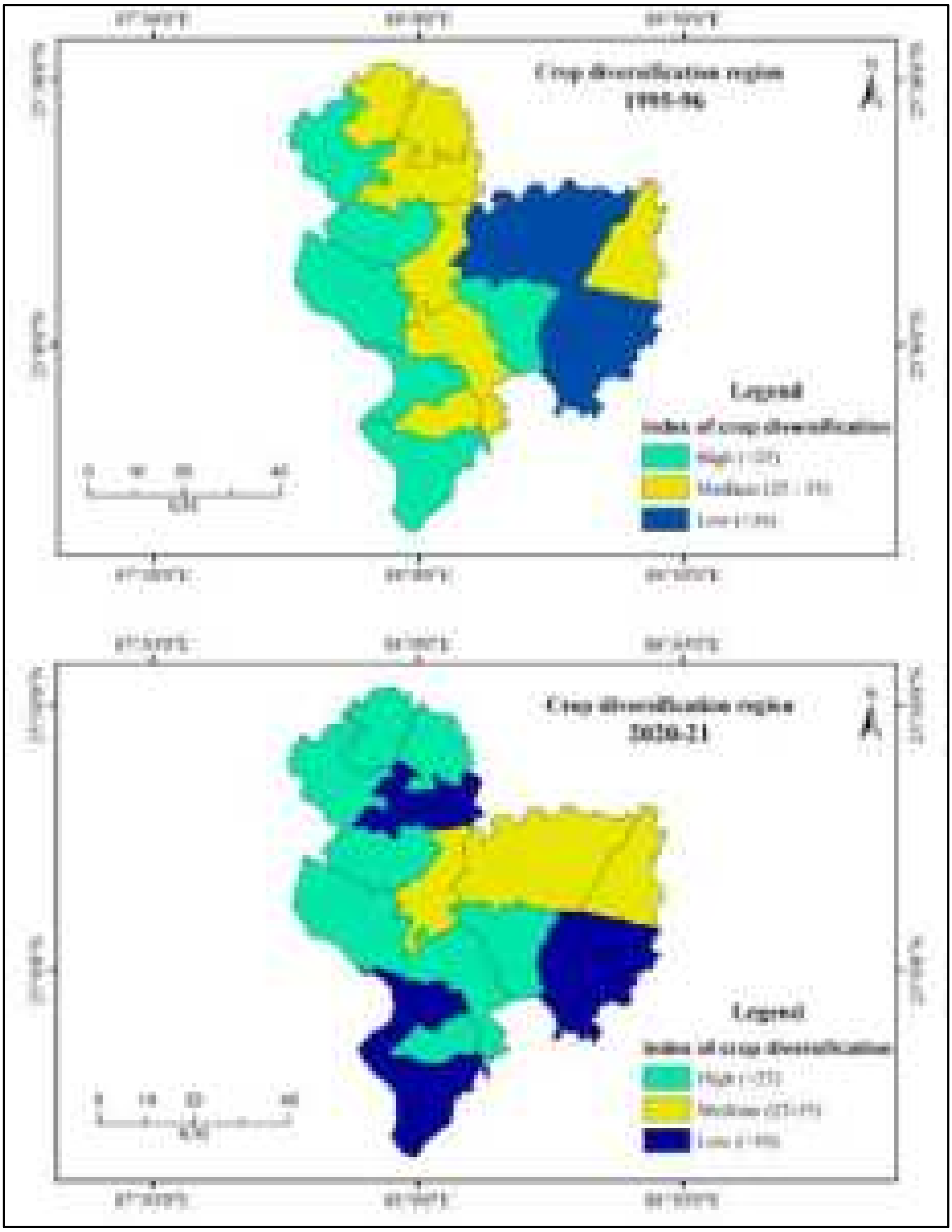
Table 4.15 Changes in crop diversification area from 1995-96 to 2020-21

Class	1995-96		2020-21		Changes	
	Area in ha.	In %	Area in ha.	In %	Area in ha.	In %
High	101186	36.42	149407	48.32	48221	11.90
medium	123517	44.46	87755	28.38	-35762	-16.08
Low	53104	19.12	72065	23.30	18961	4.18

(Calculated by the researcher)

4.5.3.2.3 Low crop diversification

Low crop diversification (>35) regions have been identified in two blocks in the district during 1995-96 and covered about 19% of the total crop diversification area. The name of the crops were winter rice (aman) and summer rice (boro) in Gazole and Habibpur (Table 4.14 and Fig.4.12). On the other hand, four blocks are identified as low crop diversification regions during 2020-2, and the crops are winter rice (aman) and summer rice (boro) in Chanchal II and Habibpur; and jute and maize in Kaliachak II and Kaliachak III (Table 4.14 and Fig 4.12). However, the area covered by this low degree of crop diversification during 2020-21 is +2.30% of the total crop diversification area.



Source: District Statistical Handbook, 1997; Agricultural Census, 1995-96 and PAO, Maldah (2021)

Fig. 4.12 Crop diversification region of Maldah district

Additionally, positive changes in low crop diversification areas are mainly found from 1995-96 to 2020-21, and the rate of change is +4.18%. Chanchal II block was with medium crop diversification during 1995-96 and transformed into low crop diversification region in 2020-21. Also, Kaliachak II and Kaliachak III were under high crop diversification in 1995-96 and changed to the low crop diversification region in 2020-21 (Fig.4.12). However, Gazole block showed progress in crop diversification, changing from low crop diversification to medium crop diversification du 1995-96 to 2020-21.

