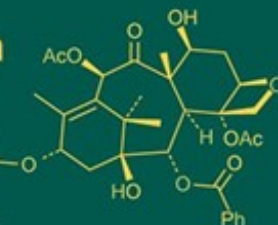
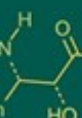
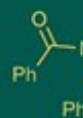
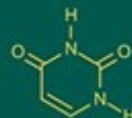


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Spatio-temporal dynamics of vegetable cultivation in Baruipur subdivision, South 24 Parganas, West Bengal

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ABSTRACT

Vegetable cultivation has increased globally over time. In India, West Bengal is a leading vegetable producer but faces several challenges such as climate variability and fluctuating market prices. Existing studies mainly focus on large-scale trends in vegetable production, area, and productivity, with limited micro-level, block-wise spatio-temporal analysis. This study examines spatio-temporal changes in the area under vegetable cultivation in the Baruipur subdivision of South 24 Parganas district, West Bengal, using secondary data from the Agriculture Census for 2000–01, 2005–06, 2010–11, and 2015–16. Vegetables were grouped into five categories: root, leafy, fruit and flower, seed and pod, and others, and their proportions were analyzed to capture changes in cropping patterns over time. The study applies percentage share analysis, mean–standard deviation classification to identify spatial patterns, absolute growth rate, and pooled OLS regression to identify key socio-economic determinants of vegetable cultivation. The results show significant spatial and temporal variation across blocks, with a clear and steady increase in fruit and vegetable production, which has become the dominant category due to higher market demand and profitability. Root vegetables show a declining trend, while leafy vegetables show moderate but inconsistent growth. Seed and pod vegetables remain relatively low and unstable throughout the study period. The regression results suggest that literacy rate has a negative, statistically significant effect on root vegetable cultivation, whereas it has a positive, significant impact on leafy vegetable cultivation; irrigation also positively influences leafy vegetable farming. However, other models are not statistically significant, suggesting that some variables have limited influence. Overall, the study reflects a gradual shift from subsistence-oriented farming to more commercially driven vegetable cultivation.

Keywords: Root vegetables, Leafy vegetables, Fruit and flower vegetables, Regression analysis, Literacy, Irrigation

Introduction

Vegetable cultivation is a crucial component of the global agricultural system, contributing significantly to food security, nutritional improvement, and economic development (Ebert, 2020)^[1]. In recent decades, global demand for vegetables has increased rapidly due to population growth, urbanization, and changing dietary preferences toward nutrient-rich foods (Pandey *et al.*, 2020)^[2]. As a result, vegetable production has expanded across many parts of the world, particularly in developing countries (Dias, 2011)^[3]. However, this expansion has not been uniform and has varied considerably over time. These differences arise from variations in agro-climatic conditions, technology adoption, irrigation infrastructure, and market accessibility (Aynalem *et al.*, 2026)^[4]. As a result, spatio-temporal variation is important for understanding how vegetable cultivation patterns change across time and space. In agriculture, spatio-temporal variation describes dynamic shifts in crop yield, area, distribution, and intensity over time and geographical space (Kallega *et al.*, 2015)^[5, 6]. Globally, climate variability, land-use changes, and economic globalization increasingly influence agricultural systems, shaping patterns of cropped area, production, and productivity over time (Hazell & Wood, 2007)^[3, 7]. Several Studies emphasize that analyzing these spatio-temporal dynamics helps identify regional disparities in cultivated area, production growth patterns, and the drivers of agricultural change, providing a scientific basis for effective planning and policy formulation (Sharma *et al.*, 2023; Wilken *et al.*, 2017)^[8, 9].

