Crop Diversification as a Measure of Sustainable Agriculture and Production Growth

Md. Faiyaz Afzal and Shamsul Haque Siddiqui

Abstract The agriculture in West Bengal is mainly of intensive subsistence nature. There is a predominance of single cropping of rice from the distant past. The rural, as well as urban people of West Bengal, are totally dependent on agriculture and allied industries for their livelihood. Thus, it is very interesting to know the degree of crop diversification so far achieved in the rural areas of West Bengal, as the sustainable income and employment of people are largely dependent on the nature and degree of diversification of crops. Crop diversification generally means, raising varieties of crops in a given area in one cropping season. Thus, the sustainability of agriculture in any area mainly depends on the degree of crop diversification in that area. Therefore, to acquire knowledge about the crop diversification and production growth in rural West Bengal two typically agricultural districts have been taken into account for the present study, namely, Uttar Dinajpur and Dakshin Dinajpur. About 80–90% population of both the districts are directly or indirectly engaged in agricultural activities. The present chapter tries to study the pattern of crop diversification and growth in agricultural production during the period 2000–2001 and 2014–2015. The variation in crop diversification is a response to the fast-changing physical and socio-cultural conditions which helps in attaining agricultural sustainability. The index of crop diversification has been employed by using the Gibbs-Martin Index of Crop Diversification (1962). The study highlights that there has been a shift in the cropping behaviour from cereals towards non-foodgrain crops, and the production of major crops has also increased manifolds in both districts.

Keywords Crop diversification · Crop diversification index · Cropping pattern · Gibbs-Martin · Sustainable agriculture

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1 Introduction

The agriculture in West Bengal is mainly of intensive subsistence nature. There has been a predominance of single cropping of rice from the distant past. The rural, as well as urban people of West Bengal, are totally dependent on agriculture and allied industries for their livelihood. Thus, it is very interesting to know the degree of crop diversification so far achieved in the rural areas of West Bengal as the sustainable income and employment of people is largely dependent on the nature and degree of diversification of crops. Crop diversification generally means the raising of varieties of crops in a given area in one cropping season. It is actually the idea of competition among the parallel crops cultivated in a region. If there is high competition among the crops in the region, there will be a higher magnitude of crop diversification and if there is less competition among the crops in the region, there will be a trend towards crop specialization or monoculture (Bhatia, 1965). Essentially, it is an indicator of the multiplication of agricultural activities which involves intense competition among various activities for space (Singh & Dhillion, 1997).

In India, crop diversification is generally considered as shifting from traditionally grown less remunerative crops to more remunerative crops (Husain 1996; Wanjari et al., 2006). The level of crop diversification is largely dependent on the geo-climatic set-up, socio-economic conditions and technological know-how in a region. The regions with a higher level of agricultural mechanization and endowed with rich farmers experience a lesser degree of diversification, while the regions with poor farmers and comparatively less mechanization generally experience a higher degree of crop diversification (Ranade, 1980; Goyal & Kumar, 2013; Dabai, 1979; Vaishampayan et al., 2019). Basically, it is a kind of farming system where a variety of alternative crops are being cultivated by the farmers in the same field, which itself has great relevance in the agricultural land use scenario and is considered as a vital component of the cropping behaviour of a region (Shafi,1981; Vyas, 1996); Ratnaparkhi, 2012). It also has great relevance in agricultural land use planning of a region, as the farmer instead of growing only one crop over the entire cultivated area grows a variety of crops like rice, wheat, maskalai (urd), musur, jute and potato. Consequently, a diversified cropping pattern can enhance the nitrogen intake of soil and makes the soil more fertile, arable and increase the sustainability of the soil. Besides this, farmers remain engaged in agricultural activities like sowing, weeding, harvesting and marketing of produced crops throughout the year which ultimately leads to employment generation. It can also bring down the risk of crop failure as different crops respond differently with the geo-climatic conditions of an area, wherein the production of a certain crop may get affected by extremely hot weather but it may be beneficial for some other alternative crops.

The main advantages of crop diversification lie in the fact that it is very helpful for planning and developing agricultural practices of an area (Bisai et al., 2016). It has been observed that the nature of crop diversification of a geographical unit is basically influenced by the existing social and economic status, educational attainment, infrastructural facilities and physical conditions of that region (Todkari,

2012). In West Bengal, the first incidence of diversified cropping took place soon after the Green Revolution period (1960s). Whereas, the initial period was favourable for the wheat but later on a gradual shift towards mustard-potato (rabi crops) has been noticed (Pal, 2008). There exists a small peasant-based farm economy in India with nearly 35% cultivated land and about 80% holding below 2 hectares on an average (Ghosh, 2011; GOI, 1997). The small size of holdings does not allow the farmers to increase their earnings by simply boosting the yield of cereals crops. However, in due course of time with the advancement of science, the water seed-fertilizer technique has enabled the farmers to change their cropping behaviour towards certain high-value cash crops by practising horticulture (Joshi et al., 2003). The results are also visible in West Bengal, as the small farmers of the state are now opting for high-value crops like tea, maize, potato, summer paddy and mustard (De, 2000).

It is a scientific solution to numerous problems experienced by the nations with high population, highest share of marginal farmers, low level of agricultural mechanization and acute physio-climatic conditions. The agricultural output of a region can be enhanced after moving from low-value to high-value crops by adopting crop diversification (Dutta, 2012). Thus, the sustainability of agriculture in any area mainly depends on the degree of crop diversification in that area. Therefore, to acquire knowledge about the crop diversification in rural West Bengal, two typically agricultural districts have been taken for the present study, namely, Uttar (North) Dinajpur and Dakshin (South) Dinajpur. These two districts are mainly agrarian as almost 85% population are dependent on agricultural activities, but due to lack of institutional and infrastructural facilities, agricultural sustainability is hindered (Government of West Bengal, 2000–2001).

2 Study Areas

Uttar and Dakshin Dinajpur districts of West Bengal have been selected as the study areas because these districts are very backwards in every aspect of socio-economic parameters and no such research has been conducted till now in these two districts. Also, a study of the cropping behaviour of two adjacent districts may give us a better understanding of crop diversification and its dynamic role in influencing the growth of production in a different way in each district. In other words, by this comparative study, we can see two sides of a single coin i.e. crop diversification.