4.5.4 Crop concentration

Crop concentration is another fundamental element of agricultural regionalization. It reveals the spatial variation in the individual crop intensity in a region at a selected point of time (Husain, 2013). The study aims mainly to categorize the areas of low, medium and high intensity of specific crops in different segments of the region (Husain, 1979). In general, crop concentration helps to recognize and differentiate areas with specific importance regarding the distribution of crops within the region. Moreover, it helps geographers and regional planners to understand the specialized region of different crops in an area at a given point in time. Temperature, moisture, natural vegetation, soil, relief, income and price, social factors and government policy significantly determine any region's crop concentration (Punithavathi et al., 2012). However, it gradually reduces productivity while regularly cultivating a specific crop in an areal unit. Because some crops absorb certain nutrients from the soil, resulting in continuous declination of natural soil fertility. Therefore, crop rotation with varied choices under particular environmental circumstances is significantly required to maintain soil fertility.

4.5.4.1 Methodology

In the present study, Bhatia's crop concentration method has been applied to quantify the index of crop concentration in the Maldah district, which basically depends on the location quotient technique. It is the most incredible way to clarify which area is appropriate for particular crop production and increase their productivity. It also gives precise and brief information about a specific crop of a region in incredible volume; it, therefore, helps to raise the quantity of land of that specific crop for farmers. In this technique, the crop concentration pattern of the different region is inspected and determined in a two-step process; at first, compare the proportion of the net sown area of the crops and arrange them in rank wise, and secondly, relates the density of crop of every areal unit of any region to the comparable density of the entire area. After determining the index value for the particular crop in the component areal units, the crops are organized in a descending or ascending order. Bhatia's formula (Bhatia, 1965) of crop concentration has been expressed as follows:

$$\textbf{Index of crop concentration} = \frac{\text{Area of x crop in the component areal unit}}{\text{Area of all crops in the component areal unit}} \div \frac{\text{Area of x crop in the entire region}}{\text{Area of all crops in the entire region}}$$

The high and low concentration of crops in the region is represented by the high and low value of the crop concentration index. However, the high crop concentration index in a particular area signifies that the concentration level in the production of that crop is high and vice versa.

4.5.4.2 Spatial pattern of crop concentration region

The pattern of crop concentration in the study area has been divided into three different categories for each crop, i.e., high, medium and low, based on the value of crop concentration acquired from Bhatia's method. The results show that a significant portion of the district is under low and medium crop concentration category for most of the crops in 1995-96 and 2020-21 (Table 4.16 and 4.17). However, the least block is covered by high crop concentration for each crop considered for the study.

4.5.4.2.1 Autumn rice (aus)

Autumn rice (aus) is one of the minor crops of Maldah district and it was richly concentrated in 1995-96 in all blocks of the district except for Harishchandrapur I and Harishchandrapur II. During 1995-96, high concentration (CI= >4.34) of autumn rice (aus) was observed in only one block, i.e., Kaliachak II; however, medium concentration (CI= 2.16-4.34) was observed in five blocks (English Bazar, Kaliachak I, Kaliachak III, Manikchak and Old Maldah). At the same time, low concentration (CI= <2.16) was noticed in Bamangola, Chanchal I, Chanchal II, Gazole, Habibpur, Ratua I, and Ratua II blocks (Table 4.16). During 2020-21, there are only two blocks, i.e., Gazole and Manikchak, where autumn rice (aus) is cultivated. Among these two blocks, Gazole is under the medium crop concentration region and Manikchak is under the high crop concentration zone (Table 4.17). A significant change has been observed in the crop concentration region of autumn rice (aus) from 1995-96 to 2020-21. Gazole block where the medium concentration of autumn rice (aus) is found in 2020-21 was under low concentration zone in 1995-96. On the other hand, Manikchak is found with high concentration autumn rice (aus) in 2020-21 and was under medium concentration in 1995-96.

4.5.4.2.2 Winter rice (aman)

Winter rice (aman) is the most significant crop of Maldah district and it was highly (CI= >1.24) concentrated in five blocks during 1995-96, i.e., Bamangola, Chanchal I, Gazole, Habibpur and Kaliachak I. The district's physical environment is appropriate for winter rice (aman) cultivation. Medium concentration (CI= 0.63-1.24) was observed in English Bazar, Chanchal II, Harishchandrapur I, Harishchandrapur II, Old Maldah and Ratua II. At the same time, low concentration (CI= <0.63) of winter rice (aman) was found in the Kaliachak II, Kaliachak III, Manikchak and Ratua I blocks (Table 4.16). During 2020-21, three blocks (Bamangola, Gazole and Habibpur) showed a high concentration of winter rice (aman); while a medium concentration of winter rice (aman) is observed in seven blocks, i.e., Chanchal I, Chanchal II, Harishchandrapur I, Harishchandrapur II, Old Maldah, Ratua I and Ratua II. On the other hand, low concentration of winter rice (aman) is noticed in English Bazar, Kaliachak I, Kaliachak II, Kaliachak III and Manikchak (Table 4.17).

