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Exploring Agricultural Transformations: A Spatio-Temporal Analysis of Crop Diversification in Purulia District, West Bengal.

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Abstract:

The crop diversification in Purulia District, West Bengal has a significant bearing on the evolving agricultural landscape in the region. Crop Diversification Index (CDI) values and its detailed examination in different blocks within the district, significant variations in crop diversification practices are observed. Blocks such as Jaypur, Arsha, Bandowan, and Para exhibited high levels of crop diversification, while in blocks like Jhalda-I, Jhalda-II, Manbazar-I, Kashipur, Neturia, Raghunathpur-I, Raghunathpur-II, and Santuri is low. Moderate levels of diversification were noted in blocks such as Baghmundi, Balarampur, Barabazar, Hura, Purulia-I, Purulia-II, Manbazar-II, and Puncha. The crop diversification in most part is attributed to agricultural diversity and crop rotation. The findings underscore the importance of promoting crop diversification as a strategy to enhance agricultural sustainability, farmer resilience, and food security in drought-prone regions like Purulia. Recommendations include encouraging farmers to adopt diversified cropping patterns through training and technical support, implementing policies for diversification, conducting further research on socio-economic factors influencing diversification decisions, and collaborating with local agricultural extension services and research institutions to disseminate information on the benefits of crop diversification. By implementing these recommendations, stakeholders can contribute to the development and resilience of the agricultural sector in Purulia District.

Keywords: *Crop Diversification, Spatio-temporal analysis, Purulia, Agriculture, diversified farming.*

1. Introduction.

Diversification of crops refers to the introduction of various crops to the existing farming system, reducing dependency on a single crop. It aims to enhance farmer income, improve food security, increase human sustenance and biodiversity, and promote sustainable agricultural practices. The needs for diversification of crops in India include reducing farmer vulnerability to market fluctuations, climate change, and pest attacks. It also aims to improve soil health, boost agricultural productivity, and enhance biodiversity. Raju et al. (2011) conducted an economic analysis of crop diversification in Karnataka, India. Their study found that crop diversification has a positive impact on agricultural production, as it leads to better resource use, nutrient recycling, reduction of risks and uncertainty, and enhance soil fertility. The study also found that crop diversification has a positive impact on economic viability, as it allows for the production of value-added products and improvement of ecology. The authors collected time series data from various published sources, including the Directorate of Economics and Statistics (DES), Bangalore, Karnataka, and the Centre for Monitoring Indian Economy (CMIE) report. The data collected covered the period from 1982-83 to 2007-08 and included information on area, production, productivity of different crops, total food production, crop-wise area under irrigation, season-wise crops grown, area under high-yielding varieties of different crops, net cultivated area, area sown more than once, gross cropped area, annual and month-wise rainfall, source-wise irrigation, year-wise fertilizer consumption, livestock population, average size of holding, farm harvest prices, and other infrastructural facilities (Raju et al., 2011).

Another study by Kumar et al. (2014) examined the factors affecting crop diversification in India. The study found that factors such as landholding size, irrigation, and access to credit can influence farmers' decisions to diversify their crops. The study also established that crop diversification can lead to increased income and reduced risk for farmers.

In a study by Singh et al. (2017), the authors analysed the impact of crop diversification on rural livelihoods in India. The study found that crop diversification can lead to increased income and improved livelihoods for farmers. Their study proved that crop diversification can have positive environmental impacts, such as improved soil health and reduced use of chemical fertilizers.

Another study Tanmay et al. (2022) provided an overview of the current state of research on crop diversification and its impact on soil health, crop yields, and pest and disease pressure. They also discussed different methods of crop diversification, including intercropping, crop rotation, and agroforestry, and provided examples of successful implementation in various regions. The authors highlighted the importance of crop diversification in sustainable agriculture and discussed how it can contribute to food security, environmental sustainability, and economic development. They also address some of the challenges and limitations of crop diversification, such as the need for specialized knowledge and skills, the potential for reduced profitability in the short term, and the risk of crop failure due to weather or other factors. (see also Barman et al., 2022).