On 1 April 1992, the West Dinajpur division of West Bengal bifurcated into two separate districts namely Uttar Dinajpur and Dakshin Dinajpur for the upliftment of socio-economic conditions and better administration. The district of Uttar Dinajpur stretches from 25°11′ N to 26°49′ N latitude and 87°49′ E to 90°00′ E longitude. This district is spread over 3140 sq. k.m. area. The district is bounded by Darjeeling and Jalpaiguri districts on the north, Kishanganj district of Bihar on the west and Malda district on its south. On the eastern side there lies the international border between India and Bangladesh (Fig. 1). According to census 2011, the total

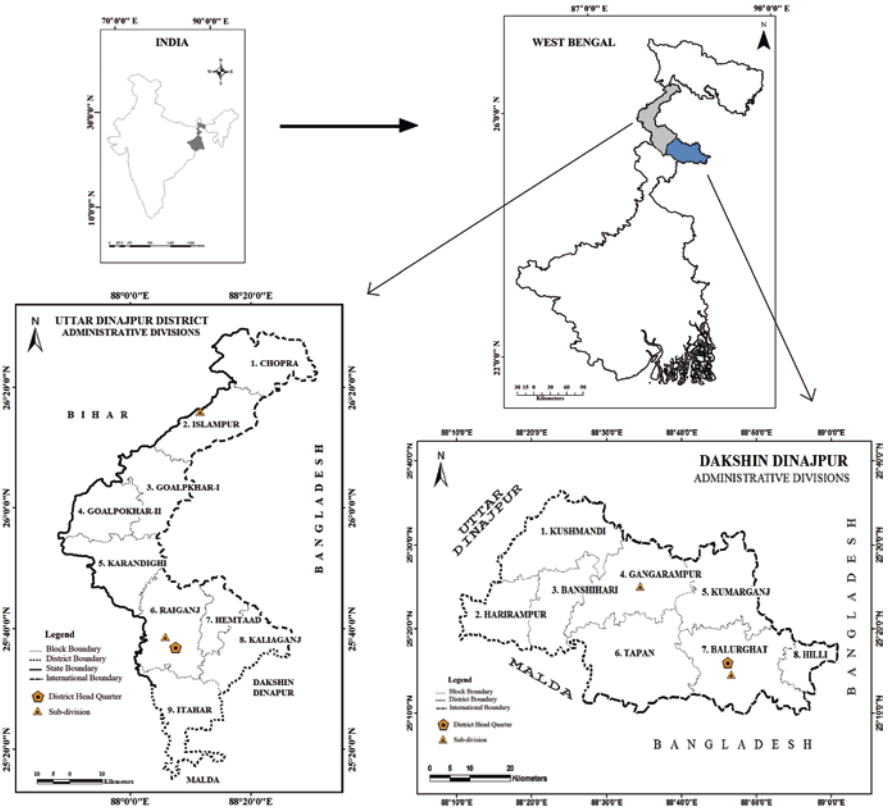


Fig. 1 Locational map of the study areas

population of the district is 30 lakhs, out of which more than 85% of people were living in villages and dependent on agricultural activities for their livelihood. The average literacy rate of the district was 60.1% (Census, 2011). The net sown area of the district is 275.6 thousand hectares (88.2%) and the cropping intensity of the district is altogether 210.07%. The district is dominated by marginal farmers with <1 hectare (only 0.88 hectares) of land on average. Rice, wheat, jute, mustard, potato, sugarcane and potato are the major crops grown in the district (Comprehensive District Agricultural Plan (C-DAP)).

On the other hand, the district of Dakshin Dinajpur stretches from 26° 35′ N to 25° 10′ N latitudes and 89° 00′ E to 87° 48′ E longitudes. This district is located in the north-eastern part of the state of West Bengal and surrounded by Uttar Dinajpur on its north and west, Malda district on the south-west and Bangladesh border lie on its east and south. According to census 2011, the total population of the district is 16 lakhs out of which almost 80% of people are engaged in agricultural activities and living in rural areas. The average literacy of the district is 72.8% (Census, 2011).

The rich alluvium soil has enabled double as well as multiple cropping in the district (Siddiqui et al., 2017). Major crops grown in the district are rice, jute, potato, wheat, mustard and maskalai. Out of the total reporting area of the district about 84% is sown and the average cropping intensity of the district is altogether 182%.

The general topography of both the districts is almost flat having a gentle slope from north to south. The old and new alluvium soil of Uttar Dinajpur is rich in organic compound and phosphate, while the old alluvium soil of Dakshin Dinajpur is rich in potassium content, besides certain parts of the district have lateritic soil near the Tapan block. The climate of Uttar Dinajpur is muggy (annual rainfall 1500–2400 mm), while Dakshin Dinajpur has a scorching climate (annual rainfall 1000–1500 mm). Apart from this, both the districts are well connected through roadways and railways with the entire state.

3 Why Crop Diversification?

Crop diversification simply means an addition of a new crop or adoption of a new cropping system on a particular farm taking into consideration the increase in production and output return from value-added crops along with the use of HYV seeds. It is an important tool for the growth of farm output which ultimately leads to the economic growth of the farming community. Crop diversification can lead to an increase in the productivity of land, provides the opportunity to raise several crops in the same land at a time, which makes farmers self-dependent and the income of small farm holders withstands the price fluctuations. It can also mitigate the effect of increasing climatic uncertainty. A diversified cropping system could balance the increasing food demand, thus sustaining food security. It reduces the dependency on off-farm inputs and minimises the risk of environmental pollution. Through the techniques of crop rotation, a check on the weed problems can be imposed which could ultimately lead to a decrease in insects and pests in the farms. Thus, the overall resilience of agricultural sustenance can better be governed by crop diversification.

4 Objectives

Hence, keeping in mind the significance of crop diversification the following objectives have been formed for the present study:

1. To outline the extent of crop diversification at the block level in both districts.
2. To analyse the relation between crop diversification and crop production in the study areas.

5 Database and Methodology

This study is entirely based on secondary sources of data collected from the Statistical Handbooks of Uttar and Dakshin Dinajpur districts for the years 2000–2001 and 2014–2015. The data has been obtained from the Bureau of Applied Economics & Statistics, Government of West Bengal. Simple statistical techniques and tools have been used for the analysis of data. Besides, the author has purposively used Gibbs-Martin's (1962) technique for the delineation of crop diversification regions of both districts. The formula for the index of crop diversification is as follows:

X is the percentage of total cropped area under an individual crop. The magnitude of the crop diversification obtained by applying this formula ranges from 0.1 to 1.0. Whereas, the index value is positively related to the magnitude of crop diversification i.e., higher the index means higher the magnitude of diversification and vice-versa.

The calculated index value of crop diversification of different blocks (2000–2001 and 2014–2015) has been categorised into three classes, viz. high, medium and low crop diversification regions. The results are being represented graphically with the help of colourful choropleth maps prepared on QGIS 2.14 software. Apart from this, the production of major crops has also been obtained from the District Statistical Handbooks of both the districts for the two time periods. The production of crops for each block of both districts is measured in tonnes. The change in production is represented by bar diagrams to have a better understanding of the growth of each crop in comparison.