4.5.4.2.3 Summer rice (boro)

During 1995-96, high (CI= >1.32) and low (CI= <0.76) concentration of summer rice (boro) was detected in seven blocks; whereas medium (CI= 0.76-1.32) concentration was detected in only one block. The blocks having high concentrations were English Bazar, Chanchal I, Chanchal II, Harishchandrapur I, Harishchandrapur II, Old Maldah and Ratua II; and low concentrations were Bamangola, Gazole, Habibpur Kaliachak I, Kaliachak II, Kaliachak III and Manikchak. In contrast, Ratua I was found with a medium concentration of summer rice (boro) (Table 4.16). During 2020-21, three blocks (Bamangola, Gazole and Habibpur) showed a high concentration of summer rice (boro); while a medium concentration is observed in seven blocks namely, Chanchal I, Chanchal II, Harishchandrapur I, Harishchandrapur II, Old Maldah, Ratua I and Ratua II. On the other hand, low concentration of summer rice (boro) is identified in English Bazar, Kaliachak I, Kaliachak II, Kaliachak III and Manikchak (Table 4.17). The

Table 4.16 Block wise concentration index of the major and minor crops of Maldah district (1995-96)

Block name	Index of crop concentration of different crops in 1995-96												
	Autumn rice (Aus)	Winter rice (Aman)	Summer rice (Boro)	Wheat	Maize	Gram	Masoor	Mas kalai	Khesari	Mustard	Jute	Sugar cane	Potato
Bamangola	0.07	1.27	0.74	0.74	0.00	0.00	0.00	0.03	0	4.84	0.00	0.00	4.34
Chanchal-I	0.48	1.83	1.35	0.55	0.01	0.13	0.32	0.01	0	0.37	2.59	0.00	0.00
Chanchal-II	0.21	1.11	1.35	0.66	0.00	0.09	0.06	0.20	0	1.18	1.64	0.00	0.56
English Bazar	3.55	0.76	1.42	0.72	1.09	5.52	1.98	0.00	0	0.26	0.07	0.66	1.35
Gazole	0.38	1.55	0.54	0.51	0.08	0.36	0.11	0.26	0	2.33	0.42	0.10	1.39
Habibpur	0.04	1.85	0.61	0.24	0.02	0.11	0.51	0.00	0	1.07	0.03	0.00	1.17
Harishchandrapur-I	0.00	1.08	1.56	0.74	0.14	0.04	0.05	0.11	0	0.95	1.37	0.00	1.53
Harishchandrapur-II	0.00	1.13	1.51	0.99	0.38	0.06	0.26	0.02	0	0.18	1.38	0.10	0.11
Kaliachak-I	2.34	1.44	0.33	1.16	0.74	1.15	1.04	0.14	0	0.21	0.15	2.02	0.17
Kaliachak-II	6.53	0.01	0.45	0.87	6.4	5.01	6.57	0.73	0	2.33	0.25	14.76	0.12
Kaliachak-III	2.60	0.16	0.49	2.31	0.47	0.85	5.43	3.94	0	0.35	1.59	5.92	0.33
Manikchak	2.57	0.07	0.20	2.52	5.44	2.91	2.28	4.71	0	0.13	1.12	3.43	1.32
Old Malda	2.90	0.90	1.42	1.15	0.61	1.04	0.13	0.14	0	0.57	0.36	0.00	0.00
Ratua-I	1.03	0.18	0.99	2.2	3.05	0.71	1.01	4.02	0	0.26	1.88	0.61	0.88
Ratua-II	0.69	0.86	1.88	0.46	1.63	3.14	1.84	1.21	0	0.02	0.34	0.10	1.32

(Calculated by the researcher)

change analysis revealed that English Bazar transformed to a low concentration of summer rice (boro) in 2020-21 from a high concentration in 1995-96. While Chanchal I, Chanchal II, Harishchandrapur I, Harishchandrapur II, Old Maldah and Ratua II converted to medium crop concentration from high crop concentration. At the same time, Bamangola, Gazole and Habibpur are transformed into high concentration of summer rice (boro) from low concentration.

4.5.4.2.4 Wheat

Wheat is another crucial cereal crop of the district and dominated by low concentration in both the years (1995-96 and 2020-21). During 1995-96, the low concentration (CI= <1.00) of wheat was observed in ten blocks, namely, Bamangola, English Bazar, Chanchal I, Chanchal II, Gazole, Habibpur, Harishchandrapur I, Harishchandrapur II, Kaliachak II and Ratua II (Table 4.16). Medium (CI= 1.00-1.75) concentration was observed in only two district blocks, i.e., Kaliachak I and Old Maldah. On the other hand, a high concentration (>1.75) was observed in three blocks i.e., Kaliachak III, Manikchak and Ratua I. During 2020-21, a high (CI= >1.75) concentration of wheat is observed only in three blocks i.e., Kaliachak I, Kaliachak II and Manikchak. Medium concentration (CI= 1.00-1.75) is observed in Bamangola, English Bazar and Gazole. On the other hand, low concentration (CI= <1.00) is found in the Chanchal I, Chanchal II, Habibpur, Harishchandrapur I, Harishchandrapur II, Kaliachak III, Old Maldah, Ratua I and Ratua II blocks (Table 4.16). The changes in crop concentration depicted Bamangola, English Bazar, Gazole and Kaliachak II was under low concentration zone in 1995-96, which is transformed into High (only Kaliachak II) and medium concentration zone during 2020-21. Kaliachak I and old Maldah were in the medium concentration zone, and it converted to the high and low concentration zone. On the contrary, Kaliachak III and Ratua I were under high concentration zone in 1995-96 and transformed into a low concentration zone in 2020-21.

