Changing Cropping Pattern in West Bengal during 1995-96 to 2023-24

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Abstract

The cropping pattern in West Bengal has undergone significant transformations over the last three decades. Based on the Transformed Herfindahl Index, the paper defines the changes in the agricultural landscape where the prevalence of foodgrains is gradually reduced and the dominance of high-value crops, including boro rice, potato, oilseeds (especially mustard), and ginger are on the increase. Although recent years are characterized by the partial re-emergence of the previous patterns of re-cropping, the general shift is a response to changing market conditions, availability of better irrigation infrastructure and encouraging policy interventions by farmers. Nevertheless, the decreasing proportion of wheat, pulses, and fibre crops show that the specific focus on research and policy assistance is necessary to ensure balanced agricultural output.

The results indicate the importance of infrastructural and technological conditions, such as the growth of irrigation, road connectivity, the use of fertilizers, and agricultural credit as the driving forces behind diversification. The paper concludes that all-encompassing policies to facilitate rural infrastructure, irrigation, and financial access, as well as the balanced use of inputs, are critical to realizing sustainable diversification, boosting farm incomes, and building a robust, market-focused agricultural sector.

Keywords: Cropping Pattern, crop diversification, agricultural credit, road density, sustainable diversification, farm incomes, market-focused, agricultural sector

1. Introduction

West Bengal has witnessed a significant transformation in its cropping pattern over the past few decades. Despite a largely constant net cultivated area, the escalating demand for food, fueled by a burgeoning population and rapid urbanization, has exerted considerable pressure on agricultural land. This has inevitably led to intensified cropping practices and a notable shift from traditional food crops towards more commercially viable alternatives. The data clearly illustrates a structural transformation within West Bengal's agriculture. The historical dominance of foodgrains has waned, giving way to an increased cultivation of high-value crops such as oilseeds, potatoes, and ginger

Background: Agriculture continues to be an important part of Indian economy that has a large role to play in GDP and employment. The past forty years have changed the cropping patterns due to many factors including the technologies of Green Revolution, liberalization, government policies, climate change, and market demand. These alterations have been stronger in West Bengal where there are agro-climatic conditions and socio-economic influences that are unique to the state. The issue of crops diversification is paramount in a developing economy such as India in general and the state of West Bengal in particular. The progressive agricultural economy has one of the following fundamental features change in the crop-mix with time in the crop growing sector. India has been experiencing diversification in the area in the sense of a shift of food-grain crops to non- food grain crops particularly since the half of the sixties in the so called crop sector (Pandey and Sharma, 1996; Vyas, 1996). Non-food grain crops such as potatoes, oilseeds and sugarcane are growing in the areas in a fairly high rate during the decade of 1980s (Chand et al., 2008). As India became self-sufficient in the production of food grains by the end of 1970s, policy shifted to diversification with the consequence that the area covered by cereal crops began to fall back after 1983-84. Since the beginning of1990s, the diversification towards horticulture was really boosted.

Similar trend is also reported by the West Bengal Human Development Report of the year 2004 which shows that, since the year 1985, the trend towards crop diversification has increased in the state. It should be noted at this point that in the same trend as was observed in all of India, diversification towards horticultural crops is also occurring in West Bengal since the early 90s. In the period of 1990-91 to 2005-06, about 13 percent of the area under cultivation in West Bengal carried fruits and vegetables followed by Orissa which has a share of 15.37 percent of the same. In Orissa and West Bengal, the ratio of the fruits and vegetables to the total value of agricultural outputs was approximately the same and stood at 46 percent in both states (Chand et al., 2008).

Farm to non-farm occupational diversification has also played a significant role in rural development of West Bengal as the agricultural sector of the state has added up to this development (Chandrasekhar, 1993). Nagaraj and Gowda (1995) found that the stability of groundnut production in Karnataka was attributed to large extent because of decrease in variability of the area. Likewise Chandrashekar and Gowda (1996) established that the groups of small farmers were more efficient in attaining high-yields than the large farmers. The analysis conducted by Singh et al. (1997) also

found out that agricultural growth and diversification depended on such determinants as total cropped area, per-hectare yield, irrigation facilities, market access, and road networks.
Over the last decades, West Bengal has undergone an apparent change in the pattern of cropping. Though there has been a relatively stable net cultivated area, a growing demand of food coupled by the growing population and rapid urbanization has placed a lot of pressure on agricultural land. This has inevitably resulted in increased agricultural activity in the form of cropping, a significant replacement of traditional food crop whose alternative is more commercially viable. The information shows clearly the structural change in the agriculture of West Bengal. Historical dominance of foodgrains has been lost, and substituted by growth of high value crops like oilseeds, potatoes and ginger.

2.Literature Review

The agricultural sector of West Bengal, along with the ongoing occupational diversification from farm to non-farm employment, has significantly contributed to the rural development of the state (Chandrasekhar, 1993). Nagaraj and Gowda (1995) concluded that the stability of groundnut production in Karnataka was largely due to a decline in area variability. Similarly, Chandrashekar and Gowda (1996) found that small farmers' groups achieved higher yield levels with greater efficiency compared to large farmers' groups. The study by Singh et al. (1997) further revealed that total cropped area, per-hectare yield, irrigation facilities, market access, and road networks were the key determinants of agricultural growth and diversification.
Birthal, et al. (2007) focused agricultural diversification in favour of high-value crops and examined the role of small holders in India. They adopted the logic model to assess the role of small farmers in diversification of crops high-value. Changing cropping pattern in theory and practice with special reference to West Bengal. Improvement of infrastructure, expected normal price, expansion of irrigation, market forces and rainfall played a dominant role in the determination of area allocation among the food crops (Kumar, 2003)
Agricultural production in Punjab had been characterised by a sharp decline in diversity in the cropping pattern and the emergence of wheat-rice specialization over the past few decades (Singh and Sidhu, 2004) The agricultural sector of West Bengal is gradually diversifying towards high value commodities, namely fruits and vegetables and flowers. Detailed investigations reveal that most of the diversification has come through individual efforts of the small farms with little support from the government (Bhattacharyya, 2008).
Agricultural diversification in West Bengal has continued since 1970. Although the diversification index rose slowly, land has shifted toward a few major crops. Over the past three decades, summer (boro) paddy, potato, and mustard have expanded, while wheat, other cereals, pulses, jute, and sugarcane have declined. Diversification varies widely across districts, occurring faster in relatively backward areas like Bankura and Midnapur than in advanced districts such as Burdwan and Hooghly (De and Chattopadhyay, **2010**)
The crop diversification in West Bengal has mainly shifted toward boro rice, potatoes, and oilseeds. Small and marginal farmers, supported by modern technology, subsidised fertilisers, improved seeds, and better irrigation (Dasgupta and Bhaumik, **2014**)
Rao, Birthal and Joshi.(**2006**) found that during diversification of agriculture in India towards, fruits, vegetables and livestock products, which carry high value proceeded fast in a number of districts. . Roy (2009), in his thesis "Changing pattern in agriculture: a case study of Koch Bihar district," analyzed the ALU pattern of Koch Bihar district, emphasizing general land use, agricultural inputs, productivity level and agricultural regionalization. He used Weaver's (1954) and Doi's (1954) method for determining crop combination region, Bhatia's (1965) method for crop diversification region and relative strength of different crop for crop ranking region. He also found some remarkable problems in the district's agricultural sector and gave remedies to overcome these problems.

3. Objectives:-

i) To examine the nature of cropping pattern change over time in West Bengal during last three decades.
ii) To prepare Crop-Diversification index of West Bengal last three decades.
iii) To analyze the factors that are responsible for change in cropping pattern in West Bengal during last three decades.