India is among the world's leading vegetable producers, supported by diverse agro-climatic zones and rising domestic demand. Over the years, vegetable crop area, production, and productivity have increased substantially. However, this growth varies significantly by region and time. (Kumari *et al.*, 2025)^[10]. Differences in irrigation facilities, technology adoption, infrastructure, and institutional support contribute to uneven development across states (Deshingkar *et al.*, 2003)^[11]. West Bengal is one of India's major vegetable-producing states, ranked second after Uttar Pradesh, owing to its fertile alluvial soil, favorable climatic conditions, and intensive cultivation practices (Deka *et al.*, 2020; Kumari *et al.*, 2025)^[12, 10]. The state has experienced sig

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nificant growth in vegetable production, but noticeable spatial and temporal disparities persist across districts. Variations in productivity and cropping patterns are influenced by factors such as irrigation availability, climatic variability, landholding structure, and access to markets (Abdeen *et al.*, 2025) [13]. Studies in eastern India further show that although vegetable production has increased, instability and variability persist over time, affecting farmers' income and regional agricultural sustainability (Gupta *et al.*, 2025) [14]. Peri-urban regions show distinct patterns of vegetable cultivation because of their proximity to metropolitan markets (Hussain *et al.*, 2014) [15]. In this context, the Baruipur subdivision of South 24 Parganas district, located in the peri-urban fringe of Kolkata, represents a significant case for analyzing spatio-temporal variation; it has undergone rapid transformation in land use and agricultural practices due to urban expansion, improved connectivity, and increasing market demand (Sarkar *et al.*, 2025; Sinha *et al.*, 2026) [16, 17]. Most existing studies concentrate on broad, large-scale trends in vegetable production, area, and productivity, with relatively little emphasis on detailed, block-level spatio-temporal analysis. This study aims to analyze spatio-temporal variation in the area under vegetable cultivation in the Baruipur subdivision of South 24 Parganas district, West Bengal.

Study area

Baruipur subdivision is located in South 24 Parganas district, West Bengal. It has seven community development blocks, namely, Baruipur, Bhargore-I, Bhargore-II, Jaynagar-I, Jaynagar-II, Kultali, and Sonarpur. It includes three municipalities: Rajpur Sonarpur, Baruipur, Jaynagar Majilpur, and 482 inhabited villages. It covers a geographical area of 1,355 square kilometers. As per the 2011 Census, Baruipur Subdivision had a population of 23,96,646, of whom 12,22,161 were males and 11,74,485 were females, resulting in a sex ratio of 960 females per 1,000 males. The urban population constituted about 31.05%, while the rural population accounted for 68.95%. The total net sown area is 86552 hectares, and 43% of the population are agricultural workers. Baruipur Subdivision, located in the peri-urban area of Kolkata, is important for vegetable cultivation because of its proximity to the city. A substantial population (43%) in the Baruipur subdivision is engaged in agriculture, with a significant portion involved in vegetable cultivation, which contributes significantly to the livelihoods of small and marginal farmers. The total area under vegetable cultivation covers 84107 hectares in South 24 Parganas, of which Baruipur subdivision comprises 34784 hectares, accounting for more than 41% of the district's total area. The region has a large proportion of farmers with small landholdings who rely heavily on vegetable cultivation as their primary income source.

