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NATURE AND EXTENT OF CROP DIVERSIFICATION: A CASE STUDY OF BANKURA DISTRICT OF WEST BENGAL

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Abstract

The implementation of crop diversification in Bankura district, West Bengal, is crucial for ensuring both economic and environmental sustainability. Shifting from conventional cereals to more valuable crops such as vegetables and fruits has enhanced the ability to withstand changes in climate. The Herfindahl-Hirschman Index (HHI) demonstrates a shift towards diversity between the years 1997 and 2017. Variables such as irrigated area, fertiliser use and agricultural finance have a beneficial impact on diversification, whereas, rainfall, and temperature have a negative effect on it. Infrastructure development, as quantified by the expansion of road networks, enhances market connectivity and enhances economic efficiency. Policy interventions targeting irrigation, finance, and rural connection are essential for effectively promoting high-value crops, thereby guaranteeing food security and economic stability in a sustainable manner.

Key Words: Crop Diversification, High Value Crops, HHI

1. Introduction

Diversifying agricultural practices and incorporating profitable and high-value crops into agricultural methods is seen as a vital approach to improve rural incomes, provide job opportunities, reduce poverty, and protect valuable land and water resources (Chand, 1996; Ryan and Spencer, 2001; Joshi et al., 2003). According to Tuteja 2011, it was asserted that the future of agriculture and the food sector will depend on diversifying crops towards high-value varieties. Additionally, there will be a greater emphasis on adding value to crops, as well as ensuring food security, nutritional security, sustainability, and profitability in both current and future agricultural development. Crop diversification is a strategy used to reduce the impact of climate change and optimise land utilisation. It is quantified by the percentage of land allocated to different crops. Agricultural diversification is implemented to mitigate the negative impacts of the current practice of crop specialisation and monoculture, with the aim of optimising resource utilisation, nutrient recycling, and soil fertility restoration. Additionally, it enhances economic sustainability through the production of value-added goods and the enhancement of ecological conditions (Guiteras ,2007; Acharya et al, 2011; Shankar et al, 2014). But the success of the crop diversification strategy in reducing poverty relies heavily on the availability of sufficient infrastructure and access to markets (Mukherjee, 2015). The accessibility of water for agriculture determines the rate at which specialisation towards traditional crops versus high value crops increases proportionally (Singh and Sidhu, 2004). The combination of continuous economic growth and the ongoing process of urbanisation have resulted in a significant increase in the demand for high-value food items (Rao et al., 2006).

However, agricultural production contains inherent uncertainties, necessitating farmers to modify and optimise their farming techniques in order to mitigate potential losses. Inadequate risk management can result in crop failures, resulting to diminished production and volatile income. Addressing this issue, the strategy of diversifying agricultural production to include a variety of crops and livestock has been acknowledged as a method to guarantee a consistent and reliable source of income for farmers (Ali, 2004). In particular, this work aimed to: (i) examine the characteristics and level of crop diversification in the research region; (ii) investigate the factors that influence crop diversification in the research area.

2. Concept of Crop Diversification

The concept of Diversification might be interpreted differently by individuals at various levels. Ellis (2000) defines the diversification of activities as the process through which rural households develop a wider range of activities and assets in order to sustain themselves and enhance their quality of life. According to Niehof (2004), diversity is seen as an essential tool that enables the reduction of vulnerability. There are two types of diversification that have been identified: farm diversification, also known as crop diversification, and income from farming diversification, also known as diversification of activities (Emrys and Ngau, 1991). The distinction between the two diversifications is predicated on the inherent characteristics of the activities. Ilbery (1991) distinguishes between farm diversification, which involves activities largely within the agricultural realm, and diversification of activities, which refers to revenue diversification from both on-farm and off-farm activities. Crop diversification refers to the cultivation of a wide range of crops, which leads to increased competition among different field crops for available arable or cultivable land. Swades and Shyamal (2012) argue that crop diversification is a crucial strategy in developing countries to alleviate the challenges faced by subsistence agricultural economies and improve the nutritional diversity of the impoverished population. Crop diversification aims to increase the range of crops produced in a specific location, so promoting the expansion of production activities and reducing the risk associated with relying on a single crop. Crop diversification is commonly seen as a transition from cultivating less profitable crops that have been traditionally grown to cultivating more profitable ones. Crop diversification and the cultivation of a wide variety of crops are employed in rain-fed areas to mitigate the risk of crop failure caused by drought or insufficient rainfall. Diversifying crops can serve as an effective strategy for farmers to manage many risks, including price fluctuations. The farmer can utilise their knowledge of the means and variances of crop prices to select a combination of crops that exhibit a minimal correlation in terms of profitability (Coyle, 1992). The farmer can mitigate the risk of reduced profit or utility caused by below-average prices for a particular crop in a given year by diversifying their crop portfolio and selecting an appropriate combination of crops. Farmers can employ diversification as a strategy to mitigate the risks associated with output and input market fluctuations. This can be achieved by selecting crops that possess distinct features, such as varying levels of drought resistance or varied harvesting seasons. The farmer can mitigate the risk of reduced profit or utility by diversifying their crop portfolio and selecting the most advantageous combination of crops. This strategy serves as a form of insurance against fluctuations in crop prices, particularly when one crop experiences below-average prices in a certain year (Bromley and Chavas 1989). Farmers have the potential to diversify their agricultural practices in order to adapt to biological, physical, or economic limitations that may impact the farming system or the availability of resources. These constraints can manifest as limited access to inputs, restricted availability of water or nutrients.