4. Hypotheses:-

i)There is a significant change in the cropping pattern and crop diversification in West Bengal over the years.
ii) Economic, Cultural, Institutional and Social factors explain significantly the change in cropping pattern & Crop diversification in West Bengal over the last three decades.

5. Database and Methodology

The primary objective of this study is to analyze the cropping pattern and crop diversification in both West Bengal and India. To achieve this, we conduct a comparative analysis at both levels using secondary data. This study relies entirely on secondary data, which has been collected, examined, and analyzed to derive meaningful results and conclusions.

The secondary data on cropping patterns has been sourced from various government publications, including the *Statistical Abstract*, *Economic Review*, *District Statistical Handbook*, *National Horticultural Board*, and reports from the Ministry of Agriculture, Government of West Bengal, as well as the *Census of India*.

i) **Correlation and Regression**:- To analyze the relationships between factors, both correlation and regression analyses are employed as needed. A correlation matrix, based on the Pearson correlation coefficient, is constructed to examine the interrelationships among variables. Regression analysis, however, is the most crucial method for accurately estimating the relationship between dependent and independent variables. .

ii) **Crop Diversification Index (CDI)**

a) Herfindahl Index (HI) Herfindahl Index (Pattayanayak, 2006) given below is computed by taking sum of squares of acreage proportion of each crop in the total cropped area. Mathematically, the index is given as below.

$$HI = \sum_{i=1}^{N} P_i^2$$

Where N is the total number of crops and Pi represents area proportion of the i-th crop in total cropped area. The index was first used to measure the regional concentration of industries (Theil, 1967). With the increase in diversification, the Herfindahl Index would decrease. This index takes a value one when there is complete concentration and approaches zero when diversification is „perfect". Thus the Herfindahl Index is bounded by Zero and one.

Transformed Herfindahl Index* Or *Crop Diversification Index

Since the Herfindahl Index is a measure of concentration, it was transformed by subtracting it from one,

$$\text{i.e. (THI= 1-HI or THI= } (1- \sum_{i=1}^{N} P_i^2)$$

. The transformed value of HI will avoid confusion to compare it with other indices. The value of transformed Herfindahl Index (1-HI) increases with the increase in diversification and assumes 0 (zero) value in case of perfect concentration i.e. when only one crop is cultivated.

6. Discussion and Result

6.1 Changing Cropping Pattern in West Bengal 1980-81 to 2023-24

Agricultural landscape in the state of West Bengal has undergone a remarkable change in advancement of a cropping pattern over the recent decades. Although the net cultivated area has remained relatively steady, the growing pressure on agricultural land has been subjected due to the increased demand of food which is caused by increasing population and urbanization. This has had an inescapable impact on increased level of cropping and a significant replacement of traditional food crops with commercially viable food crops. The statistics eloquently depict a structural change in the agriculture of West Bengal. Historically, the domination by foodgrains has been on the decline as new crops of high value are being grown, including oilseeds, potatoes, and ginger among others. This change is an active reaction to new forces in the market, the development of irrigation systems, and other policy interventions that were supposed to diversify the sector. Nonetheless, the reported decrease in the production of wheat, pulses (although there has been a recent rebound), and fibre crops also indicates particular spheres that need more investigation, a specific focus, and effective suggestions to have a more versatile and sustainable agricultural development path. A more careful look at rice production, the main product of the land, will give one a more subtle picture. The total proportion of rice grown (According to the Aus, Aman, and Boro varieties) has declined significantly from 69.3 percent in 1980-81 to 51.25 percent in 2023-24. Aus rice, which was once a highly important crop requiring monsoon rains, has seen a steep fall in share, diving down to 1.12% in 2023-24, compared to 11.16% in 1980-81. This deterioration can be explained by the fact that it is predetermined by its susceptibility to monsoon fluctuations and the relatively low yields. On the same note, Aman rice, although remaining the leading type of rice has also declined in its market share from 55.53 percent in 1980-81 to 33.68 percent in 2023-24 (Table 1).

On the other hand, high-yield winter crop, Boro rice, which is a highly irrigation-intensive crop, has experienced massive growth in its production, with the percentage rising to 16.45 percent in 2023-24 as compared to 2.59 percent in 1980-81. This is a direct result of better irrigation facilities, government efforts in encouraging the practice of Boro farming and the potential of better productivity. The agricultural practices are modified by the movement towards Boro rice, which can be regarded as the adaptation of the agricultural practices to the available resources and technological achievements. Other crop categories are no exception as important changes are observed. Agriculture It has been reduced to 5.05 percent in 1980-81 and only 1.92 percent in 2023-24. Such a fall may be explained by a higher profitability of other crops, the inappropriateness of some of the regions of West Bengal to the optimal production of wheat, and possibly a shift in preferences of consumers. Moreover, other minor cereals such as minor

millets have practically been eliminated as part of the crop system, reducing by a significant percentage of 1.94 in 1980-81 to even smaller 0.11 in 2023-24. The loss of dietary diversity and under-utilization of these nutritious crops are issues of concern because of this trend.

There was a large decrease from 9.35% in 1980-81 to 2.51 in 2009-10 in the area under total pulses. Nevertheless, positively, this trend has been slightly bouncing back, only to hit 4.43% in 2023-24(Table 1). This has been due to the rising market demand of pulses as an important source of protein and the concerted government action towards encouraging its production by various schemes and incentives.

Unlike the reduction of some of the traditional crops, there has been an incredible rise in the oil seed cultivation, especially rapeseed and mustard, which grew from 1.5 percent in 1980-81 to 7.25 percent in 2023-24. This has probably been spurred by the increasing domestic demand for edible oils, good price incentives and probably the introduction of varieties that yield more. In the same way, the cultivation of potatoes has been exhibiting a consistent upward trend, as it was 0.93% in 1980-81 and increased to 4.46% in 2023-24. It has been enabled by advancements in cold storage facilities, which have made the produce better preserved and marketed and also due to the increasing consumer market. Ginger, a spice with high value, has also recorded a steep inclination, with the share increasing by 0.02 percent in 1980-81 to 0.7 percent in 2023-24 (Table 1), which indicates that it has a high potential in the market and is profitable.

The tea plantation, which is a major economy of West Bengal, has not been very volatile, with fluctuations ranging between 1.2 percent and 1.5 percent across the years. This stability highlights the stable status of the region and the good agro-climatic factors that support the production of tea. Nevertheless, jute, which was the leading cash crop in Bengal, has continued to lose its position in 2023-24 to 5.68 in 1980-81. The decline can be linked to the availability and affordability of substitutes that are made of synthetic fibres, which have affected the demand for natural jute fibres. Moreover, other fibre crops such as mesta and cotton have nearly disappeared in the cropping system probably because of the same competitiveness factor and changing industrial demand.