4.5.4.2.5 Maize

The spatial distributions of maize showed a high concentration (CI= >4.26) only in the Kaliachak II and Manikchak during 1995-96 (Table 4.16). While medium concentration (CI= 2.13-4.46) was observed in Ratua I block. Rest of the blocks except Bamangola and Chanchal II showed low concentration (CI= <2.13) of maize cultivation. Bamangola and Chanchal II did not show maize cultivation during 1995-96. During

2020-21, medium (CI= 2.13-4.26) concentration of maize is observed in four blocks, i.e., English Bazar, Kaliachak I, Kaliachak II and Kaliachak III. Rest of the blocks are under low concentration of maize in 2020-21. No block is found with high concentration of maize in 2020-21 (Table 4.17). The change analysis revealed that the Kaliachak II and Manikchak block was under high concentration zone of maize in 1995-96 and transformed into medium and low concentration in 2020-21. On the other hand, English Bazar, Kaliachak I and Kaliachak III were under low concentration zone in 1995-96 and converted to a medium concentration zone in 2020-21. However, Ratua I is converted to low concentration zone from medium concentration of maize.

4.5.4.2.6 Gram

The spatial distributions of gram (one of the minor crops) concentration showed that the district was dominated by low concentration (CI= <1.84) during 1995-96 (Table 4.16). Ten blocks out of fifteen were in this category; however, Bamangola did not show gram cultivation during 1995-96. Manikchak and Ratua II blocks were under medium concentration zone; whereas, English Bazar and Kaliachak II were under high concentration zone during 1995-96. During 2020-21, six blocks (Chanchal I, Chanchal II, Harishchandrapur I, Harishchandrapur II, Ratua I and Ratua II) were found with no cultivation of gram and seven blocks (Bamangola, Habibpur, Gazole, Kaliachak I, Kaliachak III, Manikchak and Old Maldah) were found with low concentration (CI= <1.84) (Table 4.17). Medium and high concentration of gram are observed in Kaliachak II and English Bazar (Table 4.17). During the period of study Ratua II block is converted to no cultivation zone of gram, and Manikchak is converted to low concentration which was under medium concentration zone in 1995-96.

4.5.4.2.7 Lentil (masoor)

Lentil (masoor) is an important pulse of the district and dominated by low concentration in both the years (1995-96 and 2020-21). During 1995-96, the low concentration (CI= <2.19) was observed in eleven blocks, namely Chanchal I, Chanchal II, English Bazar, Gazole, Habibpur, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Ratua I and Ratua II (Table 4.16). Medium (CI= 2.19-4.38) concentration was observed in only one block i.e., Manikchak. On the other hand, high concentration (CI= >4.28) was observed in two blocks, i.e., Kaliachak II and Kaliachak III. However, a block (Bamangola) was caught without cultivation of lentil (masoor) during 1995-96. During 2020-21, not a

Table 4.17 Block wise concentration index of the major and minor crops of Maldah district (2020-21)

Block name	Index of crop concentration of different crops in 2020-21												
	Autumn rice (aus)	Winter rice (aman)	Summer rice (boro)	Wheat	Maize	Gram	Masoor	Mas kalai	Khesari	Rapeseed & Mustard	Jute	Sugar cane	Potato
Bamangola	0	1.28	0.99	1.56	0.33	0.10	0.26	0.03	0.23	2.12	0.11	0	0.90
Chanchal-I	0	1.15	0.95	0.18	0.21	0	0.79	0.44	0.09	1.57	2.00	0	0.80
Chanchal-II	0	1.03	1.73	0.44	0.44	0	2.28	0.25	0.07	0.52	1.20	0	0.64
English Bazar	0	0.38	0.52	1.34	2.32	9.57	1.92	4.27	6.47	0.93	0.30	3.47	0.22
Gazole	3.47	1.32	0.86	1.37	0.25	0.52	0.76	0.14	0.06	1.51	0.30	0.65	2.31
Habibpur	0	1.72	1.08	0.18	0.14	0.36	0.23	0.14	0.84	1.07	0.15	0	0.31
Harishchandrapur-I	0	0.99	1.59	0.01	1.34	0	0.44	0.29	0.09	0.37	1.47	0	0.48
Harishchandrapur-II	0	1.08	1.05	0.02	2.04	0	0.25	0.37	0.08	0.21	1.27	0	0.60
Kaliachak-I	0	0.33	0.35	3.92	2.33	0.08	0.36	2.08	3.24	1.20	0.86	13.82	0.10
Kaliachak-II	0	0.16	0.14	2.16	4.10	2.25	1.2	2.36	3.49	0.28	1.38	4.45	0.09
Kaliachak-III	0	0.21	0.03	0.23	3.46	0.13	0.33	0.36	0.40	0.16	5.42	0.11	0.05
Manikchak	8.03	0.1	0.28	6.43	1.04	0.69	0.88	3.52	3.73	0.60	2.59	7.13	0.20
Old Malda	0	0.98	1.06	0.33	0.96	0.06	0.67	0.40	0.08	1.87	0.32	0	3.21
Ratua-I	0	0.68	1.3	0.26	1.10	0	3.77	2.72	0.09	0.36	1.12	0	0.84
Ratua-II	0	1.07	1.64	0	0.82	0	0.47	1.10	0.15	0.31	1.33	0	0.76