6 Extent of Crop Diversification (2000–2001 and 2014–2015)

A spatio-temporal change of crop diversification indicates changes in the cropped area with respect to different crops (Bisai et al., 2016). Here an attempt is made to identify the changes in crop diversification regions during the period 2000–2001 and 2014–2015. The investigation reveals that there are some blocks where change is significant, while in some other blocks of the districts the change is insignificant or negligible. In some blocks, the physio-climatic conditions have put the limit on the diversification of crops and thus influencing agricultural productivity. Rice is the principal crop in all the blocks, besides numerous other crops are also being cultivated by the farmers including wheat, jute, potato and maize.

It is evident from Table 1 that both the districts have witnessed blooming diversification across the blocks during the study period. However, it is worth mentioning here that the blocks that are nearer to the sub-divisional towns have exerted rapid change in the diversification pattern, which can be visible in Figs. 2 and 3. The crop diversification index of Uttar and Dakshin Dinajpur districts has increased from 0.55 and 0.36 in 2000–2001 to 0.62 and 0.43 in 2014–2015 respectively. The Gibbs-Martin index of crop diversification has come out with three classifications of crop diversification regions in the study areas, as follows;

Table 1 Production of Major crops in Uttar Dinajpur and Dakshin Dinajpur districts, 2000–2001 to 2014–2015. (Production in Thousand tonnes)

Crops	Symbol	Uttar Dinajpur			Dakshin Dinajpur		
		2000–2001	2014–2015	Change	2000–2001	2014–2015	Change
Rice	R	628.6	599.9	−28.7	467.3	520.8	53.5
Wheat	W	86.2	89.6	3.4	25.2	41.4	16.2
Maize	M	0.1	333.1	333	0.05	7.5	7.45
Masur & gram	MG	0.8	0.1	−0.7	0.1	0.05	−0.05
Rapeseed & Mustard	RM	27	43.9	16.9	20.8	26.4	5.6
Jute	J	457.5	827.2	369.7	146.1	280.1	134
Sugarcane	S	28.7	45.5	16.8	NA	NA	00
Potato	P	133.4	222.2	88.8	87.8	123.3	35.5
Tea	T	0.01	1	0.99	NA	NA	00
Chillies (dry)	C	2.3	7.9	−5.6	1.3	3.3	−2

Source: Statistical Handbook of Uttar Dinajpur and Dakshin Dinajpur districts (2000–2001 and 2014–2015)