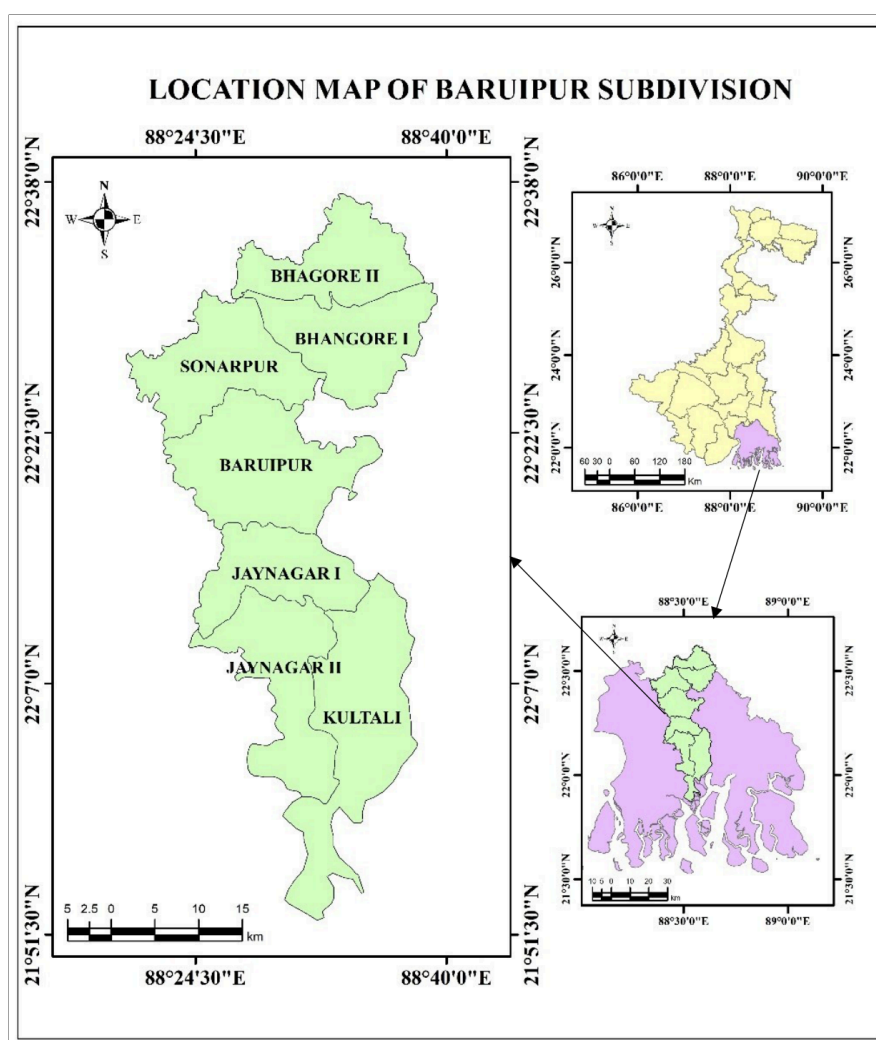


Figure 1. Location map of the Study area

Methodology

The present study uses secondary data to analyze spatiotemporal variation in the area under vegetable cultivation in the Baruipur subdivision of South 24 Parganas. Block-level data on the area under vegetable cultivation (in hectares) were obtained from the Agriculture

Census for four time periods: 2000-01, 2005-06, 2010-11, and 2015-16. For analysis, we converted the area under each vegetable crop into a percentage of the total cultivated area under vegetables. We used the mean and standard deviation to classify the data and ensure a balanced representation of variation. In this method, values below (Mean – ½ SD) were categorized as low, values between (Mean – ½ SD) and

(Mean + ½ SD) as medium, and values above (Mean + ½ SD) as high. All the vegetables were classified into five major groups based on their edible parts (Patel & Kumar, 2025; Pennington & Fisher, 2009; S. Dhaliwal, 2017) [18, 19].

This classification enabled the examination of changes in the composition and dominance of different vegetable types over time. The authors used tables and diagrams to present temporal trends, while maps (prepared using ArcGIS software) depicted the spatial distribution and variation in the area under vegetable cultivation across blocks.

Key variables and methods

This study estimates panel-data econometric models to identify and analyze the factors influencing vegetable cultivation in the study area. First, the scholars categorized all vegetables into five categories. Accordingly, the authors prepared five separate models to identify the factors driving vegetable cultivation using panel datasets. We considered two panel datasets, i.e., 2000-01 and 2015-15, due to constraints in data availability. We used corresponding socio-economic and demographic data published every decade by the Census of India. The determinants of vegetable cultivation were examined using the following equation:

Table 1. Categories of vegetables based on their edible parts

Categories	Vegetables
Leafy Vegetables	Spinach, Cabbage

Variables	Description	Mean	SD
Dependent Variables			
Root Vegetables		19.73	18.34
Leafy Vegetables		7.28	5.46
Fruit And Flower Vegetables		44.00	20.93
Seed & Pod Vegetables		1.66	3.75
Others Vegetables		27.29	24.56
Explanatory Variables			
Literacy rate	Percentage of literate population	68.71	6.05
Irrigated area	Total irrigated area in hectares	1697.35	2228.19
Net Shown Area	Total NSA in hectares	15954.1	5785.128
Marginal farmers	Farmers who have cultivated up to 1 hectare of agricultural land.	17382.86	4816.57
Small farmers	Farmers who have cultivated 1-2 hectares of agricultural land.	2325.5	998.24
Growth of Urban population	Urban population growth in percentage	12839.84	32322.84
Total number of observations (n)		14	

Source: Prepared by the author

To identify the most robust specification, we estimated three panel regression models: pooled OLS, fixed effects, and random effects. The fixed effects and random effects models did not produce statistically significant coefficients; the F-statistics were not significant in either model, so the pooled regression model was adopted as the preferred model for subsequent analysis.

Results and Discussions

The observed spatio-temporal variation in the area under vegetable cultivation across the Baruipur subdivision can be explained by a combination of economic, environmental, and infrastructural factors.

Root vegetables: The maps show distinct spatio-temporal changes in the area under root vegetable cultivation in Baruipur Subdivision between 2000–01 and 2015–16, driven by environmental suitability, market forces, and urban expansion. In 2000–01, Baruipur and Bhangore-2 had the highest share (> 44%), while Bhangore-1 and Kultali recorded moderate shares ranging between 26.25 and 44.02%. Southern blocks such as Jaynagar-1 and II had low shares (< 26.25%), indicating an initial concentration in the northern and central parts due to fertile alluvial soils, irrigation facilities, and proximity to Kolkata markets. By 2005–06, the percentage share shifted, with

Categories	Vegetables
Root Vegetables	Potato, Sweet Potato, Yam, Tapioca, Elephant Foot Yam, <i>Colocasia</i> (Arum), Other Tuber Crops, Onion, Radish, Turnip
Fruit and Flower Vegetables	Tomato, Brinjal, Lady's Finger (Bhindi), Cucumber, Bottle Gourd (Lauki), Pumpkin, Bitter Gourd, Other Gourds, Green Chili, Cauliflower
Seed and Pod Vegetables	Peas, Beans, Drumstick
Other Vegetables	Remaining minor or unclassified vegetables

Source: Patel & Kumar, 2025; S. Dhaliwal, 2017; Pennington & Fisher, 2009 (Pandey *et al.*, 2020; Pennington *et al.*, 2009; Dhaliwal, 2017) [2, 18, 19]

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \dots \dots \epsilon_i$$

Where Y_i refers to the individual vegetable category, β_0 is the Y-intercept, β_1 to β_6 = coefficients of estimated, X_{1i} is literacy rate, X_{2i} is irrigated area, X_{3i} is Net Sown Area (NSA), X_{4i} is the number of marginal farmers, X_{5i} is the number of small farmers, X_{6i} is growth of urban population, ϵ_i = error term

Description of variables

Jaynagar-1 showing high concentration (> 36.06%), while most other blocks fell within the medium range (17.16–36.06%) and Sonarpur, Jaynagar-2, and Kultali recorded low shares (< 17.26%), reflecting a gradual southward diffusion of cultivation. This trend became more pronounced in 2010–11, when Kultali and Jaynagar-2 recorded the highest shares (> 44.92%), whereas northern blocks such as Sonarpur, Bhangore-1, and Bhangore-2 remained in the medium category (25.19–44.92%). Jaynagar-1 C.D. block fell to a low share (< 25.19%), indicating a clear shift in cultivation toward southern low-land areas. However, by 2015–16, the overall percentage share declined significantly, with Kultali remaining the only high concentration zone (> 13.42%), most blocks falling in the medium range (8.42–13.42%), and Bhangore-1 and Jaynagar-1 recording low shares (< 8.42%). Notably, the blank (NA) areas in some years represent the absence of root vegetable cultivation, suggesting a complete crop shift or land-use change, possibly due to urban expansion in northern blocks or environmental constraints like waterlogging and salinity in certain southern areas (Chakraborty *et al.*, 2025; Ghosh *et al.*, 2020) [20, 21]. Root vegetables grow underground and are therefore highly sensitive to excess water and poor drainage; heavy rainfall and frequent flooding create waterlogged soil, which leads to root rot and the