Table 1 Percentage Share of Gross Cropped Area under Different Crops in West Bengal, 1980-81 to 2023-24

Crops	1980-81	1990-91	2000-01	2009-10	2023-24
Aus	11.16	8.02	7.06	3.52	1.12
Aman	55.53	55.11	49.71	42.72	33.68
Boro	2.59	4.52	10.35	14.39	16.45
Rice	69.3	67.58	67.11	60.62	51.25
Wheat	5.05	3.69	3.12	4.41	1.92
Other cereals	1.94	1.53	1.15	0.15	0.11
Total cereals	76.28	72.78	71.37	65.18	54.53
Gram	2.17	1.27	0.3	0.48	0.34
Arhar	0.35	0.29	0.07	0.03	0.01
Other pulses	6.83	5.29	3.26	2.00	3.42
Total pulses	9.35	6.85	3.62	2.51	4.43
Food grain	85.61	79.63	74.98	67.7	61.56
Rape mustard	1.5	1.71	4.35	4.68	7.25
Linseed	0.62	0.89	0.1	0.09	0.21
Til	0.15	1.41	1.15	1.16	1.54
Total oilseeds	2.36	4.13	5.92	7.09	10.04
Jute	5.68	7.98	5.78	6.42	4.81
Mesta	0.92	0.57	0.11	0.11	0.08
Cotton	0.02	0.003	0.001	0.01	0.003
Total fibre	6.67	8.57	5.9	6.56	4.90
Tea	1.24	1.23	1.17	1.14	1.47
Sugarcane	0.54	0.19	0.14	0.17	0.13
Potato	0.93	1.52	2.25	3.19	4.46
Chillies	0.12	0.32	0.56	0.63	0.69
Ginger	0.02	0.04	0.06	0.1	0.7

Gross cropped area	100	100	100	100	100

Sources: Government of West Bengal, *Statistical Abstract, Economic Review*, various issues

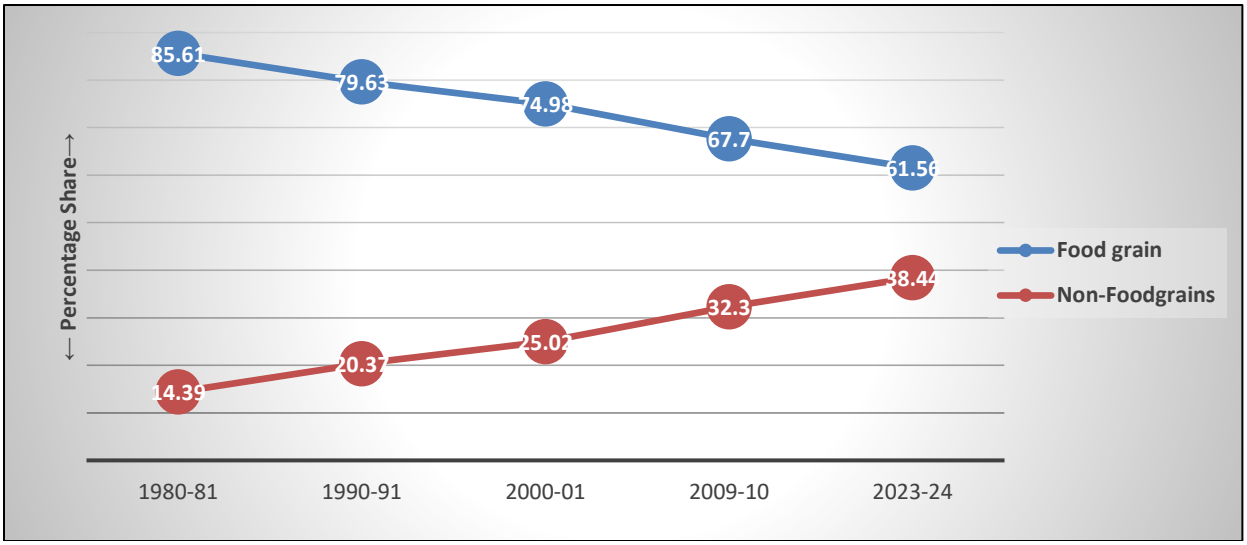
Figure 1 presents the long-term trends in the percent share of cultivated area of foodgrains and non-foodgrains in West Bengal between 1980- 81 and 2023-24. This amount is a clear indication that there is a structural change in the cropping pattern of the state with gradual decreasing share of foodgrains and an increasing share of non-foodgrain crops.

Foodgrains have taken a dominant space of the total cropped area in the early 1980s, meaning that subsistence-oriented agriculture took precedence and the policy focus was on food security, especially on rice farming. In the long run, though, the percentage of area covered by foodgrains is in a constant decreasing trend. This downward trend is further intensified after the 1990s and with the further economic reforms, agricultural policies and growing integration in the market.

In comparison, the area share under the non-foodgrains portrays a steady upward trend during the study period. This growth is an indication of more diversification to commercial and high-value crops like oilseeds, fibres, vegetables, fruits, spices and other cash crops. The increasing non-foodgrains preference among the farmers can be explained by the fact that the engagement is more profitable, prices are high, the crop cycles are short, and the demand is increasing in urban and export markets.

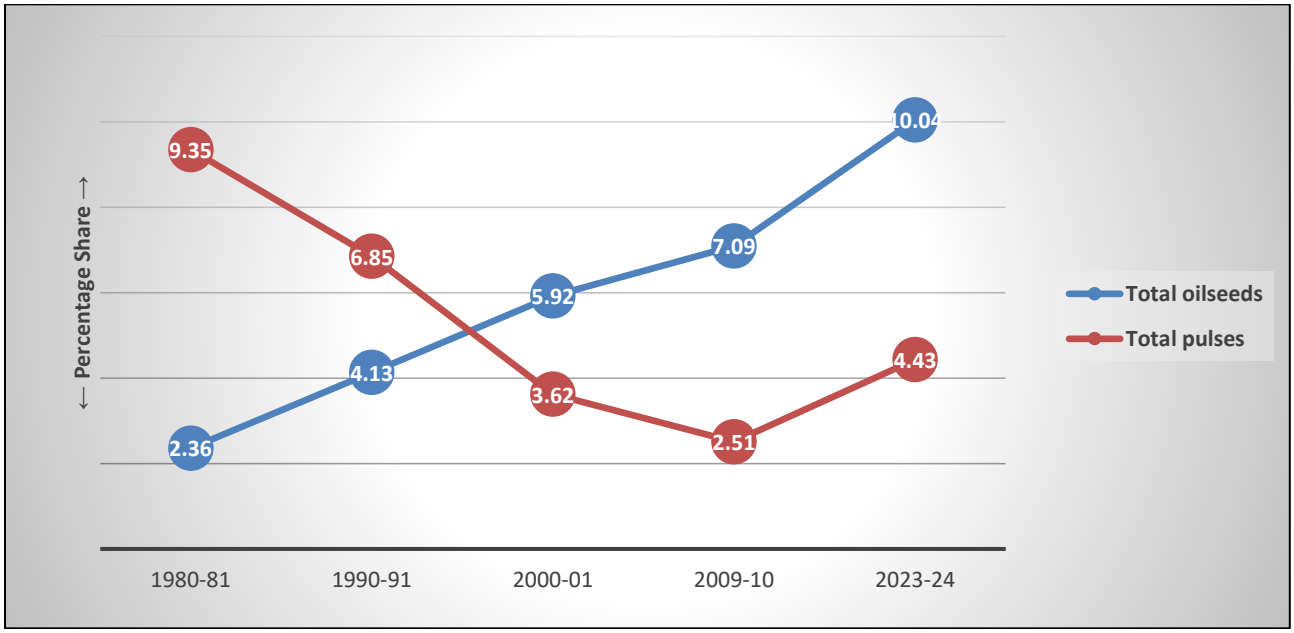
The negative correlation between food and non-food grains as seen in the figure (Figure1) signifies the redistribution of land in traditional cereal-based farming to the new diversified system of cropping. This shift has been enabled by improvements in irrigation, modern inputs, technological advancements and better market accessibility. Also, increasing population pressure on the land and the necessity to increase the income of the farms have promoted the shift of the farmers to more profitable crops per unit of land.