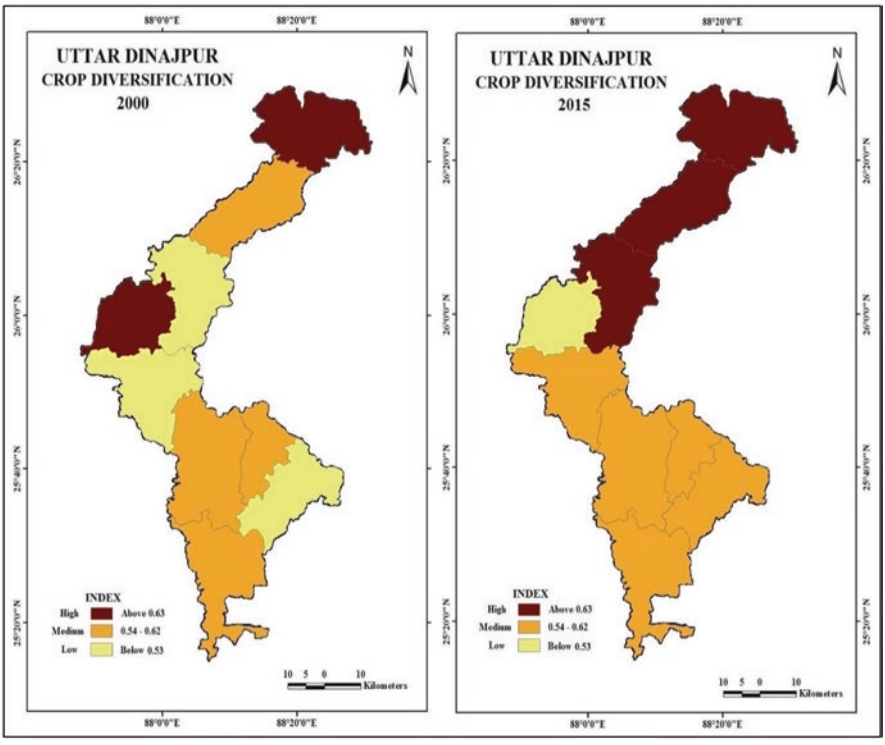


Fig. 2 Crop diversification during 2002–2015 in Uttar Dinajpur

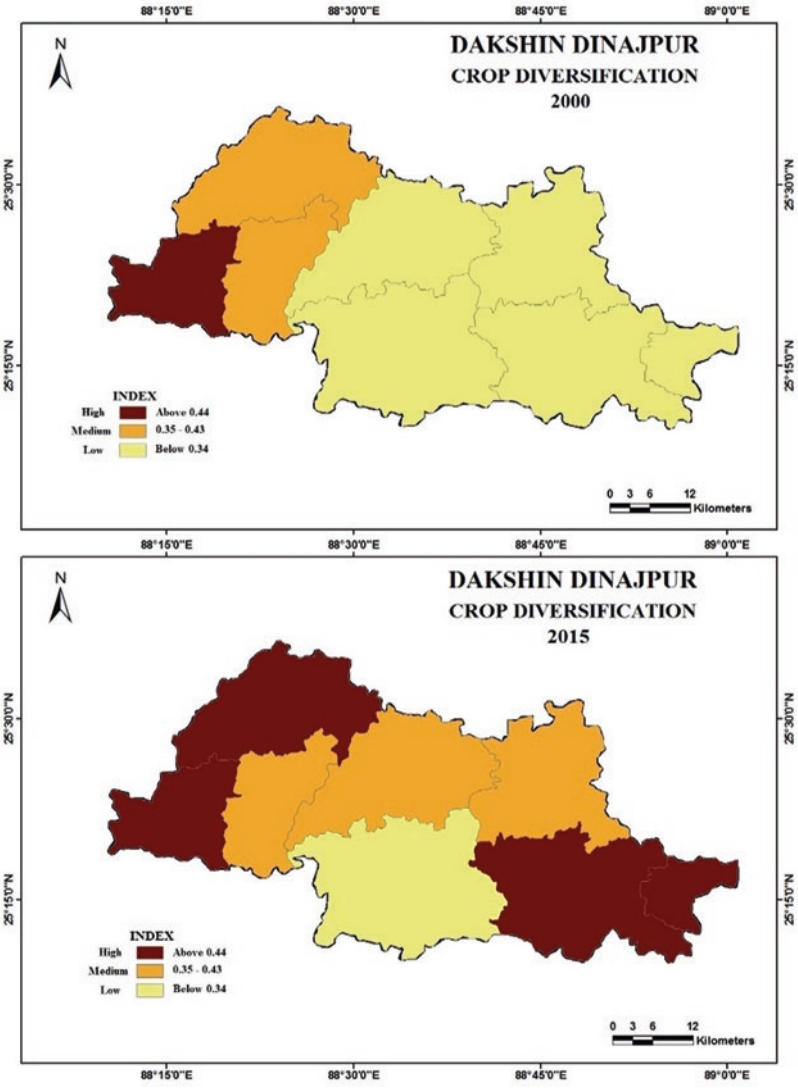


Fig. 3 Crop diversification during 2002–2015 in Dakshin Dinajpur

6.1 High Crop Diversification Region

Out of the total nine blocks of Uttar Dinajpur district, two blocks came under the category of high crop diversification in the year 2000–2001. Chopra block with a crop diversification index (ICD) of 0.67 had a significant region of 5 to 6 crops such as rice, jute, wheat, till, potato and linseed. The other block i.e., Goalpokhar-II recorded 0.63 ICD and also cultivated crops like rice, jute, wheat, mustard, potato, maskalai and linseed. In 2015, as many as 8–9 crops are being cultivated in high

crop diversification regions. Presently, out of the nine blocks, three come under the high category namely, Islampur, Goalpokhar-I and Chopra. Islampur block with ICD 0.70 and Goalpokhar-I block with ICD 0.68, has a significant region of rice, jute, mustard, potato, wheat, maize, till, and maskalai. While in Chopra block (ICD 0.64), the cultivation of various crops like rice, wheat, jute and potato is being done as before, but the area for these crops has decreased and the area of few cash crops such as maize, tea and pineapple has increased significantly.

On the other hand, in Dakshin Dinajpur district, out of the total eight blocks, only one block came under high crop diversification region in the year 2000–2001 i.e., Harirampur (ICD 0.59), which has a significant region of rice, mustard, wheat, jute, potato and masur. In 2014–2015, the number of blocks under high crop diversification has increased to four blocks i.e.; Kushmandi (0.54), Harirampur (0.51), Balurghat (0.47) and Hili (0.45) with significant crops like rice, mustard, jute, wheat, potato and maskalai.

The sub-divisional towns in both the districts are exerting diversified cropping patterns due to accessibility of modern amenities, irrigation facilities and increasing demand of varying ranges of food products in the market.

6.2 Medium Crop Diversification Region

In 2000–2001, four out of nine blocks of Uttar Dinajpur came under medium crop diversity region namely, Islampur (0.61), Itahar (0.59), Raiganj (0.57) and Hemtabad (0.55). In these blocks, moderate crop diversification prevailed with 4–5 major crops being cultivated such as rice, wheat, jute, mustard, gram and potato. While in the year 2014–2015, the number of blocks under this category has increased to six blocks, namely Hemtabad (0.62), Kaliaganj (0.62), Itahar (0.60), Raiganj (0.58), Goalpokhar-II (0.56) and Karandighi (0.57). It is a sign that the district is moving gradually towards crop diversification by opting for more than 6 to 8 crops being cultivated instead of the traditional single- or double-crop dominance.

On the other hand, in Dakshin Dinajpur district the number of blocks under medium crop diversification region has increased from two blocks i.e., Banshihari (0.42) and Kushmandi (0.40) in 2000–2001 to three blocks out of eight in 2014–2015 i.e., Gangarampur (0.44), Kumarganj (0.38) and Banshihari (0.35). All these blocks are moving steadily towards diversification with cultivating crops like rice, mustard, jute, wheat, potato, maskalai and masur. Thus, the trend of diversification is visible too in Dakshin Dinajpur district.

6.3 Low Crop Diversification Region

There were three blocks of Uttar Dinajpur district that came under low crop diversification region in the year 2000–2001 namely, Goalpokhar-I (0.51), Karandighi (0.28) and Kaliaganj (0.39). Among them Kaliaganj has the lowest ICD, thus it can

be said that this block has practised a single or double cropping system of traditional crops like rice, jute and wheat. But in 2014–2015, there is no such block that comes under this category, which means that the district is completely devoid of a mono-cropping system and it is a positive sign for crop diversification.

In Dakshin Dinajpur district, earlier there were five blocks under low crop diversification region namely, Kumarganj (0.34), Tapan (0.33), Balurghat (0.31), Hili (0.27) and Gangarampur (0.23). In all these blocks there was a dominance of mono-cropping or double cropping in 2000–2001. But in 2014–2015, only one block i.e., Tapan (0.25) came under the low crop diversification region with the cultivation of 2 to 3 crops like rice, mustard and jute only. In this block, rice occupies as much as 74.8% of the gross cropped area. It means there is a single cropping system in the block and it seems that this block is moving towards crop specialization rather than diversification.

7 Spatial Analysis of Crop Diversification (2000–2001 to 2014–2015)

From the foregoing discussion, we came to know that there exists a trend of gradual shifting towards diversification in both districts. More precisely speaking, the nature of crop cultivation in both the districts is quite similar, but the only difference is that while in Uttar Dinajpur farmers are opting for food crops such as maize and cash crops like sugarcane, tea, potato and chillies, in Dakshin Dinajpur pulses such as masur, maskalai and gram and oilseeds are preferred by the farmers. Moreover, in both the districts high crop diversification regions include the cultivation of more than six to seven crops. In Uttar Dinajpur district the pace of moving towards diversification is comparatively slower than Dakshin Dinajpur as evident from Figs. 2 and 3 i.e., in the last 14 years the number of blocks under the high crop diversification category increased from two to three in Uttar Dinajpur, while in Dakshin Dinajpur the number of blocks under high crop diversification category has increased from one to four. Overall, the degree of diversification in Uttar Dinajpur district is comparatively high as all the blocks of the district fall under the high and medium category and there is no block under the low crop diversification category.

8 Status of Crop Production (2000–2001 to 2014–2015)

There has been a significant change in the agrarian situation of West Bengal during the last 50 years, especially on account of the land reform programme, popularly known as ‘operation barga’, which was successfully implemented around the 1970s under the communist regime. Owing to this policy, the surplus agricultural lands of the *Jamindars* (big land-lords), were reconsolidated among the land-less labourers

by the Government. Since then, the production and productivity of major crops were increased significantly in the state. In general, the agricultural population of the state is generally dominated by marginal and small farmers, which constitutes about 85–90% of the total farmers. These small and marginal farmers have no choice except to raise a variety of crops from the same land, so as to minimise the risk of crop failure. The study on the behaviour of farmers to choose a certain crop suggests that the farmers are taking up agriculture alternatively. They are choosing diversification of crops, integrated farming system and modern hybrid seeds to have more remuneration, better input use efficiency and less risk involvement.