(Calculated by the researcher)

single block is found with high (CI= >4.28) concentration of lentil (masoor) in the district; even medium concentration (CI= 2.19-4.38) of lentil (masoor) was observed in only two blocks which are Chanchal II and Ratua I. Rest of the blocks of the district are identified as the low concentration (CI= <2.19) of lentil (masoor). It is also observed from the change analysis of lentil (masoor) from 1995-96 to 2020-21 that the Manikchak block is transformed to low concentration from medium concentration, and Kaliachak II and Kaliachak III are transformed to low concentration from high concentration. On the contrary, Chanchal II and Ratua I have a medium concentration in 2020-21, which were in a low concentration zone in 1995-96 (Table 4.16 and 4.17).

4.5.4.2.8 Urad (maskalai)

Urad (maskalai) is another major crop of the district. The spatial distributions of urad (maskalai) concentration showed most of the blocks of the district belonged to low (CI= <1.57) concentration during 1995-96 (Table 4.16). High concentration (>3.14) was observed only in Kaliachak III, Manikchak and Ratua I blocks; however, no block was observed with medium concentration (CI= 1.57-3.14) of urad (maskalai) in 1995-96. During 2020-21, low concentration (CI= <1.57) of urad (maskalai) is also dominated the districts (Table 4.17). Ten blocks are found with low concentration of urad (maskalai) during 2020-21. While the medium concentration of urad (maskalai) is noticed in the Kaliachak I, Kaliachak II and Ratua I blocks. At the same time, high concentration of urad (maskalai) is identified in the English Bazar and Manikchak blocks (Table 4.17).

4.5.4.2.9 Khesari

Khesari is one of the minor crops of Malda district. For crop concentration analysis of khesari, the data of 2003-04 has been used instead of 1995-96, due to the unavailability of data for 1995-96. The concentration pattern of khesari revealed most of the blocks of the district belonged to low (CI= <1.37) concentration during 2003-04. The blocks that showed a low concentration of khesari were Chanchal I, Harishchandrapur II, Kaliachak I, Kaliachak III, Old Maldah, Ratua I and Ratua II (Table 4.16). However, four blocks showed no cultivation of khesari this year, which are Bamangola, Chanchal II, Habibpur and Harishchandrapur I (Table 4.16). On the other hand, medium concentration (CI= 1.37-2.74) was observed in the English Bazar and Gazole; and high concentration (CI= >2.74) was observed in Kaliachak II and Manikchak blocks (Table

4.16). During 2020-21, most of the blocks (11 blocks) of the district are under a low concentration zone. In contrast, the rest of the four blocks i.e., English Bazar, Kaliachak I, Kaliachak II and Manikchak are under a high concentration of khesari (Table 4.17).

4.5.4.2.10 Rapeseed & mustard

The concentration pattern of rapeseed & mustard also showed similar results to pulses in the district, dominated by low concentration (CI= <1.62) in the majority of the blocks. Twelve blocks out of fifteen were found with low concentration during 1995-96. Medium concentration (CI= 1.62-3.23) were observed in Gazole and Kaliachak II blocks; however, Bamangola block was found with a high concentration (CI= >3.23) of rapeseed & mustard during 1995-96. During 2020-21, only two blocks, namely Bamangola and Old Maldah are under the medium concentration of rapeseed & mustard. The rest of the blocks are observed with low concentration of rapeseed & mustard. Surprisingly, no blocks are fallen in the high concentration zone during 2020-21. Gazole and Kaliachak II blocks were in the medium concentration zone during 1995-96, transformed to a low concentration zone in 2020-21. On the contrary, Bamangola block is transformed into a medium concentration category of rapeseed & mustard during 2020-21 from the high concentration zone.

4.5.4.2.11 Jute

During 1995-96, seven blocks of the district belonged to the low (CI=<0.86) concentration jute; however, six blocks were found with medium (CI= 0.86-1.72) and one block was found with high (CI= >1.72) concentration (Table 4.16). At the same time, Bamangola block was caught with no jute cultivation during 1995-96. The blocks that showed a low concentration of jute were English Bazar, Gazole, Habibpur, Kaliachak I, Kaliachak II, Old Maldah and Ratua II (Table 4.16). Medium concentration was observed in Chanchal II, Harishchandrapur I, Harishchandrapur II, Kaliachak III, Manikchak and Ratua I blocks, whereas high concentration was found in Chanchal I. During 2020-21, the medium concentration of jute dominated the major blocks of the districts, observed in the Chanchal II, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Kaliachak II, Ratua I and Ratua II (Table 4.17). In comparison, low and high concentration of jute are observed in five and three blocks, respectively. Ratua I was observed with high concentration of jute in 1995-96, transformed into medium concentration in 2020-21. At the same time, Manikchak and

Kaliachak III blocks were in the medium concentration zone and converted to a high concentration zone in 2020-21.