Figure 1 Trends of the Percentage Share of area under foodgrains and non-foodgrains in West Bengal, 1980-81 to 2023-24



In Figure 2, it is seen that the percentage share of cultivated area under oilseeds and pulses in West Bengal has differing trends between 1980 81 and 2023 24, and hence the figures indicate an improvement in this area in the recent past. Pulses had the highest proportion of the cropped area with 9.35 per cent in 198081 and oilseeds had 2.36 per cent. This trend shows the historic significance of pulses in local diets and the use of pulses in low-input, rain-fed agriculture. But as time passes the area under pulses tends to decrease drastically and continuously as the figure goes down to 6.85 per cent in 199091, 3.62 per cent in 200001 and a low of 2.51 per cent in 200910. Despite a slight increase up to 4.43 per cent by the year 202324, the general pattern shows that pulse cultivation contracts significantly. Nevertheless, the percentage of area covered by pulses records a slow though consistent decrease over the duration of the study (Figure 2). On the contrary, oilseeds record a consistent steady growth during the study period. They had a share of 2.36 per cent in 198091, then 5.92 percent in 200001 and 10.04 per cent in 202324. This positive trend indicates that the farmers are more inclined towards oilseeds because of the improved price incentives, high demand for edible oils in the market, and the governmental policies aimed at decreasing the ratio of imports. (Figure 2)

Figure 2 Trends of the Percentage Share of area under Oilseeds and Pulses in West Bengal, 1980-81 to 2023-24



6.2 Crop Diversification of West Bengal

Crop diversification: This is a very important indicator of development in the agricultural sector as it indicates changes in the past in the cropping pattern. The trend in diversification offers information regarding the flexibility of agriculture to economic, climatic and policy induced changes. This paper compares the character of crop diversification in West Bengal in comparison to the entire India through building a crop diversification index and a measurement of the area of non-foodgrains over the varying periods of time. Birthal, et al. (2007) investigated the role of smallholders in India, agricultural diversification towards high-value crops and agricultural diversification. West Bengal is slowly shifting to high value products, that is, fruits and vegetables as well as flowers, Bhattacharyya (2008).

The crop diversification index of West Bengal showed a stable growth over the years. It increased by 0.71 in 1995-96 up to 0.80 in 2010-11, then up to 0.83 in 2021-22. Conversely, the national indicators of India were comparatively greater, and they started with 0.80 in 1995-96 and increased to 0.82 in 2010-11 and to 0.84 in 2021-22.

The statistics show that the index of diversification was growing in West Bengal, but the index of West Bengal was steadily below the national value, which proves a comparatively slow rate of diversification in the state (Table 2 and Figure 3). Agricultural diversification in South Asia in favour of high-value commodities happened due to increasing per capita income, alteration in food consumption pattern, accelerating urbanization and infrastructural development, such as roads, the pace of agricultural diversification was very slow in most South Asian countries, Joshi et al. (2003) This is a similar trend in the percentage of non-foodgrain to gross cropped area. This share in West Bengal rose to 34.50 in 2009-10 and to 37.56 in 2021-22, on top of this, 26.71 in 1995-96. (Table 2 and Figure 4). It is noteworthy that as of 2021-22, West Bengal had a minor percentage of area under non-foodgrain crops compared to the national average, suggesting that the state has been more prone to diversification in recent years.

In order to gain more insight into such trends, the statistical data were evaluated: The mean index of crop diversification in India (0.8239) was still higher than in West Bengal (0.7750), which supported the observation of diversification being greater on the national level. The CV of West Bengal (0.0012) was significantly more than that of India, which means that there were more variations in diversification patterns in the state. A statistical comparison of the percentage of the area under non-foodgrains brought to light: The mean value of the percentage of non-foodgrain area in West Bengal is 33.45%, which was more than the national average. The standard deviation of West Bengal (3.09) was higher than that of India, indicating that there must have been more variation in the cropping patterns in the state. West Bengal's CV was bigger than India's, which once again confirms higher fluctuations in the agricultural diversification of the state

Table 2 Crop Diversification Index and Percentage of Area under Non-foodgrains in West Bengal, 1990-91 to 2013-14

Years	Crop diversification index (WB)	% of non-foodgrains area (WB)
1995-96	0.7176	26.71
1996-97	0.7231	28.62

1997-98	0.7255	28.97
1998-99	0.7315	29.76
1999-00	0.7311	28.88
2000-01	0.7586	32.06
2001-02	0.7418	30.38
2002-03	0.7457	31.24
2003-04	0.7489	31.57
2004-05	0.7513	31.78
2005-06	0.7532	32.18
2006-07	0.7682	33.95
2007-08	0.7914	34.67
2008-09	0.7766	33.31
2009-10	0.778	34.5
2010-11	0.8038	36.95
2011-12	0.7702	35.21
2012-13	0.7768	35.28
2013-14	0.7874	35.15
2014-15	0.8024	35.54
2015-16	0.8035	35.98
2016-17	0.818	36.21
2017-18	0.8214	36.34
2018-19	0.8256	36.05
2029-20	0.8142	36.76
2020-21	0.8287	37.36
2021-22	0.8315	37.56
Mean	**0.7750**	**33.45**
SD	**0.035**	**3.09**
CV	**0.0012**	**0.101**

Sources: Statistical Abstract & Economic Review of West Bengal, Statistical Appendix India

Figure 3 Trends of the Crop Diversification Index in West Bengal & India, 1995-96 to 2021-22

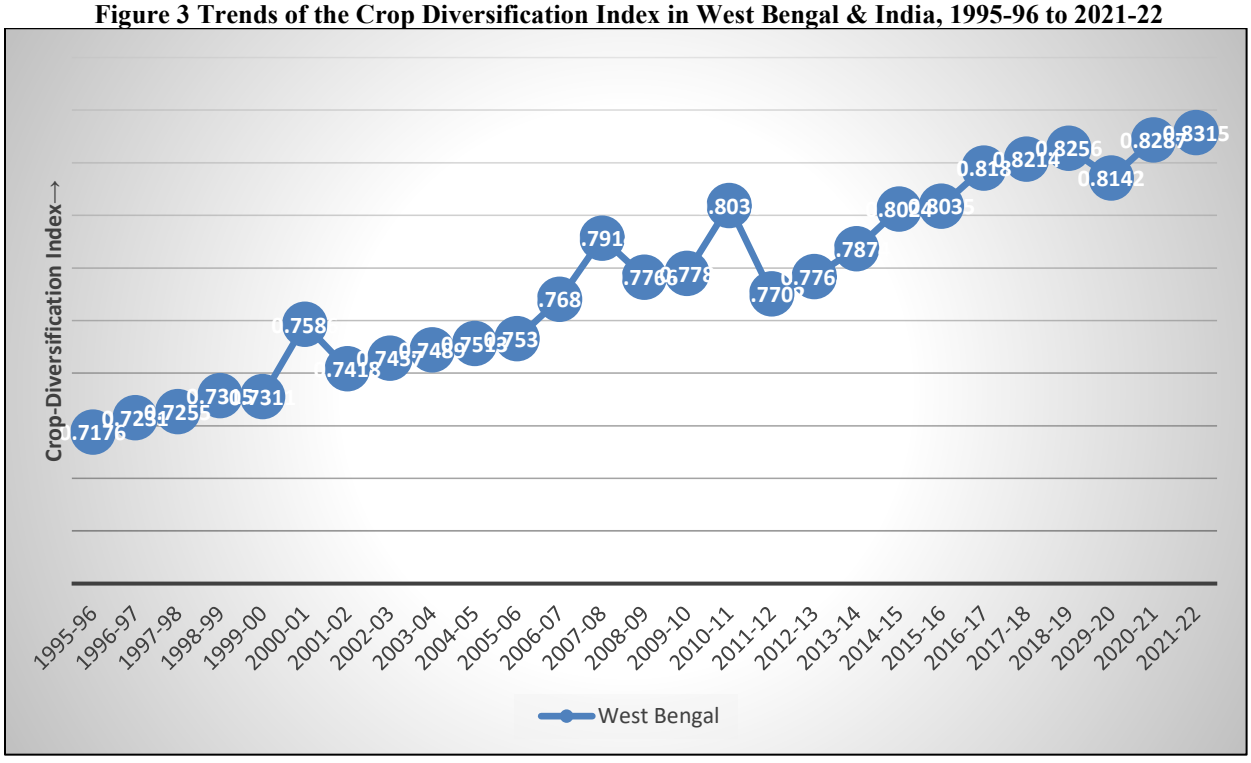
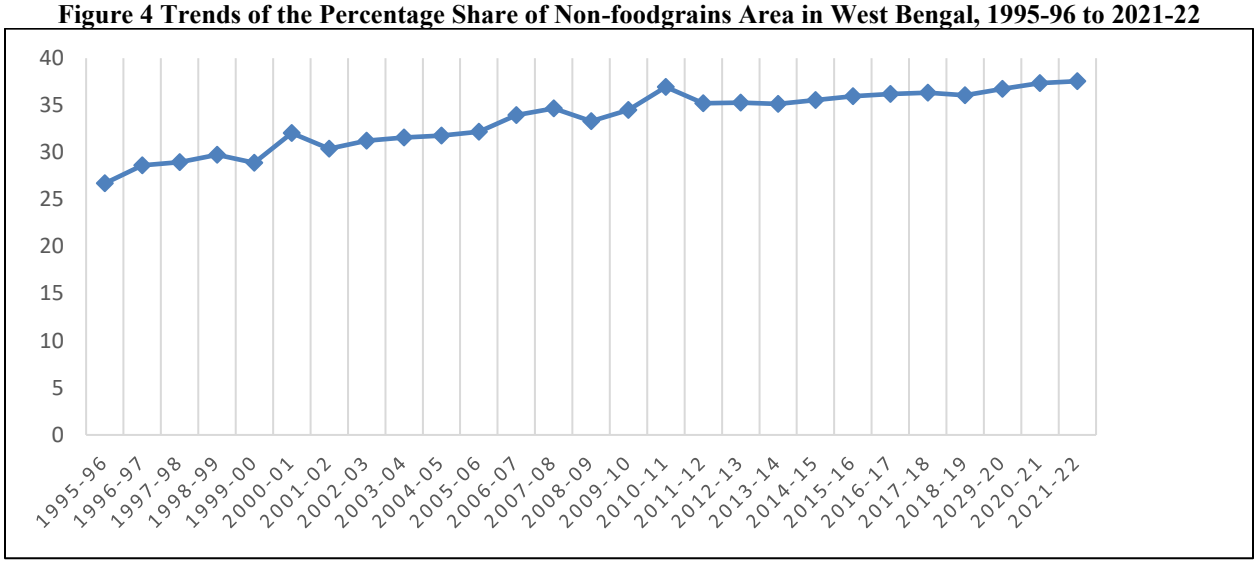