3. Measurement of Crop Diversification:

Crop diversification can be measured using many ways that assess the level of dispersion and concentration of activities in a specific period and space using a single quantitative indicator. Various indices can be used to assess the level of crop diversification at a specific moment in time. These include Bhatia's Method, Jashbir Singh's Method, Herfindahl Index (HI), Transformed Herfindahl Index (THI), Ogive Index (OI), Entropy Index (EI), Modified Entropy Index (MEI), Composite Entropy Index (CEI), Gini Coefficient (Gi), and Simpson Index (SI). This study utilises the Herfindahl index due to its extensive usage in the agricultural diversification literature. In addition, the index is straightforward to calculate.

4. Methodology

4.1 Study Area:

West Bengal is predominantly an agrarian state. It possesses favourable climatic condition for agriculture along with good quality of alluvial soil, ample of water resources and large number of population who are dependent on agriculture for their livelihood. But our study area Bankura district of West Bengal is one of the backward districts in the state. The majority of the region is distinguished by its undulating geography. The land's average gradient ranges from 0.4% to 10%. The soil predominantly consists of laterite, which is characterised by its light texture and acidic properties. The productivity of soil is very low. The soil exhibits a light and porous texture, characterised by a scarcity of organic matter and a limited ability to retain water. Nevertheless, the eastern and southern regions of this district exhibit higher productivity compared to the western region. The district's principal crop is rice. Despite the district's vulnerability to drought, it has the potential to increase food production during years with enough rainfall. Potatoes, wheat, vegetables, mustard, summer tomatoes, and rice are among the most important crops. From last two decade farmers of the district started to produce some high value crops like potato, vegitables, fruits, flowers etc. As the of agriculture in the district not yet taped fully so there is an ample scope of diversifying cropping pattern. In this paper we will try analyse the trends of crop diversification and also identify the factors responsible for crop diversification.

4.2 Data Source:

The study utilises the district-level dataset provided by the Department of Planning, Statistics and Programme Monitoring, Government of West Bengal. The study applied a secondary data set provided by the District Statistical Handbook of Bankura district, which was prepared and compiled by the Bureau of Applied Economics and Statistics, Govt. of West Bengal (Dept. of Planning Statistics and Programme Monitoring, Govt. of West Bengal, 2021). The data covers the 21 years period from starting from 1997 to 2017.

4.3 Analytical techniques

In order to analyse crop diversification and the factors that influence it in Bankura, we collected secondary data from District Statistical Handbook of Bankura district. The data includes information on variables such as the area under different crops, irrigated area, net sown area, cropping intensity, percentage of urban population to total population of the state, fertiliser use, annual rainfall, road density etc. In order to find out the extent of diversity we will collect area under different major crops in the district over the time period from 1997 to 2017. The research takes into account a total of seventeen different types of crops, which are categorised into five types. Total cereals, total pulses, oil seeds, fibres, and miscellaneous crops are the kinds of crops that fall under these categories. Under the category of total cereals, crops such as rice, wheat, maize, and other cereals are taken into consideration. Under the category of total pulses, gramme, tur, and other pulses are taken into consideration. Under the category of oil seeds, three seeds such as rapeseed and mustarded, linseed, and other oil seeds are taken into consideration. Under the category of fibre, jute, mesta, and other fibres are taken into consideration. Finally, under the category of miscellaneous crops, sugarcane, potato, chilies (dry), and ginger are considered. To measure the diversification we will use Herfindahl-Hirschman index (HHI). It is the most frequently used method for measuring the crop diversity. The Herfindahl-Hirschman Index (HHI) is calculated by summing the squares of the proportions of acreage for each type of crop in relation to the total area of crops. The HHI is determined by using the following equation

$$\mathrm{HHI} = \sum_{i=1}^{n} P_i^2$$

$$\text{Where } P_i = \frac{A_i}{\sum_{i=1}^{n} A_i}$$

Here n is the total number of crops practicing in a particular plot of land and each crops are practicing under the area denoted by A_i. The Herfindahl-Hirschman Index (HHI) is calculated as the sum of the squared acreage proportions of each crop in the total planted area. As diversification rises, the squared proportions of individual crops in the overall area drop, resulting in a decrease in the indicators known as Herfindahl-Hirschman Index (HHI). The Herfindahl–Hirschman Index equals one in the presence of specialisation. The value tends towards zero with diversification.