This article addresses some of the challenges and limitations of crop diversification, such as the need for specialized knowledge and skills, the potential for reduced profitability in the short term, and the risk of crop failure due to weather or other factors. Overall, this review article provides a comprehensive overview of the current state of research on crop diversification in

agriculture and highlights the need for further research and implementation of sustainable agricultural practices.

2. Objectives of the Study.

In arid to semi-arid regions where the soil is also less fertile, crop diversification is a need which increases agricultural biodiversity, production and sustain the ecosystem. This also improves soil fertility and its micronutrients and produces quality food grains and nutritional security.

1) Analysis the temporal change of crop diversification.
2) Elaborate the regional variations in crop diversification.
3) Analysis of the pattern of crop diversification of the district.

3. Study Area.

The Purulia district in West Bengal (Figure 1) is 6,259 square kilometers (2,417 square miles). It's located between 22.60° and 23.50° north latitudes and 85.75° and 86.65° east longitudes (Wikipedia). The district is known for its drought-prone climate and semi-arid region. It's located in the Eastern Plateau and Hills agro-climatic region and the Chhotonagpur South and West Bengal Plateau sub-region (WBDMD). The district is made up of three types of soil, including clay loam and clay in the valleys. The soil is acidic throughout the district, with a pH ranging from 5.5 to 7.2. The soil also contains an average of 0.04% nitrogen (LKP, Purulia).

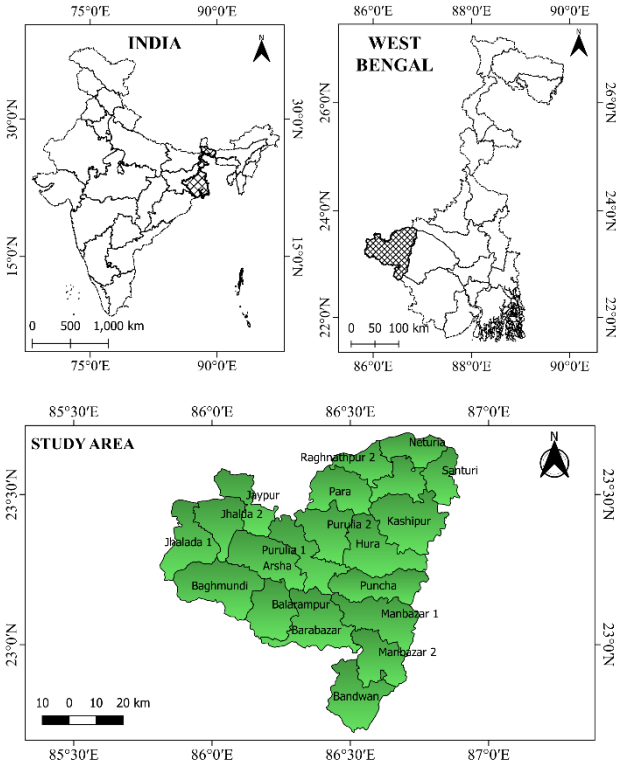

Figure 1: Location map of the study area showing the various blocks of Purulia District.

Purulia is a plateau region and about 60% of the total cultivated area is upland. Cultivation in the district is predominantly mono-crop. Out of the total agricultural holding, about 73% belongs to small and marginal farmers having scattered and fragmented small holding. Paddy is the primary crop of the district. 57% of the total land is under net-cropped and only 15% of the net cropped area is under multi-crop cultivation. 83% of the net-cropped area is under Kharif paddy cultivation. Cropping intensity is 114.59. The crops are grown mostly under rain fed conditions, generally with low fertilizer consumption per unit area Thus per hectare production is also low as compared to other districts of West Bengal.

4. Data and Methodology.

Data Sources:

The primary data source for this research is the District Statistical Handbook, Purulia, for the years 2010, 2012, and 2014. These handbooks provide comprehensive information on agricultural production at the block level, including data on the share of different crops cultivated in Purulia district. The data from these handbooks were meticulously collected, cleaned, and processed to analyze crop diversification trends in the region.