4.5.4.2.12 Sugarcane

Sugarcane is one of the minor crops of Maldah district. The concentration pattern of sugarcane revealed that the district was dominated low (CI= <4.92) concentrations in 1995-96. Five blocks were found with low concentrations of sugarcane during 1995-96. At the same time, six blocks were found with no sugarcane cultivation in the district (Table 4.16). However, Kaliachak III and Kaliachak II were found with medium (CI= 4.92-9.84) and high (CI= >9.84) concentrations of sugarcane, respectively. During 2020-21, most of the blocks (nine blocks) of the district were found without sugarcane cultivation. Correspondingly, four blocks i.e., English Bazar, Gazole, Kaliachak II and Kaliachak III were observed with a low concentration of sugarcane; one block, i.e., Manikchak, is found with a medium concentration and Kaliachak I is found with a high concentration of sugarcane (Table 4.17). The change analysis found that Kaliachak III was in medium concentration zone in 1995-96 and transformed into a low concentration zone in 2020-21; Kaliachak II was in a high concentration zone and transformed into a low concentration of sugarcane in 2020-21.

4.5.4.2.13 Potato

The spatial distributions of potato concentration also showed that most of the blocks belonged to low concentration of potato during 1995-96 (Table 4.16). Eleven blocks out of fifteen were found with a low (CI=<1.45) concentration. However, a medium (CI=1.45-2.90) concentration was observed in the Harishchandrapur I, and a high (CI= >2.90) concentration was observed in Bamangola block. During 2020-21, low concentration is also dominated the majority of the blocks (13 blocks) of the districts. In contrast, a medium concentration of potato was observed in Gazole, and high concentration was observed in the Old Maldah block (Table 4.17). A significant change has also been observed from the change analysis of potatoes during 1995-96 to 2020-21. Harishchandrapur, I block is transformed to low concentration from medium concentration, and Bamangola block is transformed to low concentration from high concentration.

4.5.5 Intensity of cropping

Cropping intensity is also known as farming intensity, is defined as the ratio between gross cropped area (GCA) and net sown area (NSA). The idea of cropping intensity mainly denotes land reuse for crop production during an agricultural year. Thus, it refers to nurturing many crops in the same agricultural land during an agricultural year. The degree of the land's productive capacity, mainly enriched through modern technology, is shown by cropping intensity. However, it results from a region's numerous physical (viz. rainfall, the fertility of land) and cultural or socio-economic (viz. labour force, population pressure) factors. Thus, it helps agricultural scientists to plan by providing the agricultural prosperity index. However, there is an increasing tendency of population density in the district, which recommends increasing the magnitude of the agricultural land or cropping intensity by enhancing crop production.

4.5.5.1 Methodology

The determination of cropping intensity using the traditional method, i.e., the ratio of GCA and NSA has been used by several researchers in their thesis and article (Roy, 2009; Das, 2017; Sultana, 2017; Jana, 2017). But this technique has some disadvantages, such as avoiding the length of the crop cultivation period. Moreover, different crops are ripening in different periods. Therefore, this traditional technique cannot accurately interpret the cropping intensity of any region. To overcome this problem cropping intensity method of Rao and Brookfield (1977-78) has been used in this study. In this technique, the duration of each crop has been taken into consideration and successfully used by several researchers and geographers (Dayal, 1978; Roy, 2009; Chhetri, 2011). This technique of cropping intensity may be calculated as follows:

$$Ic = \sum_{i=1}^{n} \frac{A_{ci}.d_i + A_{cj}.d_j + \cdots \ldots \ldots \ldots \ldots A_{cn}.d_n}{Q}$$

Where,

I_c = Cropping intensity index

A_{ci} = The area under i^th^ crop

d_i = Duration of i^th^ crop

Q = Net sown area

4.5.5.2 Spatial pattern of cropping intensity region

By using the formula of Rao and Brookfield (1977-78), the calculation has been done and a vivid picture of the spatial pattern of cropping intensity is obtained. The more extended crop halts in the field, require the greater the agricultural inputs, labour and irrigation water. The intensity of cropping is basically the ratio of the sum of area under numerous crops which are multiplied by crop duration to the net sown area. It is a better method of cropping intensity than the traditional method (Roy, 2009). To analyze the intensity of cropping, 15 blocks of Maldah district were quantified and mapped by choropleth using the data for the year 1995-96 and 2020-21. Thirteen crops (nine major and four minor) i.e., autumn rice (aus), winter rice (aman), summer rice (boro), wheat, maize, gram, masoor, maskalai, khesari, rapeseed & mustard, jute, sugarcane and potato have been taken into consideration and are multiplied by the average duration of crops. By summing up, all values for each block are divided by the net sown area of the block. The block-wise cropping intensity for the year 1995-96 and 2020-21 of Maldah district and its changing pattern has been presented in Table 4.18. The obtained results revealed that Habibpur has the lowest cropping intensity value (Ic=3.06) in 1995-96. The other four blocks which have the most negligible Ic value were Habibpur (Ic=3.07), Kaliachak I (Ic=3.07), Old Maldah (Ic=3.07) and English Bazar (Ic=3.08). Whereas Kaliachak II had reported as the highest cropping intensity value (Ic=3.51) in 1995-96. During 2020-21, the highest and lowest cropping intensity is observed in the Kaliachak III (Ic=4.30) and Habibpur (Ic=3.15) blocks, respectively. Kaliachak II (Ic=4.19) block also is an important cropping intensity block in the district and positioned second highest in 2020-21 (Table 4.18).