Ordinary least square method should be use to determine the significant factors that influence diversification. The analysis use time series data from 1997 to 2017. The Herfindahl-Hirschman Index (HHI) (Y)should be treated as depended variable. The mathematical function for OLS can be written as

$Y(HI) = a + b_1X_1 + b_2X_2 + \ldots\ldots\ldots. + b_nX_n + U$

Here,

Y is the dependent variable i.e, the value of Herfindahl-Hirschman Index (HHI).

X_1 = Cropping intensity (CrpInt) which is derived by Gross cropped area divide by net shown area.

X_2 = Total irrigated area in the district (Ia)

X_3 = Total fertiliser consumed in the district denoted by Flt

X_4 = Total Credit (AGcrd) available for agricultural sector.

X_5 = Total road length (Road) in the study district.

X_6 = Total storage (Storage) capacity including warehouse and cold storage.

X_7 = Annual average temperature(Tepmt).

X_8 = Annual average Precipitation (Rain)

U = error term

Now the regression equation become

$$\mathrm{HHI}_t = \alpha_0 + \alpha_1 \mathrm{CrpInt}_t + \alpha_2 \mathrm{Ia}_t + \alpha_3 \mathrm{Flt}_t + \alpha_4 \mathrm{AGLcrd}_t + \alpha_5 \mathrm{Road}_t + \alpha_6\ \mathrm{Storage}_t + \alpha_7 \mathrm{Tempt}_t + \alpha_8 \mathrm{Rain}_t + \epsilon_t$$

5. **Results and Discussion**

At first to find out the extent of diversity we will calculate HHI value for the study district. The calculation of HHI showing that the values are moving towards 0(Zero) so we can say that the farmers are moving towards high value remunerative crops.

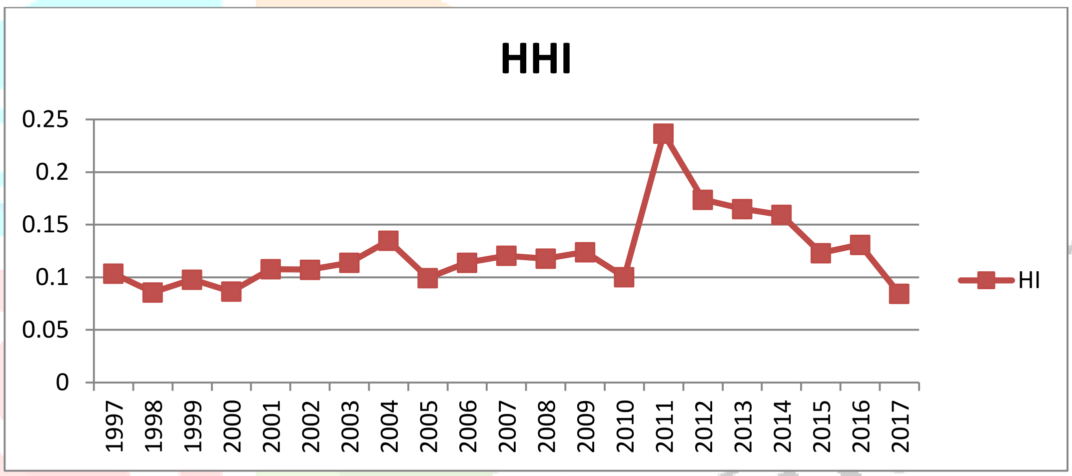
Table-1: Herfindahl Index for 17 Crops of Bankura over 25 Years

Year	HHI	Year	HHI
1997	0.103481	2008	0.117851
1998	0.085762	2009	0.12396
1999	0.097972	2010	0.100339
2000	0.086583	2011	0.236663
2001	0.107782	2012	0.173891
2002	0.107319	2013	0.165055
2003	0.113802	2014	0.159416
2004	0.134746	2015	0.123108
2005	0.099391	2016	0.131046
2006	0.11398	2017	0.084349
2007	0.120539		

Source: Study Estimates from DSHB 1997-2021 prepared by Authors, 2024

Now we have plotted the Table - 1 in the Figure No -1

Figure No - 1 **Herfindahl Index for 17 Crops of Bankura over 21Years**



Source: Study Estimates from DSHB1997-2017 by Authors, 2024

Figure No -1 reflect that most of the year the value of HHI moving around 0.9 which signifies the existence of high level of diversification.