Figure 4 Trends of the Percentage Share of Non-foodgrains Area in West Bengal, 1995-96 to 2021-22



The Crop Diversification Index (DI) in West Bengal has grown at a CAGR of 0.55%**,** which is significantly higher than India's overall growth rate**.** This suggests that farmers in West Bengal have been shifting towards a more diverse cropping pattern at a faster rate than the national average. The percentage of land under non-foodgrains in West Bengal has increased at a CAGR of 1.27% (Table 3). This indicates a substantial shift away from traditional foodgrain production towards cash crops, horticulture, and other high-value agricultural products.

Table 3 Compound Annual Growth Rate (CAGR) of DI and Percentage of Non-foodgrains area in West Bengal, 1995-96 to 2021-22

State/Country	Variable	CAGR	Level of Significant
West Bengal	**Crop diversification index**	0.55	1 per cent
	% of non-foodgrains area	1.27	1 per cent

6.3 Factors Influencing Crop Diversification in West Bengal,1995-96 to 2023-24

It is observed that the rudimentary infrastructure is needed to develop agriculture in West Bengal both in space and time. One of the best areas of improvement towards better agricultural productivity is irrigation. In an effort to analyse the forces that determine the diversification towards high valued crops in the state, there are various explanatory variables that are investigated. The diverse canals built over the years can provide large-scale irrigation to support the farmers diversifying their production to more rewarding crops like potato, oilseeds and can also change to the cultivation of summer paddy, which is entirely irrigation intensive. The Simpson index and concentration of non-food crops, Jha, et al. (2009)

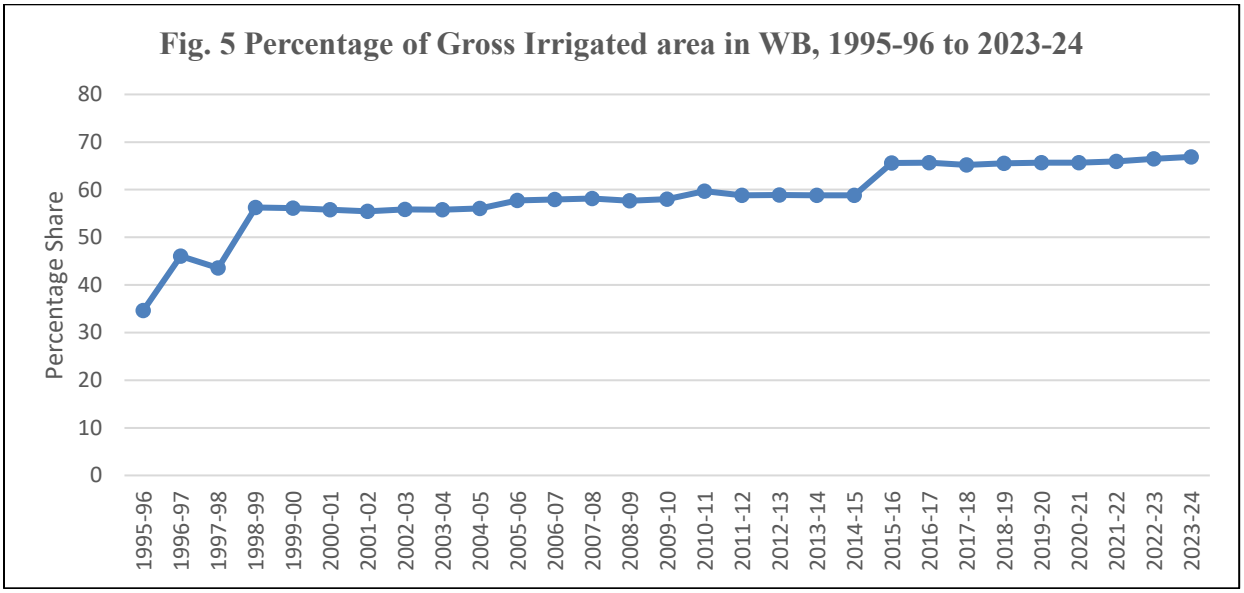
Infrastructure and Crop Diversification.