Table 4.18 also shows the changes in cropping intensity from 1995-96 to 2020-21. However, all the blocks showed positive changes during 1995-96 to 2020-21. Maximum positive change is observed in Kaliachak III (+1.07) block and minimum positive change is observed in Bamangola (+0.06) block. These changing values can be categorized into three classes i.e., low (<0.40), medium (0.40-0.74) and high (>0.74). The changes with low positive intensity were observed in Bamangola, Chanchal I, Chanchal II, Gazole, Habibpur, Harishchandrapur I, Manikchak, Ratua I and Ratua II block. Similarly, medium positive changes were identified in English Bazar, Harishchandrapur II, Kaliachak II and Old Maldah block. Whereas, Kaliachak I and

Kaliachak III block showed high positive changes during 1995-96 to 2020-21 (Table 4.18).

Table 4.18 Block wise changes in cropping intensity of Maldah district (1995-96 to 2020-21)

Name of the Blocks	Cropping Intensity		Changes in Cropping Intensity
	1995-96	2020-21	
Bamangola	3.24	3.30	0.06
Chanchal-I	3.22	3.38	0.15
Chanchal-II	3.18	3.27	0.08
English Bazar	3.08	3.72	0.64
Gazole	3.15	3.29	0.15
Habibpur	3.06	3.15	0.09
Harishchandrapur-I	3.17	3.49	0.32
Harishchandrapur-II	3.13	3.63	0.50
Kaliachak-I	3.07	3.93	0.86
Kaliachak-II	3.51	4.19	0.68
Kaliachak-III	3.23	4.30	1.07
Manikchak	3.35	3.62	0.27
Old Maldah	3.07	3.51	0.44
Ratua-I	3.29	3.41	0.12
Ratua-II	3.10	3.35	0.25

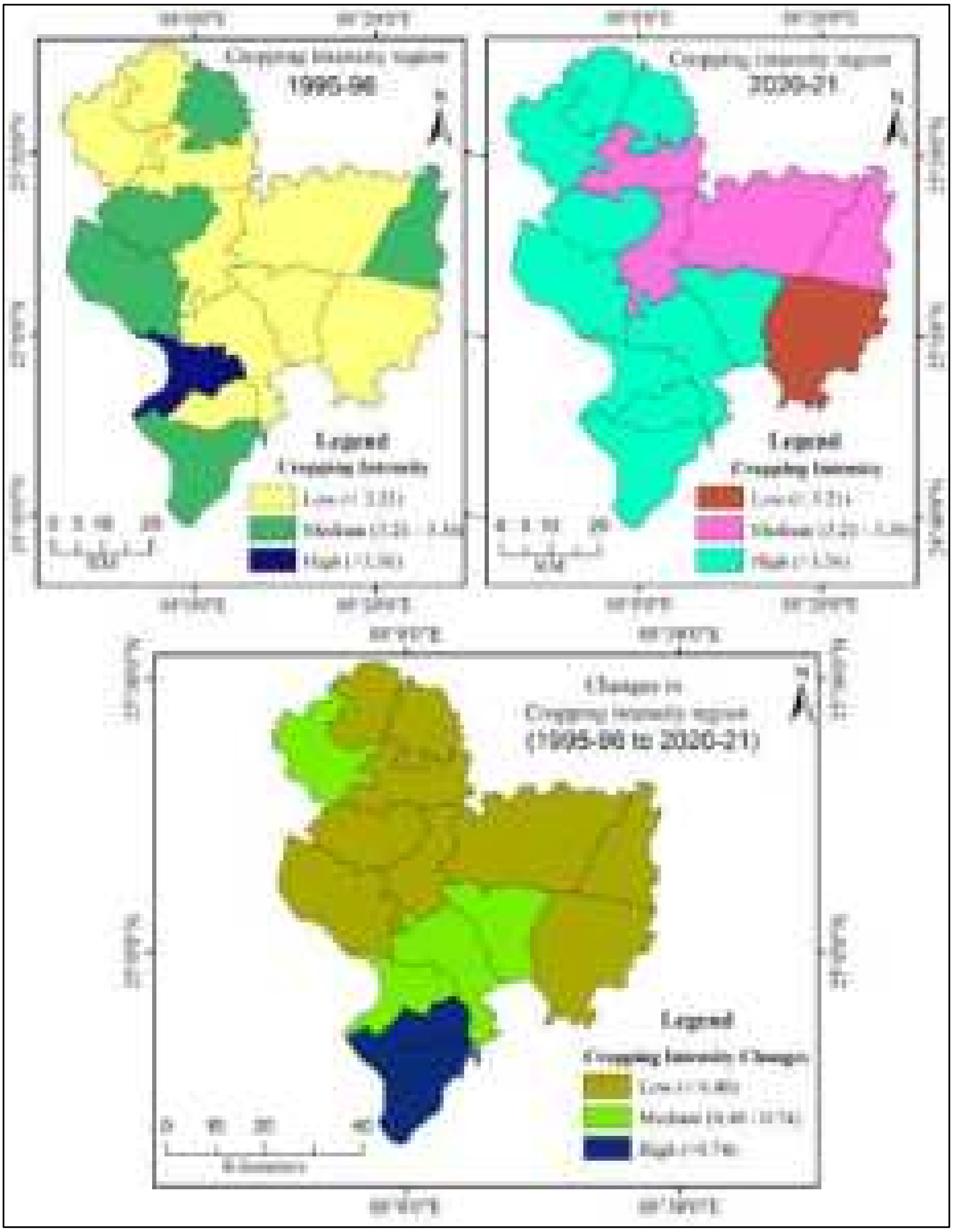
(Calculated by the researcher)

Using the results, a worksheet of index scale has been prepared to differentiate the district into low, medium and high-intensity regions considering all the blocks (Table 4.19 and Fig. 4.13). Low cropping intensity (Ic=<3.21) was dominated the district in 1995-96. Nine blocks (Chanchal II, English Bazar, Gazole, Habibpur, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Old Maldah and Ratua II) were under low cropping intensity region during 1995-96. Five blocks (Bamangola, Chanchal I, Kaliachak III, Manikchak, and Ratua I) were under medium (Ic=3.21-3.36), and only one block i.e., Kaliachak II was under high (>3.36) cropping intensity region in 1995-96 (Table 4.19 and Fig.4.13).