Data Collection and Compilation:

1. **Data Extraction:** The initial step involved extracting block-wise data on crop production shares for the years 2010-11, 2012-13, and 2013-14 from the District Statistical Handbook, Purulia.
2. **Data Cleaning:** The extracted data was cleaned to eliminate any anomalies, inconsistencies or missing values. Data entry errors and outliers were also identified and corrected.
3. **Data Aggregation:** Subsequently, the cleaned data was aggregated to calculate the Crop Diversification Index (CDI) at the block level for each of the three years under consideration.

Calculation of Crop Diversification Index (CDI):

To gauge crop diversification, the Gibbs Martin's Index formula was employed. The CDI was calculated as follows:

$$CDI = 1 - \sum_{i=1}^{n} \left(\frac{S_i}{S_{total}}\right)^2$$

Where:

- CDI = Crop Diversification Index for a specific block and year.
- n = Number of different crops cultivated in the block.
- S_i = Share of each crop in the total cropped area in the block.
- S_{total} = Total cropped area in the block.

The CDI Index ranges from 0 (no diversification) to 1 (maximum diversification). We see a significant spread in the data, indicating a wide variation in crop cultivation practices across blocks (Table 1).

Presentation of Results:

1. **Calculation Tables:** Create tables presenting the CDI values for each block in Purulia district for the years 2010-11, 2012-13, and 2013-14. Organize the tables to facilitate easy comparison and identification of trends over time. Additionally, include statistical measures such as means, standard deviations, and percentiles to summarize the data.
2. **Thematic Maps:** Develop thematic maps to visually represent the spatial distribution of crop diversification in Purulia district for each of the three years. Utilize a geographic information system software (ArcGIS Desktop, QGIS) to create maps that employ color

coding to indicate the CDI values in different blocks, allowing readers to grasp regional diversification patterns at a glance.

5. Result and Finding.

5.1. Analysis the pattern of crop diversification of this district.

Pattern of 2010-11: The CDI values across the blocks vary widely, ranging from 0.00 to 0.63. This indicates significant differences in crop diversification practices among the blocks (Figure 2). The diversification can be categorized into:

(a) Blocks with high diversification: Blocks such as Jaypur (0.40), Arsha (0.35), Bandowan (0.63), and Para (0.36) have relatively higher CDI values, suggesting a more diversified agricultural landscape in these areas.
(b) Moderate Diversification: Blocks such as Baghmundi, Balarampur, Barabazar, Hura, Purulia-I, Purulia-II, Manbazar-II, Puncha also show moderate levels of crop diversification, with CDI values ranging from 0.13 to 0.33.
(c) Blocks with Low Diversification: Conversely, blocks like Jhalda-I, Jhalda-II, Manbazar-I, Kashipur, Neturia, Raghunathpur-I, Raghunathpur-II, and Santuri have CDI values close to zero, indicating very low levels of crop diversification. These blocks might be predominantly focused on monoculture or have limited agricultural diversity.

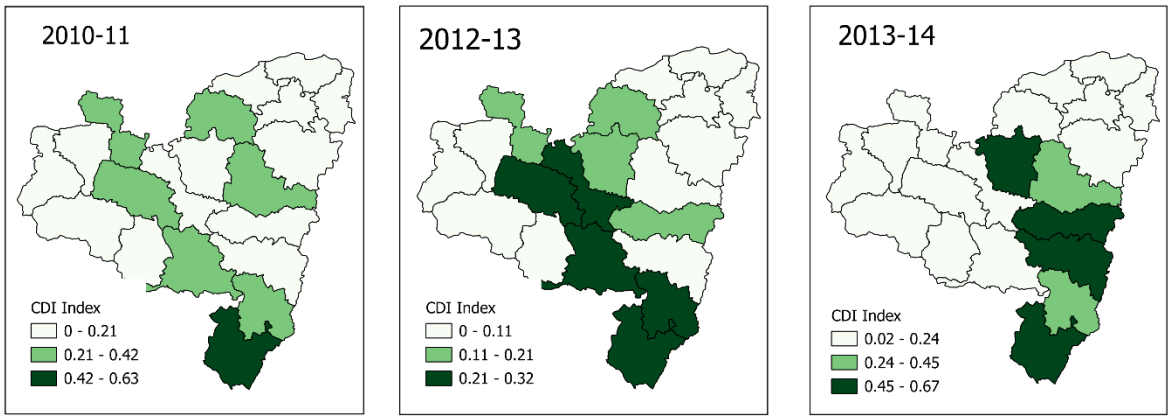

Figure 2: Pattern of Crop diversification of the study area on 2010-11, 2012-13 and 2013-14.