Now, to find out the answer of our second research question we will run OLS model. Result of the simple OLS model depicted in Table no -2

Table No 2– Result of OLS Estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0131	0.0574	0.2284	0.8231
CrpInt	0.0240	0.0299	0.8001	0.4392
Ia	0.2776	0.0692	4.0085	0.0010
Flt	-0.0942	0.0473	-1.9220	0.0050
AGLcrd	0.2300	0.0873	2.6351	0.0218
Road	0.6099	0.2587	2.3575	0.0347
Storage	0.0357	0.0329	1.0835	0.2999
Tempt	-0.0847	0.0299	-2.8320	0.0086
Rain	-0.1676	0.0523	-3.2046	0.0035
R-squared	0.8246	Mean dependent var		0.1232
Adjusted R-squared	0.7076	S.D. dependent var		0.0359
S.E. of regression	0.0194	Akaike info criterion		- 4.7487
Sum squared resid	0.0045	Schwarz criterion		-4.3010
Log likelihood	58.8609	Hannan-Quinn criter.		-4.6515
F-statistic	7.0506	Durbin-Watson stat		1.8688
Prob(F-statistic)	0.0015			

Source: Estimated by authors, 2024

The R-squared value is 0.824573, indicating that approximately 82.5% of the variance in the dependent variable is explained by the independent variables in the model. The adjusted R-squared is 0.707621, which adjusts for the number of independent variables in the model. The F-statistic is 7.050558 with a p-value of 0.001505, suggesting that the overall regression model is statistically significant. Standard Error (S.E.) of regression: 0.019409. A result of 1.868783, which is less than 2, suggests that there is no autocorrelation in the residuals, according to the Durbin-Watson statistic.

Further table 2 explain that the cropping intensity is not statically significant as the p-value is more than 0.05 and coefficient value is also negligible. Irrigated area (Ia) and agricultural credit (AGLcrd) both coefficient are positive and their values are 0.2776 and 0.2300 respectively which indicate that one unit increase in these variables will enhance the crop diversity by 0.27 and 0.23 unit respectively. Further these two independent variables are statically significant as their p-values are 0.001 and 0.021 which are below the level of 95% significance. So to promote crop diversification we have to increase credit and irrigational facilities. The coefficient of another important component fertiliser (Flt) is -0.0942 signifies that one unit increase in fertiliser consumption crop diversification will reduce by 0.09 units. It is also statically significant as the p-value is 0.005 which is below of 0.05 values. This happen because fertiliser mainly use for cereal crops. Further it may be explain as the cost of production of traditional crops has increased due to over use of fertiliser so the farmer want shift their cropping pattern to reduce their cost burden. Road length (Road) is also highly significant determinant of Crop diversity as the p value is 0.034 and which is below the level of 95% significance and coefficient indicate that one unit change in road length increase the crop diversity by 0.6099 units. Annual average rainfall (Rain) and average annual temperature (Tempt) these two variables are highly significant as their p-values are 0.0086 and 0.0035 respectively which are below the level of 95% significance. Further Coefficients indicates that one unit change in Annual average rainfall (Rain) and annual average temperature (Tempt) will negatively change the cropping pattern against the high value crops by 0.08 and 0.16 times respectively. This is because Bankura fall in a dry region of West Bengal and the farmers, particularly small farmers will not take any risk to shift their cropping pattern.

Now we have to check the multicollinearity in the regression model. It means the existence of exact linear relationship among few or all independent variables. Examine the variance inflation factor (VIF) in table-3 to check for multicollinearity among the regressors.

Table No – 3 VIF

Variable	Centered VIF
CrpInt	1.978238
Ia	1.10140
Flt	1.839523
AGLcrd	1.33798
Road	0.451765
Sorage	1.386182
Tempt	1.263007
Rain	1.316436

Source: Estimated by authors, 2024

As the centered VIF values for all variables are below 2, implies that multicollinearity is not a problem for such predicative regressors explanation over crop diversity.

6. Conclusion

From the above discussion we can say that diversification of cropping pattern is already exist in Bankura and this is established by the HHI result. The study investigated the factors influencing agricultural production in Bankura, incorporating variables such as cropping intensity, irrigated area, fertiliser usage, credit availability for agriculture, road infrastructure, and storage facilities. Analysed time series data from 1997 to 2017 to determine patterns in rainfall and temperature. The data was analysed using the econometric approach of data analysis. Econometric analysis reveals that irrigated area, available credit for agriculture, and road length have a positive and significant impact on crop diversity. Conversely, fertiliser consumption, rainfall, and temperature have a negative and significant effect on crop diversity. On the other hand, cropping intensity and storage have an insignificant effect on crop diversity. The study suggests that government policies should prioritise the enhancement of irrigation, accessibility of financing, and the extension of road connectivity. These measures would lead to a shift in cropping patterns towards high-value crops.

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