Table 4.19 Category of cropping intensity of Maldah district (1995-96 & 2020-21)

Sl. No	Cropping Intensity Class	Cropping Intensity Range	1995-96		2020-21	
			No. of Blocks	Name of the Blocks	No. of Blocks	Name of the Blocks
1	Low	<3.21	9	Chanchal II, English Bazar, Gazole, Habibpur, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Old Maldah and Ratua II	1	Habibpur
2	Medium	3.21-3.36	5	Bamangola, Chanchal I, Kaliachak III, Manikchak and Ratua I	4	Bamangola, Chanchal II, Gazole and Ratua II
3	High	>3.36	1	Kaliachak II	10	Chanchal I, English Bazar, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Kaliachak II, Kaliachak III Manikchak, Old Malda and Ratua I

(Calculated by the researcher)



Source: District Statistical Handbook, 1997; Agricultural Census, 1995-96 and PAO, Maldah (2021)

Fig 4.13 Changing pattern of cropping intensity region of Maldah district (1995-96 to 2020-21)

During 2020-21, Habibpur is the only block, found under low cropping intensity zone. However, four blocks (Bamangola, Chanchal II, Gazole and Ratua II) are under medium intensity region in 2020-21. On the other hand, ten blocks (Chanchal I, English Bazar, Harishchandrapur I, Harishchandrapur II, Kaliachak I, Kaliachak II, Kaliachak

III, Manikchak, Old Maldah and Ratua I) are found with high cropping intensity region during 2020-21.

A remarkable change in cropping intensity region has been observed from 1995-96 to 2020-21. As in 2020-21, only one block, i.e., Habibpur, is under the low-intensity category but in 1995-96, there were nine blocks in this category. So, eight blocks have shown significant changes of cropping intensity from low to medium (Chanchal II, Gazole and Ratua II) and high (English Bazar, Harishchandrapur I, Harishchandrapur II, Kaliachak I and Old Maldah). Similarly, ten blocks are found in the high cropping intensity category in 2020-21; while there was only one block under high cropping intensity in 1995-96 (Table 4.19 and Fig. 4.13). Also, there were five blocks in 1995-96 and four blocks in 2020-21in the medium cropping intensity category. So, the high cropping intensity in most of the blocks of the district has significantly increased during 1995-96 to 2020-21. Therefore, the blocks were under the low and medium category in 1995-96 and have shifted to the high category in 2020-21.

4.5.6 Conclusion

This chapter has clearly discussed the Spatio- temporal changes of ALU pattern and agricultural regionalization in Maldah district. For temporal analysis, the data of 1980-81 to 2020-21 have been taken into consideration, while for spatial analysis the data of 1995-96 to 2020-21 have been taken into consideration due to unavailability of block-level data before 1995-96. The trend analysis results clearly revealed a decreasing trend ($\alpha = 0.01$) in the area and production of autumn rice (aus) among cereals during 1980-81 to 2020-21. However, the productivity of the autumn rice (aus) showed an increasing trend ($\alpha = 0.01$). Among pulses, the area of gram and khesari showed a significant decreasing ($\alpha = 0.01$) trend. However, their productivity increased significantly ($\alpha = 0.1$) during the study period. Similarly, the area, production and productivity of rapeseed & mustard (Oilseeds) showed a significant ($\alpha = 0.01$) increasing trend. Among cash crops, the area of jute has significantly ($\alpha = 0.01$) decreased in the district, though the production and productivity showed a significant ($\alpha = 0.01$) increasing trend during 1980-81 to 2020-21. On the other hand, the analysis of the trend of the major crops has been disproved the hypothesis I that there is a significant decreasing trend in the area under major crops. The analysis of agricultural regionalization considering crop ranking, crop combination, crop diversification, crop concentration and cropping intensity also showed remarkable changes during the study period. Potato and maize have noticeably changed their rank during 1980-81 to 2020-21, from 7th to 3rd and from 10th to 4th respectively. For the crop combination region, a decrease of two crop combinations in three blocks has been observed; however, a block caught with five crop combinations in 2020-21. The positive changes have been observed in high and low crop diversification regions and negative changes in medium crop diversification regions during 1995-96 to 2020-21. Most of the crops are observed with medium concentration in the majority of the blocks in both the period. Winter rice (aman) is the most significant crop of the district; highly concentrated in seven blocks in 2020-21 and it was highly concentrated in six blocks during 1995-96. Various factors are responsible for such changes in ALU patterns in the district, such as lack of labour, unavailability of pond or water body, high cost of fertilizers and manures, shortages of irrigation facilities and neighbor cultivation.

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