Pattern of 2012-13: High diversification Blocks blocks (e.g., Arsa, Barabazar, Bandowan etc) exhibit relatively high crop diversification. This suggeststing cultivation of a wider variety of crops, potentially leading to benefits like reduced risk from pests, improved soil health, and income stability for farmers. Low diversification blocks indicates a strong reliance on a single or few crops, making them more susceptible to price fluctuations, weather variations, and pest attacks.

Pattern of 2013-14: There is a significant variation in CDI across the blocks, indicating differing levels of crop diversification. Blocks like Bandowan (0.673), Puncha (0.644), Manbazar-I (0.499), and Purulia-II (0.498) exhibit relatively high diversification, while others like Kashipur (0.020), Jhalda-I (0.030), Jhalda-II (0.031), Neturia (0.032), Para (0.021), and Raghunathpur-II (0.041) have very low diversification. The high diversification in Bandowan, Puncha, Manbazar-I, and Purulia-II could be attributed to the better irrigation facilities allowing cultivation of a wider range of crops.

Table 1: Table Showing the Crop Diversification index (CDI) on 2010-11, 2012-13 and 2013-14.

Name of Block	CDI 2010-11	CDI 2012-13	CDI 2013-14
Arsha	0.35	0.22	0.07
Baghmundi	0.21	0.02	0.08
Balarampur	0.15	0.05	0.05
Barabazar	0.22	0.23	0.14
Bandowan	0.63	0.24	0.67
Hura	0.22	0.07	0.36
Jaypur	0.4	0.16	0.18
Jhalda-I	0	0	0.03
Jhalda-II	0.07	0.03	0.03
Kashipur	0.02	0.02	0.02
Manbazar-I	0.02	0.04	0.5
Manbazar-II	0.33	0.32	0.29
Para	0.36	0.2	0.02
Puncha	0.13	0.11	0.64
Purulia-I	0.21	0.24	0.08
Neturia	0	0	0.03
Purulia-II	0.15	0.15	0.5
Raghunathpur-I	0.01	0.01	0.19
Raghunathpur-II	0.06	0.01	0.04
Santuri	0.02	0	0.2

Source: District Statistical Handbook. Purulia

5.2 Temporal Change of Crop Diversification.

- **Blocks with Consistent Increase in CDI:** Jhalda-I, Kashipur, Neturia, Manbazar-I, Raghunathpur, and Purulia-II. These blocks show a steady rise in CDI over the three years, indicating a positive trend towards crop diversification (Figure 3.
- **Blocks with Consistent Decrease in CDI:** Balarampur, Jhalda-II, Para, and Manbazar-II. These blocks experienced a decline in CDI across all three years, suggesting a shift towards monoculture or less diverse cropping patterns.
- **Blocks with Fluctuations in CDI:** The remaining blocks (Arsha, Baghmundi, Barabazar, Jaipur, Bandowan, Hura, Puncha, Purulia-I, and Santuri) exhibit fluctuations in their CDI values. Some blocks show an initial decrease followed by an increase, while others show the opposite pattern. These fluctuations indicate that the level of crop diversification in these blocks is not consistent and may be influenced by various factors.