spread of fungal diseases. Controlling these diseases often requires pesticides, but the high cost of these inputs makes them unaffordable for many small vegetable farmers. As a result, farmers face significant risks of total crop loss, which discourages them from continuing root vegetable cultivation. Consequently, they tend to shift toward crops that are more moisture-tolerant and less vulnerable to such environmental stresses (Pathak *et al.*, 2021) [22]. The declining class intervals over time further indicate a reduced relative importance of root vegetables in the cropping system, as farmers increasingly shifted toward high-value vegetables. This pattern is consistent with studies in other parts of India, where researchers have observed crop diversification, a declining share of traditional crops, and spatial relocation of cultivation in response to market demand, improved connectivity, and peri-urbanization (Bithal *et al.*, 2005; Pingali, 2007) [23, 3, 24].

Leafy vegetables: In 2000–01, the highest share of leafy vegetables (> 10.09%) was concentrated in Jaynagar-2, while most northern and central blocks such as Bhangore-1, Bhangore-2, and Baruipur recorded moderate shares (3.12–10.09%), and Sonarpur and Jaynagar-1 remained in the low category (< 3.12%). By 2005–06, Jaynagar-2 concentration increased further (> 20.7%), while Baruipur and Bhangore remained in the medium category (11.01–20.7%), and Kultali and other southern parts remained in the low category (< 11.01%). Sonarpur and Jaynagar-1 showed no leafy vegetable cultivation. In 2010–11, a significant shift occurred as northern blocks like Sonarpur and Bhangore-2 recorded the highest shares (> 7.61%), while central areas remained moderate (3.59–7.61%) and southern blocks such as Jaynagar-1 and Jaynagar-2 dropped to low shares (< 3.59%), and Kultali showed no cultivation. By 2015–16, Bhangore-2 showed a high share (> 10.63%), most blocks fell into the medium category (7.2–10.63%), and Jaynagar-1 and Jaynagar-2 remained in the low category (< 7.2%). Blank areas in some periods reflect localized cultivation gaps due to environmental constraints or farmers' deliberate shift toward more lucrative vegetable categories. Overall, the percentage share indicates that leafy vegetable cultivation experienced both spatial fluctuation and moderate growth, with a shift from southern dominance (2000–01).

(2000–01 to 2015–16)

Fruit and Flower vegetables: Figure 4 shows a clear pattern of expansion, diffusion, and eventual dominance across most blocks in the study area. In 2000–01, Jaynagar-1 and Jaynagar-2 had high concentrations (> 50.55%), while Bhangore-1 and 2 recorded moderate concentrations (28.33–50.55%), and Kultali remained in the low category (< 28.33%). In 2005–06, Kultali emerged as a high-concentration zone (> 54.51%), while most other blocks moved into the medium category (31.7–54.51%), and Bhangore-1 and II recorded relatively lower shares (< 31.87%). In 2010–11, the percentage share further increased, with Bhangore-1 and Jaynagar-1 recording very high shares (> 60.05%), while most other blocks such as Sonarpur, Baruipur, and Kultali fell within the medium range (46.87–60.05%), indicating widespread adoption across the subdivision. However, by 2015–16,