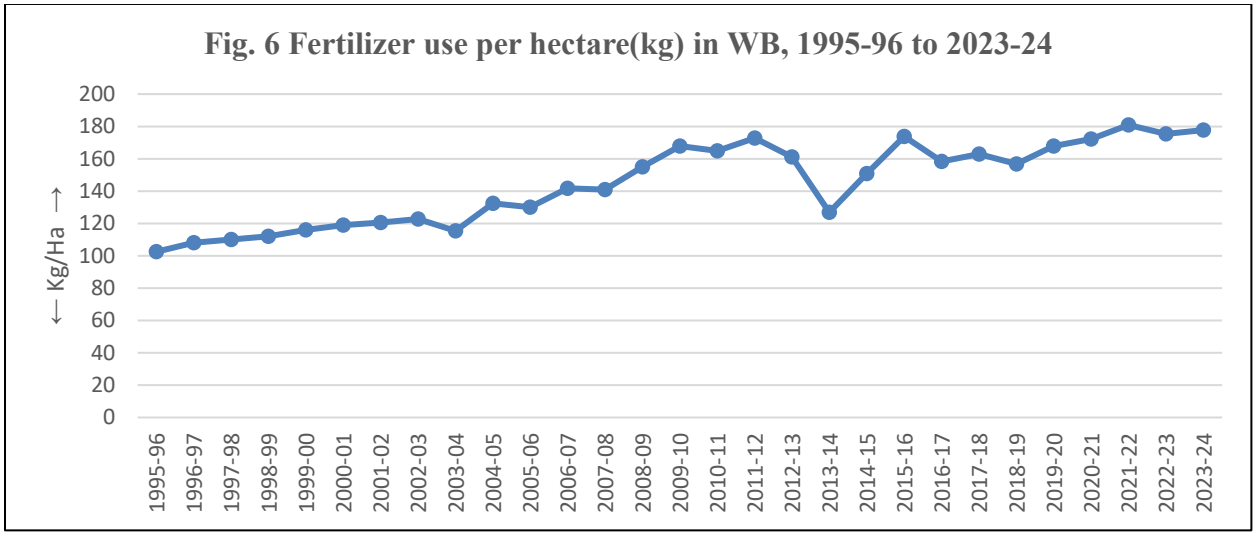
Basic infrastructure provision over space and time has been a key ingredient in the development of agriculture in West Bengal. Irrigation is one of the other infrastructural aspects that are very important in the process of increasing agricultural productivity. Availability of large-scale irrigation which mostly depends on a comprehensive system of canals that have been built over the years have been instrumental in changing the agricultural face of the country. This has facilitated farmers to diversify their production to high-value and better remuneration crops, including potatoes and oilseeds and also shift to summer paddy production which is totally irrigation dependent. In order to figure out the major drivers that can affect the crop diversification in West Bengal, some explanatory variables have been analysed. These are the infrastructural variables like percentage of irrigated area (PIA), road density (RD) and agricultural credit (AC), and the technological variables like use of fertilizers in each hectare (FUPH). All these factors have contributed much in the shape of the cropping patterns in the state.

Irrigation and Diversification of Crops.

The main cause of crop diversification in West Bengal is irrigation. The use of irrigation facilities has helped in the transformation of traditional farming of cereals to more profitable crops (Fig.5). The access to water in the form of canals and other sources of irrigation has enabled farmers to be able to plant high-value crops, hence enhancing agricultural earnings and the overall output of the farm.

Role of Chemical Fertilizers in Modifying Cropping Pattern: Chemical fertilizers have been of importance in changing the agricultural productivity and diversification over the years. The application of fertilizer per hectare has been rising at an alarming rate over 1995-96 to 2023-24 by 177.7 kg per hectare as compared to 102.5 kg per hectare (Fig. 6). This tremendous increase has increased the soil fertility and the yield of crops and farmers can now move towards the nutrient-intensive and high-value crop production. Fertilizers contain nutrients such as nitrogen (N), phosphorus (P) and potassium (K), which are important in accelerating the growth of plants and making them resistant to pests and diseases. Consequently, farmers have had the opportunity of maximising land utilisation, diversifying crops and increasing the supply of food, fibre and biofuels to satisfy increasing food production, consumption and industrial needs. Also, the use of fertilizers has helped the world to have enough food, as it can be assured of a constant and higher agricultural production.

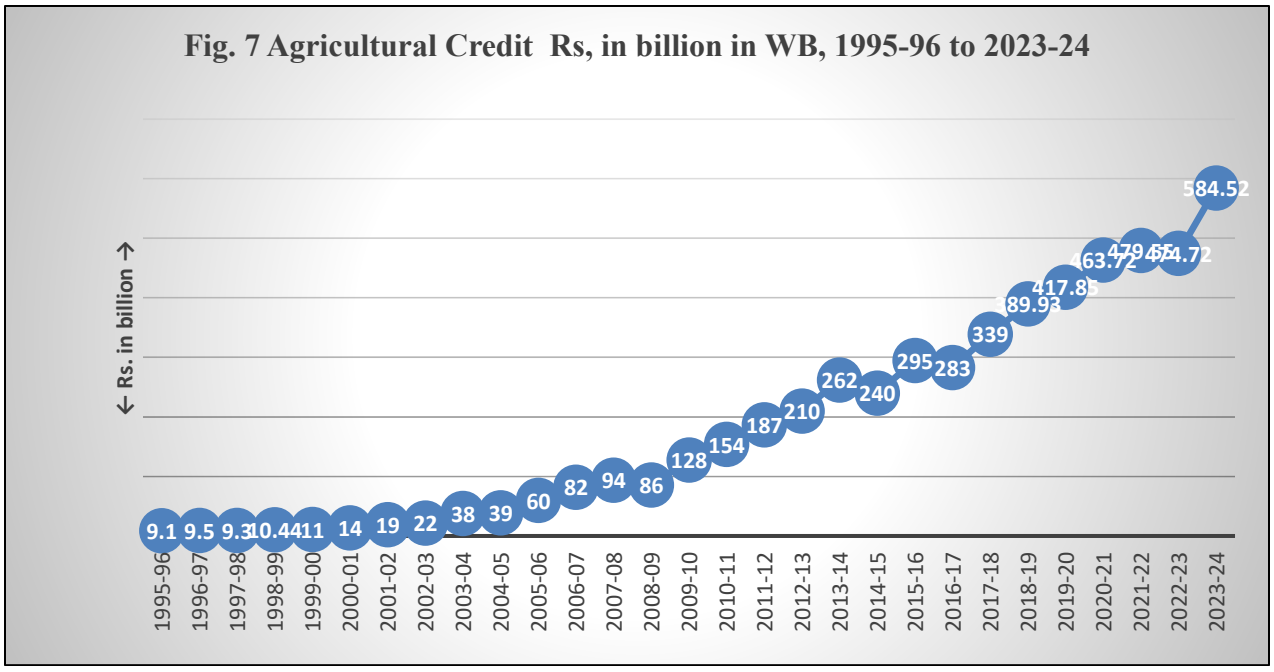




Farming and Density of Roads.: Another important aspect affecting the cropping pattern in West Bengal is the density of the roads (RD). The density of roads, as defined as the summation of the length of all the road networks in the geographical area, is very crucial in enhancing accessibility to the market, minimizing transportation expenses, and easing the transit of agricultural inputs and outputs. The relationship between the intensity of roads and crop diversification is also apparent because the higher the connectivity, the more likely that farmers would grow perishable and high-value crops that necessitate effective supply chain operations. The West Bengal road density has experienced impressive growth over the years, showing 0.57 km/ sq km in 1995-96 and 3.74 km/ sq km in 2023- 24(Table-4 & Fig. 8) and this growth has led to a tremendous growth in the agricultural sector as it has enhanced the accessibility of markets, delivery of agricultural inputs promptly and commercialization of farming.

Crop Diversification and Agricultural Credit: Accessibility of agricultural credit has been instrumental in the diversification of crop in West Bengal. Availability of credit enables the farmers as it gives them the funds to invest in modern farming, high yielding crops, mechanization and better irrigation methods. The institutional credit, more so, minimizes financial constraints, and farmers can use innovative and diversified cropping pattern that result to increased productivity and profitability. There is a positive relationship that is very strong between the diversification index and the agricultural credit in West Bengal. With good credit available to the farmers, they feel freer to take calculated risks and stop heavily relying on the traditional staple crops and instead venture into alternative options, which are more profitable and resistant. This does not only enhances farm incomes but it also enhances the agricultural sector in general by reducing the risk posed by monocropping and climate change.