The cropping pattern of the state, as well as the individual districts, is dominated by foodgrain crops. Thus, for estimating the agricultural production in Uttar and Dakshin Dinajpur districts, the major food crops such as rice, wheat, pulses and other cash crops such as jute, maize, sugarcane, potato and tea have been taken into account. The crop-wise data reveals that except rice and masur, the production of almost all the other crops has increased significantly from 2000–2001 to 2014–2015 in Uttar Dinajpur districts (Figs. 4 and Fig. 5). In Dakshin Dinajpur district, the production of rice has increased from 467.3 thousand tonnes to 520.8 thousand tonnes in the last 14 years (Fig. 4). The production of maize has drastically increased manifolds in Uttar Dinajpur from 0.1 to 333.1 thousand tonnes with a rate of 78.4%, while in Dakshin Dinajpur the rate of maize production was quite lower i.e., 43%. The production of mustard has increased from 27 thousand tonnes and 20.8 thousand tonnes in 2000–2001 to 43.9 thousand tonnes and 26.4 thousand tonnes in 2014–2015 in Uttar and Dakshin Dinajpur respectively (Table 1 and Fig. 6). The production of jute and dry chillies has also increased positively in subsequent years in both districts.

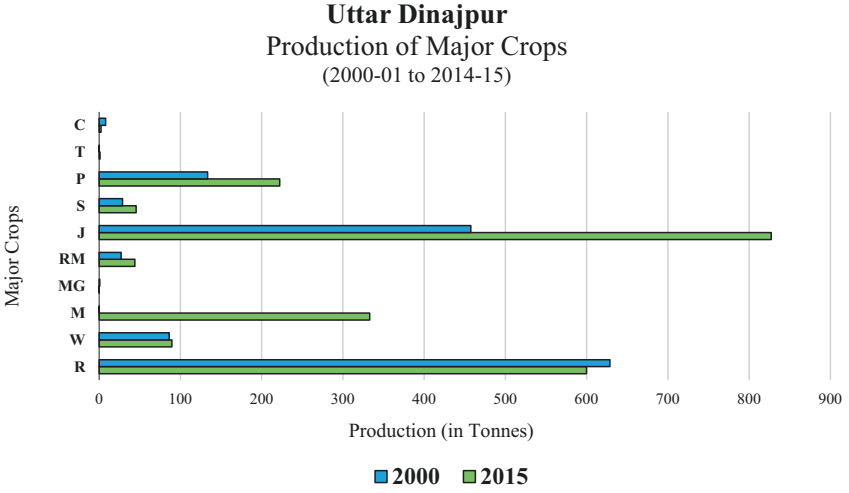


Fig. 4 Production of major crops in Uttar Dinajpur

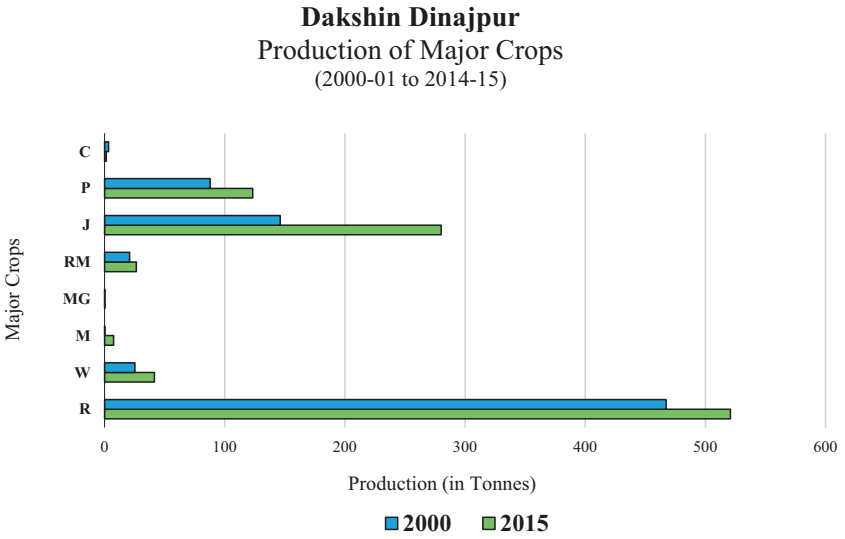
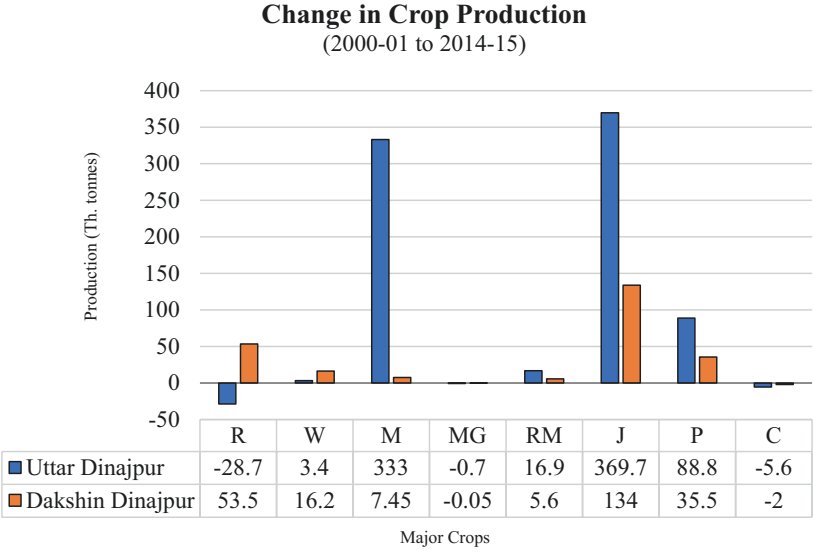


Fig. 5 Production of major crops in Dakshin Dinajpur



	R	W	M	MG	RM	J	P	C
Uttar Dinajpur	-28.7	3.4	333	-0.7	16.9	369.7	88.8	-5.6
Dakshin Dinajpur	53.5	16.2	7.45	-0.05	5.6	134	35.5	-2

Fig. 6 Changes in crop production in both selected study area

The major difference that can be sought from the comparative analysis is that Uttar Dinajpur districts are moving towards more remunerative cash crops and therefore the production of cash crops in the district has boosted tremendously, while the production of cereals or food crops has experienced sluggish growth. On the other hand, the district of Dakshin Dinajpur has opted for growing the traditional crops to fulfil the local demand of food crops and oilseeds by using modern hybrid seeds and therefore the production of cereals as well as food crops like potato has increased significantly in the district.