the pattern became more stable, with Bhangore-1 remaining the high concentration zone (> 58.47%), while most other blocks maintained moderate shares (49.58–58.47%), and Kultali and parts of Jaynagar-2 recorded relatively lower shares (< 49.95%). The increasing percentage share indicates that fruit and flower vegetables have become the dominant component of the vegetable cropping system in the study area. This can be explained by high market demand, better price realization, shorter cropping cycles, and suitability for peri-urban agriculture, especially near Kolkata. Farmers are likely shifting towards these crops because of higher profitability and improved transport and market linkages (Joshi *et al.*, 2006; Mariyono, 2018) [25, 26]. The growing dominance of fruit and flower vegetables across most blocks aligns with the theory of agricultural commercialization and crop diversification, which posits that farmers gradually shift from low-value subsistence crops to high-value, market-oriented crops. Several studies in India show that rising urban demand, better price realization, and improved transport connectivity encourage farmers to allocate more land to perishable but profitable vegetables such as tomato, brinjal, and cauliflower (Bithal *et al.*, 2005; Pingali, 2007) [23, 24].

Seed and Pod vegetables: In 2000–01, the highest share (> 9.14%) was observed only in Jaynagar-1, while Bhangore-1 recorded moderate values (1.49–9.14%), and Baruipur remained in the low category (< 1.49%); several blocks such as Sonarpur, Jaynagar-2, Kultali, and Bhangore-2 showed blank (NA) areas, indicating absence of cultivation, likely due to limited preference for these crops and unsuitable agro-climatic conditions. In 2005–06, the overall percentage share decreased drastically, with Jaynagar-2 block emerging as the zone with the highest share.

Most other blocks recorded very low or negligible shares (< 0.11% or 0.11–0.73%), and Sonarpur and Jaynagar-1 showed no cultivation, reflecting the reduced importance of this category. In the year 2010–11, a temporary shift occurred, with northern blocks such as Bhangore-1, Bhangore-2, and Sonarpur recording higher shares (> 1.24%), while southern blocks, including Jaynagar-1, Jaynagar-2, and Baruipur, remained in the low category (< 0.57%). However, by 2015–16, the pattern became localized again, with Jaynagar-1 emerging as the only high-concentration zone (> 1.98%), while Baruipur, Bhangore-1, and Kultali recorded moderate shares (0.5–1.98%). Most other blocks showed low values (< 0.5%) or absence (NA), particularly in Sonarpur. The percentage share of seed and pod vegetables remains very low and inconsistent over time, especially when compared to other vegetable categories, suggesting that seed and pod vegetables are a minor and unstable component of the cropping system in the study area. This pattern is consistent with broader findings in India, where studies highlight a shift away from less profitable or less demanded crops toward high-value horticultural crops driven by urban markets, better price realization, and commercialization of agriculture (Bithal *et al.*, 2005; Joshi *et al.*, 2006; Orsini *et al.*, 2013; Pingali, 2007) [23, 25, 27, 24].

Table 2. Distribution of Area under Vegetable Categories, Baruipur Subdivision

Blocks	Year	Root vegetables(%)	Leafy vegetables(%)	Fruit and flower vegetables (%)	Seed & pod vegetables (%)	Other vegetables (%)
Baruipur	2000-2001	50.12	3.87	7.99	0.24	37.77
	2005-2006	34.42	17.88	45.96	0.19	1.54
	2010-2011	43.38	5.14	47.94	0.48	3.05
	2015-2016	11.02	9.76	52.23	0.83	26.15
Bhangore-1	2000-2001	30.73	5.40	50.42	1.58	11.88
	2005-2006	18.55	20.69	31.75	0.04	28.96
	2010-2011	28.31	5.50	61.91	1.32	2.95
	2015-2016	4.82	8.69	71.33	0.05	15.10

(continued on next page)