The growth of agricultural credit in West Bengal has been spectacular over the years. Agricultural credit disbursed in total has become substantially higher, with the amounts spent on it ranging between 9.1 billion in 1995-96 up to 584.52 billion in 2023-24(Fig. 7). This tremendous growth stands as an indication of the growing institutional backing of farmers, and as one of the factors that are shaping the agrarian environment through credit accessibility. Farmers can now afford to combine high-value crops with improved financial support.



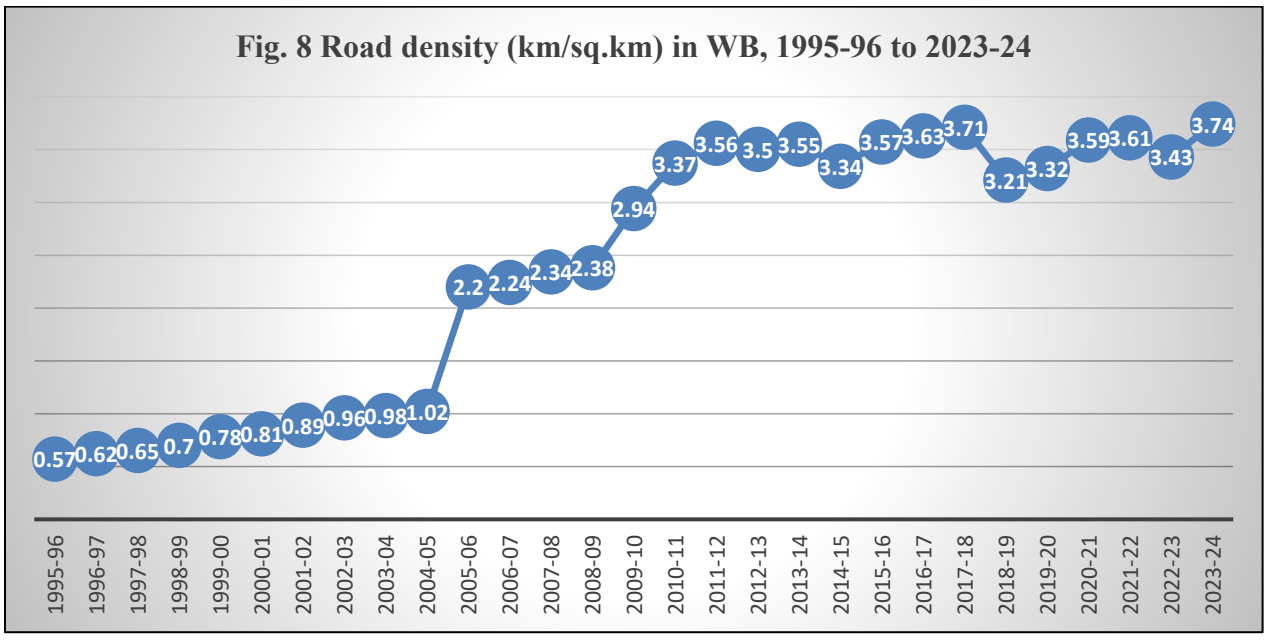


Table 4 Diversification Index in Relation to Percentage of Irrigated Area, Road Density and Fertilizer Use per Hectare Agricultural Credit in West Bengal, 1995-96 to 2023-24

Year	Diversification Index	Percentage of Gross Irrigated area	Fertilizer use per hectare(kg)	Road density (km/sq.km)	Credit to agriculture (Commercial Bank) Rs, in billion
1995-96	0.7176	34.60	102.5	0.57	9.1
1996-97	0.7231	46.03	108	0.62	9.5
1997-98	0.7255	43.54	110	0.65	9.3
1998-99	0.7315	56.26	112	0.70	10.44
1999-00	0.7311	56.13	116	0.78	11
2000-01	0.7586	55.82	119.0	0.81	14
2001-02	0.7418	55.48	120.5	0.89	19
2002-03	0.7457	55.85	122.8	0.96	22
2003-04	0.7489	55.76	115.5	0.98	38
2004-05	0.7513	56.07	132.5	1.02	39
2005-06	0.7532	57.72	130.0	2.20	60
2006-07	0.7682	57.93	141.7	2.24	82
2007-08	0.7914	58.14	141.0	2.34	94
2008-09	0.7766	57.67	155.0	2.38	86
2009-10	0.7780	57.98	167.8	2.94	128
2010-11	0.8038	59.66	164.9	3.37	154
2011-12	0.8032	58.84	172.9	3.56	187
2012-13	0.8076	58.87	161.2	3.50	210
2013-14	0.8098	58.85	126.9	3.55	262
2014-15	0.8024	58.82	150.9	3.34	240
2015-16	0.8035	65.63	173.8	3.57	295
2016-17	0.8180	65.66	158.3	3.63	283
2017-18	0.8214	65.18	162.9	3.71	339
2018-19	0.8256	65.52	156.8	3.21	389.93
2019-20	0.8142	65.65	167.9	3.32	417.85
2020-21	0.8287	65.68	172.2	3.59	463.72
2021-22	0.8315	65.92	180.9	3.61	479.55
2022-23	0.8134	66.46	175.4	3.43	474.72
2023-24	0.8298	66.89	177.7	3.74	584.52

Sources: Government of West Bengal, *Statistical Abstract, Economic Review*, various issues, RBI

Table 5 shows the outcomes of a multiple regression analysis into the relationship between the Diversification Index (DI) and the chosen infrastructural and economic variables in West Bengal between the years 1995-96 and 2023-24. The variables that were used in the model as explanatory variables are the percentage of gross irrigated area (PGIA), fertilizer applied per hectare (FUH), road density (RD) and agricultural credit (AC).

The estimated model shows the high level of explanatory power where R^2 equals 0.89 and adjusted R^2 equals 0.88, which means that the chosen variables explain almost 89 per cent of the change in the Diversification Index. The key point is that the overall regression is significant based on the large F-value of 130.23, which also indicates that the explanatory variables are jointly significant and the model is also robust.

The intercept value is positive, and it has a high value at the 1 per cent level indicating that the state has a high level of crop diversification even when the variations of the factors used in explaining the phenomena are absent. This indicates the traditionally diversified farming aspect of West Bengal, which is determined by the agro-climatic aspects and the ancient practices of agriculture.

The percent gross irrigated area (PGIA) is one of the explanatory variables that show a positive and statistically significant coefficient in the 5 per cent level. This is to show that increase in the area under irrigation positively affects crop diversification as it lessens production risk and allows farmers to abandon the traditional irrigation-free crop production practices to the more diverse and more lucrative high value crop production systems. Enhanced irrigation allows the practice of multiple cropping and cultivation of crops that are water intensive and thus increase the level of diversification.

Fertilizer use per hectare (FUH) in contrast is positively but statistically insignificant, the coefficient of which has a t-value of very low significance and a p-value of very high significance. This implies that the differences in the fertilizers utilization are not a significant independent effect on the diversification of crops in West Bengal. The potential reason is that the state use of fertilizer could be specialized on a small number of crops, especially rice, thus supporting crop intensification as opposed to crop diversification. This observation suggests that input intensity can not be effective to encourage diversification due to absence of complementary variables like market access and irrigation without such variables.

The road density (RD) turns out to be one of the most powerful predictors of the crop diversification having a positive coefficient that is statistically significant at the level of 1 per cent. The level and importance of this coefficient support the fact that physical infrastructure is crucial in diversification. Enhanced road network decreases the cost of transporting goods, increases their access to input and output markets, and pushes farmers to use their land to produce commercial and high-valuable goods, which fosters diversification.

On the same note, agricultural credit (AC) affects the diversification positively and with a significant level of 1 per cent. With credit, farmers can invest in high-quality farm inputs, irrigation, mechanization and more profitable but risky crops. This observation has been significant in highlighting the role of financial inclusion and credit delivery systems in the development of diversified agricultural systems.