9 Crop Diversification and Production Growth

A keen observation of the block-wise data of crop diversification and crop production, reveals that the blocks in which the Index of Crop Diversification (ICD) has increased during 2000–2001 and 2014–2015, the production of crops has also increased and vice-versa. For example, in Uttar Dinajpur district the ICD value of seven blocks (Islampur, Goalpokhar-I, Karandighi, Raiganj, Kaliaganj and Itahar) has increased during the study period, except Chopra block. As a result, the production of crops in almost all the seven blocks has increased for the majority of the crops. For instance, in Goalpokhar-I block the ICD has increased from 0.51 in 2000–2001 to 0.68 in 2014–2015, simultaneously the production has increased for rice (from 57.7 thousand tonnes to 105.9 thousand tonnes), wheat (from 8.3 thousand tonnes to 9.9 thousand tonnes), potato (from 12.9 thousand tonnes to 32.7 thousand tonnes), masur (from 5 tonnes to 18 tonnes), maskalai (from 60 tonnes to 322 tonnes), mustard (from 2.8 thousand tonnes to 3 thousand tonnes) and jute (from 42.5 thousand tonnes to 79.4 thousand tonnes). While in Chopra block the ICD has decreased from 0.67 in 2000–2001 to 0.64 in 2014–2015, simultaneously the production has decreased for rice (from 45.9 thousand tonnes to 44 thousand tonnes), wheat (from 9.2 thousand tonnes to 7.7 thousand tonnes), potato (from 31.8 thousand tonnes to 24.7 thousand tonnes) and jute (from 66.1 thousand tonnes to 50.8 thousand tonnes) during the period from 2000–2001 to 2014–2015 (Figs. 7 and 8). However, it is worth mentioning here that the Chopra block of Uttar Dinajpur has rapidly moved towards the specialised cultivation of tea and pineapple, which can be seen as the main cause of this fall in the production of food crops.

Similarly, in the Dakshin Dinajpur district, the ICD value of five blocks (Kushmandi, Gangarampur, Kumarganj, Balurghat and Hili) has increased from 2000–2001 to 2014–2015. While the ICD of Harirampur, Banshihari and Tapan has decreased during the study period. Here also, the production of major crops has increased in those blocks whose ICD has increased, while the production of most of the crops like rice, masur, maskalai, gram and jute has decreased in those blocks whose ICD has decreased. Banshihari block, the ICD has been found to be decreased from 0.42 in 2000–2001 to 0.35 in 2014–2015, simultaneously the production has also decreased for rice (from 45.7 thousand tonnes to 37.9 thousand tonnes), potato (from 6.8 thousand tonnes to 6.5 thousand tonnes), masur, maskali and gram became

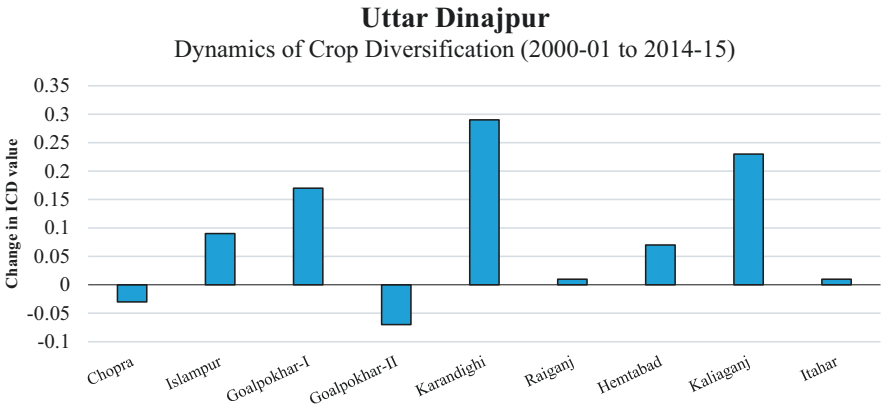
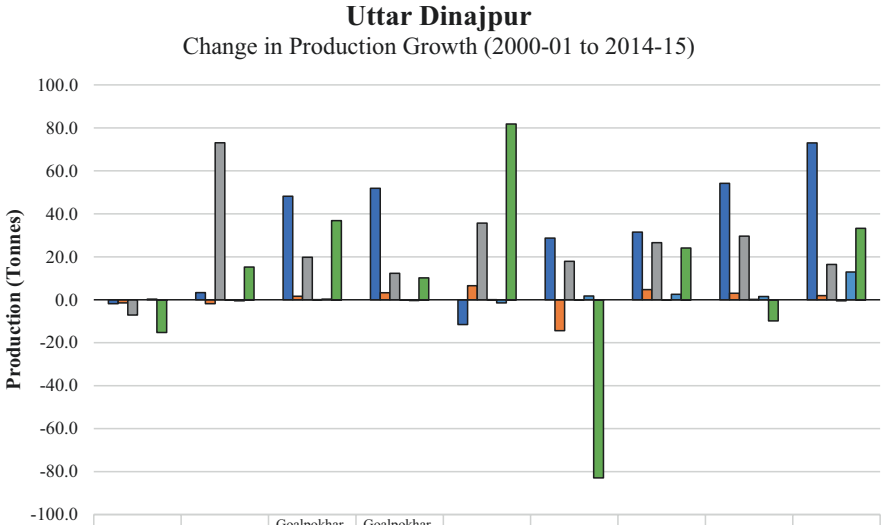


Fig. 7 Dynamics of crop diversification during 2002–2015 in Uttar Dinajpur



	Chopra	Islampur	Goalpokhar-I	Goalpokhar-II	Karandighi	Raiganj	Hemtabad	Kaliaganj	Itahar
Rice	-1.86	3.30	48.20	51.88	-11.52	28.69	31.49	54.20	73.04
Wheat	-1.46	-1.82	1.64	3.23	6.53	-14.40	4.74	3.00	1.93
Potato	-7.11	73.06	19.81	12.35	35.67	17.94	26.57	29.62	16.44
Masur	0.00	-0.01	0.01	-0.01	0.04	-0.05	-0.01	0.15	-0.51
Mustard	0.25	-0.50	0.25	-0.36	-1.49	1.77	2.54	1.54	12.89
Jute	-15.25	15.22	36.83	10.22	81.83	-82.94	24.12	-9.82	33.21

Fig. 8 Changes in crop production growth in in Uttar Dinajpur

nil and jute (from 18.6 thousand tonnes to 16 thousand tonnes). While the ICD value of Gangarampur has increased from 0.23 in 2000–2001 to 2014–2015, simultaneously the production has increased for rice (from 50.7 thousand tonnes to 83 thousand tonnes), wheat (from 2.7 thousand tonnes to 3.2 thousand tonnes), potato (from 2.2 thousand tonnes to 40.1 thousand tonnes), masur (from 5 tonnes to 160 tonnes),

maskalai (from 10 tonnes to 137 tonnes) and jute (from 23.2 thousand tonnes to 45 thousand tonnes) (Figs. 9 and 10).