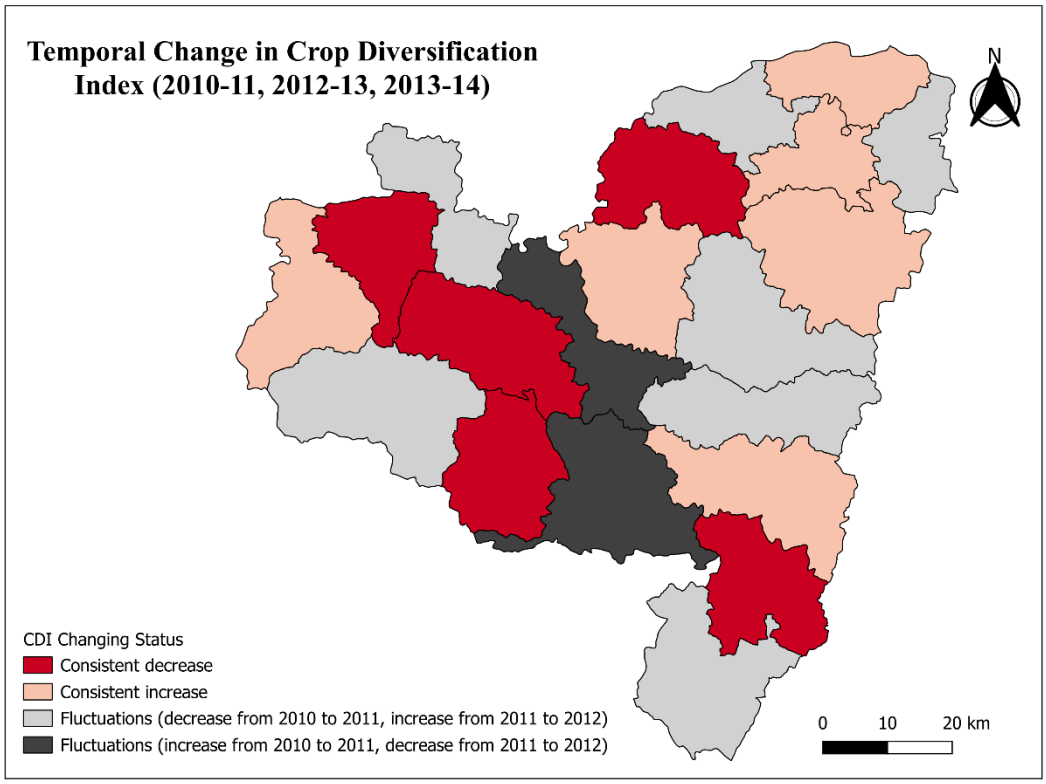

Figure 3: Temporal Change of Crop diversification Index.

5.3 Regional Variations in Crop Diversification across Purulia District Blocks (2010-2014)

This table (Table 1) allows us to analyze the variations in Crop Diversification Index (CDI) across different blocks in Purulia district for the three years (2010-11, 2012-13, and 2013-14). Here's a breakdown of the observed variations:

High vs. Low Diversification:

- High CDI (Diversified): Blocks like Bandowan (consistently high), Puncha (high in 2013-14), Manbazar-I (increases over time), and Purulia-II (increases over time) exhibit consistently high or increasing CDI values. This suggests a wider variety of crops being cultivated in these regions.
- Low CDI (Less Diversified): Blocks like Kashipur (consistently low), Jhalda-I & Jhalda-II (very low and steady), Neturia (very low and steady), and Para (declines over time) show consistently low or declining CDI values. This indicates a reliance on a limited number of crops in these areas.