Table 5 Percentage of Irrigated Area, Fertilizer Use Per Hectare, Agricultural Credit and Road Density in Relation to Diversification Index in West Bengal, 1995-96 to 2023-24

Variables	***Coefficients***	***Standard Error***	***t-Value***	***P-Value***
Intercept	0.6744	0.0217	31.02	0.000***
Percentage of Gross Irrigated area(PGIA)	0.001	0.0004	2.45	0.022**
Fertilizer use per hectare(kg/Ha)(FUH)	0.0001	0.0002	0.07	0.951
Road density (km/sq.km)(RD)	0.0184	0.0031	5.61	0.000***
Agricultural Credit (Rs, in billion)(AC)	0.0002	0.0001	2.87	0.008***
Adj R-squared	0.88			
R Square	0.89			
Significant F-Value	130.23	*Number of obs =*	*29*	

, *** Indicates coefficient significant at 1 percent level ,

** Indicate coefficient significant at 5 percent level, *Indicates coefficient significant at10 percent level.

6.4 Determinants of Percentage of Area under Non-Foodgrains in West Bengal (1995–96 to 2023–24)

The findings of a multiple regression analysis performed to determine the relationship between the percentage of net sown area under non-foodgrains (NFA) and the selected infrastructural and economic variables in West Bengal in the period 1995-96 to 2023-24 are presented in table 6. The model has the percentage of gross irrigated area (PGIA), fertilizer application per hectare (FUPH), road density (RD), and agricultural credit (AC) as the explanatory variables. The general performance of the model is quite good. The value of $R^2 = 0.60$ means that the variation of the area under non-foodgrains can be accounted by the variables included and the value of adjusted $R^2 = 0.53$ implies that it moderately but significantly explains the variation after the adjustment of degrees of freedom. The entire regression equation is significant at the 5 per cent level which is indicated by an F-value of 8.89, which proves that the set of explanatory variables is jointly significant.

The intercept value is positive and statistically significant at 5 per cent level which means that even without changes in the explanatory variables, a good percentage of West Bengal agricultural land is under non-foodgrain crops. This indicates structural existence of commercial and non- food crops within the state pattern of cropping during the period of study.

The percentage of gross irrigated area (PGIA) is among the explanatory variables whose coefficient is positive and significant to a level of 10 per cent. This implies that an increase in the area under irrigation system will motivate farmers to use more land in commercial production of non-foodgrain crops which tend to be more water-demanding and commercially based. With enhanced irrigation, production risk is reduced and can adopt a land-use pattern that is not focused on subsistence foodgrain production.

Among others, the coefficient of fertilizer use per hectare (FUPH) is negative, and statistically not significant, which means that an increase of fertilizer intensity does not always lead to an increase of non-foodgrain area. This could be

explained by the fact that the focal point of fertilizer application has been on foodgrain crops, especially rice, in West Bengal which has enhanced foodgrain domination as opposed to land-use diversification.

One of the determinants in non-foodgrain area is road density (RD), the coefficient of which is positive and significant at the level of 5 per cent. This observation emphasizes the relevance of transport infrastructure in diversifying land-use. Better connectivity of the place reduces both the marketing and transportation expenses, improves access to the urban and export markets, and allows commercial and non-food crop production, raising the proportion of land to non-foodgrains.

Alternatively, agricultural credit (AC) has a positive yet statistically irrelevant correlation with non-foodgrain area. This would imply that, as much as credit supply encourages the general agricultural development, it can be utilized to boost the modern production of foodgrains other than increasing the area covered by non-foodgrain crops. Institutional credit can, therefore, have a minor direct effect in affecting land-use change in West Bengal.

In general, the findings provided in Table 6 suggest infrastructure development, especially road connectivity and irrigation growth as the most important predictors in explaining variation in the field of non-foodgrains in West Bengal. Conversely, agricultural credit and fertilizer use seem to have relatively minor direct impacts on the diversification of land-use. The results indicate that policies directed at encouraging non-foodgrain farming ought to focus on enhancement of rural facilities and irrigation systems and special support systems that persuade farmers to shift land to commercially viable non-food crops.

Table 6 Percentage of Irrigated Area, Fertilizer Use Per Hectare, Agricultural Credit and Road Density in Relation to Percentage of non-foodgrains area(NFA) in West Bengal, 1995-96 to 2023-24

Variables	***Coefficients***	***Standard Error***	***t-Value***	***P-Value***
Intercept	19.626	8.707	2.25	0.034**
Percentage of Gross Irrigated area(PGIA)	0.262	0.152	1.75	0.092*
Fertilizer use per hectare(kg/Ha)(FUPH)	-0.045	0.060	-0.74	0.464
Road density (km/sq.km)(RD)	2.426	1.196	2.09	0.050**
Agricultural Credit (Rs, in billion)(AC)	0.002	0.007	0.17	0.868
Adj R-squared	0.53			
R Square	0.60			
Significant F-Value	8.89	Number of obs = 29		

, *** Indicates coefficient significant at 1 percent level ,

** Indicate coefficient significant at 5 percent level, *Indicates coefficient significant at10 percent level.

7. Conclusion

Overall, the paper analyses the shifts in cropping patterns in the agricultural landscape of West Bengal. The paper examines crop diversification using the Transformed Herfindahl Index to identify changes over time. In the last four decades, boro rice, potato, and oilseeds (especially mustard) have emerged among the important crops that have emerged among the farmers. Nevertheless, the past few years have seen the recurrence of some of the previous cropping patterns. This data demonstrates a structural change in the agriculture sector of West Bengal, whereby foodgrain supremacy has decreased and high-value crops such as oilseeds, potatoes, and ginger have been on the rise. The transition to Boro rice, an addition of oilseeds and the introduction of horticulture suggest adaptation to dynamic market conditions, the enhancement of irrigation and the intervention of policies. Nonetheless, the decline in wheat, pulses, and fibre crops indicates a need for further research and support in these areas to ensure balanced agricultural production.

As observed in the comparative analysis, although both West Bengal and India have recorded a rising rate of crop diversification over the years, West Bengal has lagged behind the national average in these developments, and this has been more volatile. Infrastructural and technological changes have played a big role in transforming the agricultural sector of West Bengal. The growth of irrigation, the rise in the application of chemical fertilizers, the rise in road connectivity, and the availability of agricultural credit have all added to the higher crop diversification. These aspects have helped the farmers to turn to high-value crops, which have increased the incomes of rural people and the economy in general. In the future, further investment in rural infrastructure, sustainable development of agriculture, and the financial assistance system will be essential in guaranteeing the sustainability and stability of the agrarian sector in the state.

Altogether, the findings introduced and imply that infrastructure development (particularly roads), institutional credit, and irrigation expansion have a conclusive role in determining crop diversification in West Bengal. On the contrary, the ratio of fertilizer applied to hectares seems to favour intensive instead of diversifying. The results suggest that the policy focused on diversification promotion must focus on rural infrastructure enhancement, the growth of irrigation, and agricultural credit institutions to bring about permanent diversification and increase farm earnings.

The discussion of the percentage of land area under non-foodgrain crops also supports the assertion that road connection, irrigation, and access to credit are important in supporting the diversification of land use to high-value and commercial crops. With better infrastructure and financial assistance, farmers will be able to react to market opportunities, minimise the risk of production, and increase profitability.

In general, the results highlight the necessity of a comprehensive policy that helps to improve the rural infrastructure, increase the area of irrigation, provide better access to institutional credit, and encourage the balanced use of inputs. This kind of strategy is crucial towards ensuring agricultural diversification, farm incomes and developing a more resilient and market-oriented agricultural sector in India.

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