Hence, among the different strategies and technologies, crop diversification and inclusion of new hybrid varieties of seeds are the prioritised technologies to increase production, stabilise the farm income and maximise profitability. Introducing a greater variety of crops in a particular agro-system may provide better agricultural

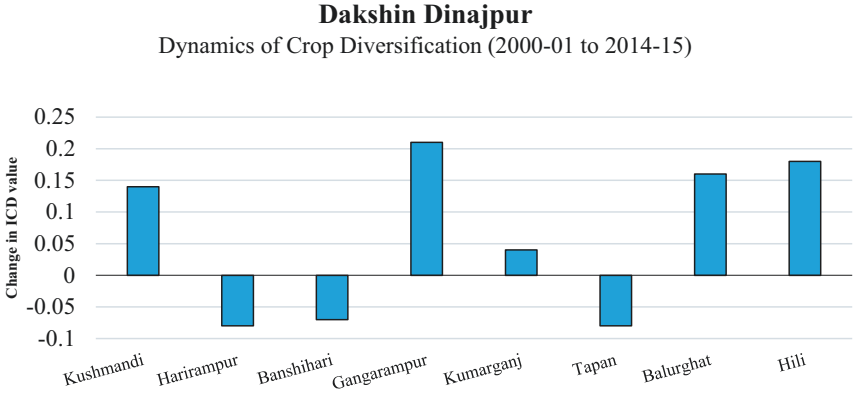
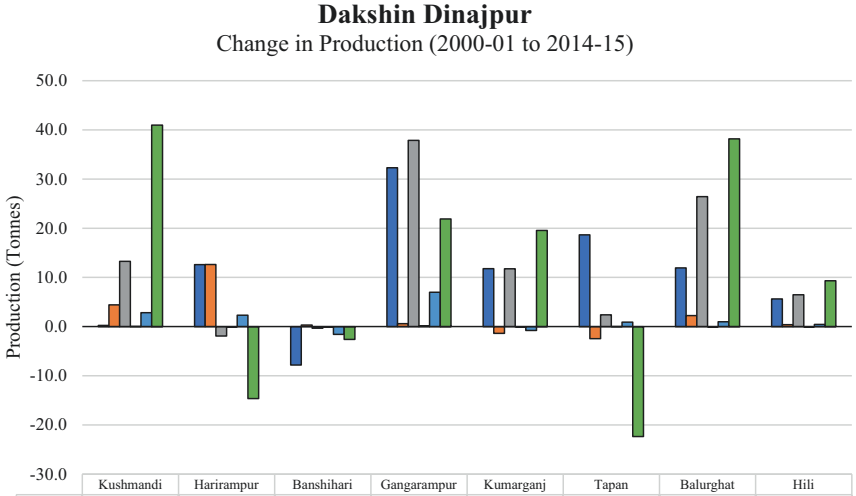


Fig. 9 Dynamics of crop diversification during 2002–2015 in Dakshin Dinajpur



	Kushmandi	Harirampur	Banshihari	Gangarampur	Kumarganj	Tapan	Balurghat	Hili
Rice	0.228	12.614	-7.818	32.305	11.802	18.649	11.935	5.62
Wheat	4.423	12.626	0.313	0.586	-1.382	-2.436	2.238	0.411
Potato	13.255	-1.91	-0.322	37.873	11.757	2.386	26.428	6.449
Masur	0.038	-0.005	-0.005	0.155	-0.005	0.001	-0.005	-0.005
Mustard	2.841	2.298	-1.573	6.996	-0.79	0.914	0.976	0.451
Jute	40.959	-14.637	-2.608	21.873	19.567	-22.368	38.182	9.317

Fig. 10 Changes in crop production growth in in Dakshin Dinajpur

output that can lead to a balanced natural bio-diversity, equilibrium in the ecosystem and ability to tackle the underlying stress (Khanam et al., 2018).

10 Conclusion

About 64% area of Uttar Dinajpur was under high and moderate crop diversification in 2000–2001, which has increased to 82.4% in 2014–2015 and about 33% area was under specialised traditional mono-cropping in 2000–2001 which is now completely absent. It means this district is now completely under a diversified cropping pattern. On the other hand, in Dakshin Dinajpur district about 44.5% area was under high and moderate crop diversification in 2000–2001, which has now increased to about 73.7% in 2014–2015. However, the traditional mono-cropping area has drastically decreased from 66.8% in 2000–2001 to 20% in 2014–2015. The change under high diversification area for Uttar Dinajpur was 10.5%, while the change for Dakshin Dinajpur was 27.5%. In both cases, the blocks which are nearer to the subdivisional towns or urban areas are experiencing diversified cropping pattern due to the accessibility and availability of irrigation and infrastructural facilities entertaining multiple cropping systems (District Statistical Handbook, 2000).

Diversification of crops from traditional cereals to cash crops can improve the economic condition of the farmers in both the districts and they may become self-reliant in terms of food production. It can also manage price risk, on the assumption that not all products will suffer low market prices at the same time and increase the profitability of the farming community. Special attention should be given to the least diversified block of Tapan in Dakshin Dinajpur district for improvement of soil characteristics as the block has lateritic soil which is not favourable for crop cultivation, from the above analysis it has been reported that both the said districts are doing well in terms of agriculture practising a more diverse cropping system with due course of time and the production of several crops grown at a faster rate which can be seen as a major influencing factor for sustainable agriculture and the future of these two districts is bright concerning to minimising the regional disparities in agriculture and the overall agricultural growth.

Appendixes

Appendix A: Block-Wise Index of Crop Diversification (ICD) and Production of Major Crops in Uttar Dinajpur District, 2000–2001

Blocks	ICD	Rice		Wheat	Potato	Masur	Maskalai	Khesari	Till	Mustard	Linseed	Gram	Jute
Chopra	0.67	A	24,760	4730	1750	NA	100	NA	3840	390	1570	NA	12,780
		P	44,090	9250	31,820	NA	40	NA	1850	320	350	NA	66,100
Islampur	0.61	A	23,965	3120	950	5	130	5	2080	2580	240	20	8230
		P	48,365	5740	23,390	5	60	5	1260	2230	60	10	53,710
Goalpokhar-I	0.51	A	30,095	4290	570	5	150	NA	1020	3510	5	NA	4700
		P	57,705	8300	12,950	5	60	NA	720	2840	5	NA	42,580
Goalpokhar-II	0.63	A	19,945	3730	1020	30	820	NA	80	3310	350	70	5770
		P	48,625	7990	22,990	10	340	NA	30	2430	110	30	47,920
Karandighi	0.28	A	49,445	1940	110	50	NA	NA	NA	5140	80	NA	2030
		P	128,235	5050	2090	40	NA	NA	NA	4530	20	NA	19,910
Raiganj	0.57	A	45,210	6880	280	210	70	90	NA	8860	520	240	10,100
		P	123,470	21,160	6990	210	40	100	NA	6460	270	110	97,600
Hemtabad	0.55	A	17,965	4420	480	130	280	5	NA	2100	170	70	2430
		P	42,135	9640	7570	60	340	5	NA	1580	70	30	21,620
Kaliaganj	0.39	A	34,520	2700	350	50	20	5	NA	2940	150	50	3950
		P	53,700	4580	5930	20	10	5	NA	1740	40	20	25,860
Itahar	0.59	A	37,340	5700	1230	1190	60	5	NA	5500	5	1240	9010
		P	82,290	14,530	19,640	530	20	5	NA	4890	5	570	82,170