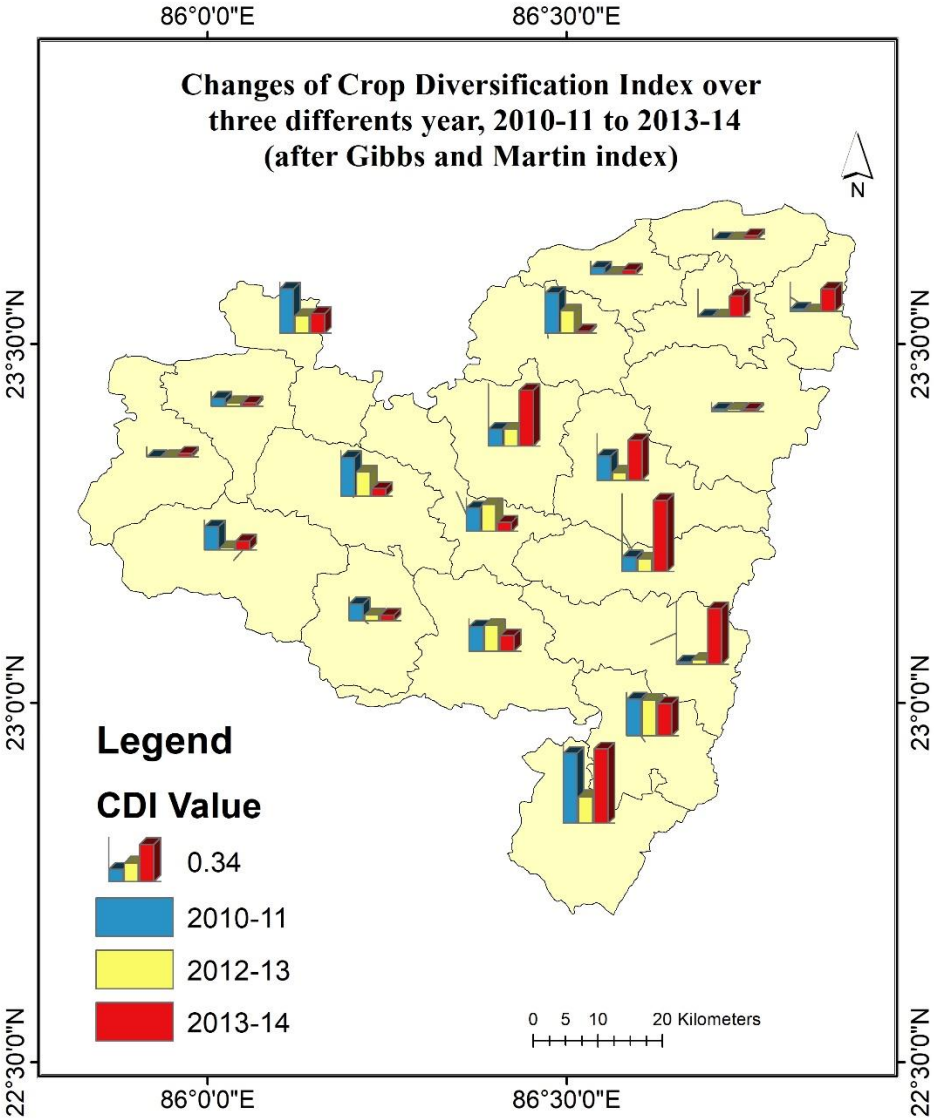

Figure 4: Status of crop diversification index over three different years.

Changes over Time:

- Increasing Trend: Manbazar-I, Purulia-II, and Raghunathpur-I show a positive trend in CDI, suggesting a shift towards crop diversification over the years.
- Decreasing Trend: Balarampur, Jhalda-II, and Para depict a declining CDI, indicating a potential shift towards monoculture or less diverse cropping patterns.
- Fluctuations: Several blocks, including Arsha, Baghmundi, Barabazar, Jaipur, Bandowan (except 2012-13), Hura, Puncha (except 2013-14), Purulia-I, and Santuri, display fluctuations in their CDI values. This suggests these areas might be adopting crop diversification practices inconsistently.

6. Conclusion and Recommendations.

The spatio-temporal analysis of crop diversification in Purulia District, West Bengal, has provided valuable insights into the changing agricultural landscape of the region. Through the use of CDI values, graphical representations, and statistical analyses, this study has highlighted the temporal changes, regional variations, and patterns of crop diversification in the district. The findings underscore the importance of understanding and promoting crop diversification as a strategy to enhance agricultural sustainability, farmer resilience, and food security in drought-prone regions like Purulia.

Based on the research findings, several recommendations can be made to further promote crop diversification in Purulia District, Firstly encourage farmers to adopt diversified cropping patterns by providing training, technical support, and access to diverse seeds and inputs. Implement policies that incentivize crop diversification, such as price support mechanisms, subsidies for alternative crops, and market linkages for diverse produce. Conduct further research to explore the socio-economic factors influencing crop diversification decisions and the impact of diversification on farmer livelihoods. Collaborate with local agricultural extension services, NGOs, and research institutions to disseminate information on the benefits of crop diversification and best practices for implementation. By implementing these recommendations, stakeholders can work towards enhancing crop diversification efforts in Purulia District, contributing to the overall development and resilience of the agricultural sector in the region.

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