A Area (in Hectare), *P* Production (in Tonnes)
Source: ICD Calculated by the researcher on the basis of Gibbs-Martin Index from Statistical Handbook of Uttar Dinajpur, 2000–2001

Appendix B: Block-Wise Index of Crop Diversification (ICD) and Production of Major Crops in Uttar Dinajpur District, 2014–2015

Blocks	ICD	Rice		Wheat	Potato	Masur	Maskalai	Till	Mustard	Gram	Jute	Maize	Sugarcane
Chopra	0.64	A	11,891	3067	684	NA	24	341	916	NA	3806	682	NA
		P	45,946	7788	24,709	NA	17	245	574	NA	50,848	1193	NA
Islampur	0.70	A	15,935	2260	2730	NA	45	338	4177	20	4885	1603	NA
		P	51,669	3921	96,453	NA	33	193	1728	19	68,927	4077	NA
Goalpokhar-I	0.68	A	25,667	5380	1480	24	446	412	6296	NA	5351	4456	2
		P	105,901	9938	32,756	18	322	236	3089	NA	79,409	11,334	214
Goalpokhar-II	0.56	A	21,618	5109	859	NA	NA	NA	3612	NA	3126	NA	NA
		P	100,505	11,216	35,335	NA	NA	NA	2072	NA	58,144	NA	NA
Karandighi	0.57	A	32,709	5999	1564	105	47	24	4004	NA	6530	955	183
		P	116,715	11,580	37,755	81	34	15	3043	NA	101,737	2429	19,584
Raiganj	0.58	A	34,025	3413	1076	240	64	NA	7771	NA	7614	896	240
		P	152,157	6761	24,926	164	46	NA	8228	NA	14,657	2279	25,683
Hemtabad	0.62	A	15,766	4585	1001	57	183	72	3296	32	2606	NA	NA
		P	73,623	14,382	34,143	55	190	44	4121	30	45,735	NA	NA
Kaliaganj	0.62	A	25,317	2970	1442	203	439	NA	4169	NA	9897	682	NA
		P	107,899	7576	35,552	169	267	NA	3276	NA	16,043	1735	NA
Itahar	0.60	A	35,487	5729	857	37	15	NA	13,031	NA	6511	NA	NA
		P	155,330	16,462	36,083	25	7	NA	17,779	NA	115,375	NA	NA

A Area (in Hectare), *P* Production (in Tonnes)

Source: ICD **c**alculated by the researcher on the basis of Gibbs-Martin Index from Statistical Handbook of Uttar Dinajpur, 2014–2015

Appendix C: Block-Wise Index of Crop Diversification (ICD) and Production of Major Crops in Dakshin Dinajpur District, 2000–2001

Blocks	ICD	Rice		Wheat	Potato	Masur	Maskalai	Mustard	Linseed	Gram	Jute
Kushmandi	0.40	A	34,450	2240	990	60	760	4460	60	30	2170
		P	67,990	4850	17,150	20	460	2570	10	10	16,950
Harirampur	0.59	A	9300	1250	590	5	5	2440	NA	5	1940
		P	26,240	3290	8710	5	5	1500	NA	5	23,220
Banshihari	0.42	A	21,700	940	500	5	40	3570	NA	NA	2250
		P	45,780	2290	6850	5	20	2530	NA	NA	18,650
Gangarampur	0.23	A	28,620	1040	160	5	10	1140	5	5	1800
		P	50,790	2700	2240	5	10	870	5	5	23,220
Kumarganj	0.34	A	28,060	1290	470	10	5	2390	10	5	2690
		P	51,570	3720	7610	5	5	1960	5	5	28,880
Tapan	0.33	A	44,320	1410	430	5	10	5810	NA	5	2850
		P	94,460	4000	6280	5	10	5260	NA	5	38,400
Balurghat	0.31	A	36,370	1080	1320	10	100	2210	5	NA	2930
		P	71,330	2770	15,170	5	60	1990	5	NA	28,010
Hili	0.27	A	8260	280	230	5	5	360	5	NA	530
		P	17,230	620	3110	5	5	390	5	NA	5200

A Area (in Hectare), *P* Production (in Tonnes)
Source: ICD calculated by the researcher on the basis of Gibbs-Martin Index from Statistical Handbook of Dakshin Dinajpur, 2000–2001

Appendix D: Block-Wise Index of Crop Diversification (ICD) and Production of Major Crops in Dakshin Dinajpur District, 2014–2015

Blocks	ICD	Rice		Wheat	Potato	Masur	Maskalai	Mustard	Gram	Jute	Maize
Kushmandi	0.54	A	23,738	2398	905	75	NA	5181	NA	3980	42
		P	68,218	9273	30,405	58	NA	5411	NA	57,909	102
Harirampur	0.51	A	16,241	4215	220	NA	NA	2939	NA	632	NA
		P	38,854	15,916	6800	NA	NA	3798	NA	8583	NA
Banshihari	0.35	A	15,885	988	190	NA	NA	1685	NA	1165	NA
		P	37,962	2603	6528	NA	NA	957	NA	16,042	NA
Gangarampur	0.44	A	28,025	1081	1392	187	306	4893	NA	2479	NA
		P	83,095	3286	40,113	160	137	7866	NA	45,093	NA
Kumarganj	0.38	A	23,497	825	550	NA	157	1975	11	3150	130
		P	63,372	2338	19,367	NA	62	1170	15	48,447	317

Blocks	ICD	Rice		Wheat	Potato	Masur	Maskalai	Mustard	Gram	Jute	Maize
Tapan	0.25	A	37,835	542	271	12	NA	4363	NA	956	NA
		P	113,109	1564	8666	6	NA	6174	NA	16,032	NA
Balurghat	0.47	A	28,627	1849	1662	NA	250	2910	NA	4762	NA
		P	83,265	5008	41,598	NA	143	2966	NA	66,192	NA
Hili	0.45	A	7528	394	411	NA	NA	865	NA	1144	NA
		P	22,850	1031	9559	NA	NA	841	NA	14,517	NA

A Area (in Hectare), *P* Production (in Tonnes)
Source: ICD calculated by the researcher on the basis of Gibbs-Martin Index from Statistical Handbook of Dakshin Dinajpur, 2014–2015

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