Blocks	Year	Root vegetables(%)	Leafy vegetables(%)	Fruit and flower vegetables (%)	Seed & pod vegetables (%)	Other vegetables (%)
Bhagore-2	2000-2001	59.00	9.18	31.47	0.00	0.36
	2005-2006	47.64	14.86	18.78	0.27	18.45
	2010-2011	26.67	12.29	47.21	1.58	12.25
	2015-2016	13.27	15.44	55.33	1.23	14.74
Jaynagar-1	2000-2001	22.04	0.86	53.25	14.12	9.73
	2005-2006	46.86	0.00	53.14	0.00	0.00
	2010-2011	0.70	1.17	76.34	0.23	21.56
	2015-2016	8.27	5.70	53.00	4.15	28.88
Jaynagar-2	2000-2001	10.91	19.35	69.10	0.00	0.64
	2005-2006	32.58	25.76	32.58	1.52	7.58
	2010-2011	63.70	2.03	34.15	0.11	0.00
	2015-2016	0.00	4.80	54.63	0.34	40.24
Kultali	2000-2001	38.01	0.00	24.43	0.00	37.56
	2005-2006	6.31	0.08	88.00	0.10	5.49
	2010-2011	47.30	0.00	51.87	0.83	0.00
	2015-2016	19.33	8.64	43.58	0.83	27.62
Sonarpur	2000-2001	0.00	0.98	0.00	0.00	99.02
	2005-2006	0.27	0.00	32.15	0.00	67.57
	2010-2011	35.35	7.48	54.80	1.78	0.59
	2015-2016	8.81	9.37	49.37	0.00	32.46

Source: Agriculture Census of India (2000-2001 to 2015-16)

Other vegetables: The maps (Fig. 6) indicate that in 2000–01 and 2005–06, Sonarpur remained the dominant block (> 45.62% and > 33.92%), while southern blocks mostly recorded low shares. In 2010–11, the concentration shifted to Jaynagar-1 (> 12.46%), with several blocks, such as Jaynagar-2 and Kultali, showing no cultivation (NA), indicating crop substitution or low preference. In 2015–16, the pattern

again changed, with Sonarpur and Jaynagar-2 emerging as high-concentration zones (> 31.02%), while most other blocks showed moderate to low shares. Overall, the category shows instability and shifting concentration, and blank areas reflect a complete absence of cultivation, likely due to low profitability and replacement by more market-oriented vegetable crops.

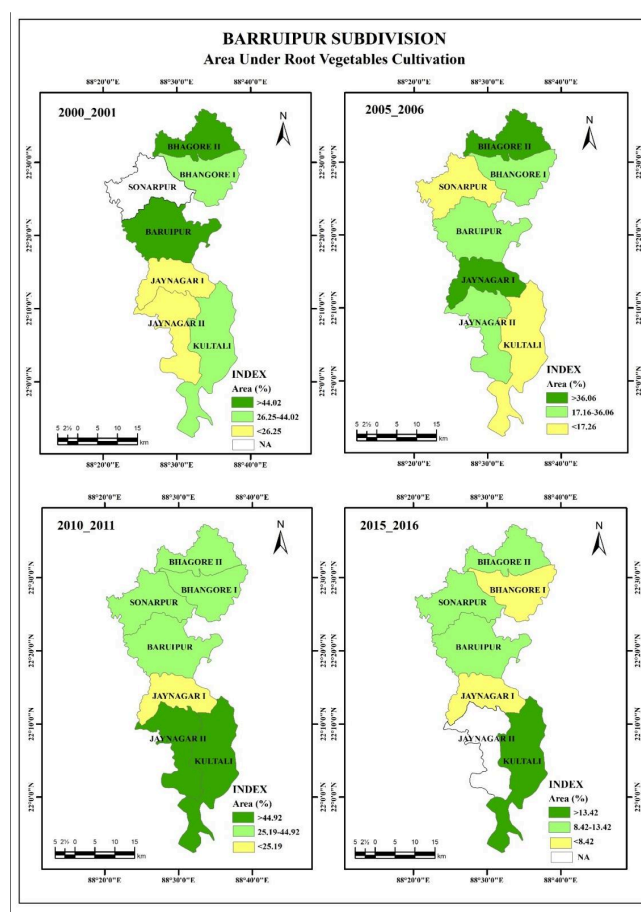


Figure 2. Area under Root vegetables (2000-2001 to 2015-16)

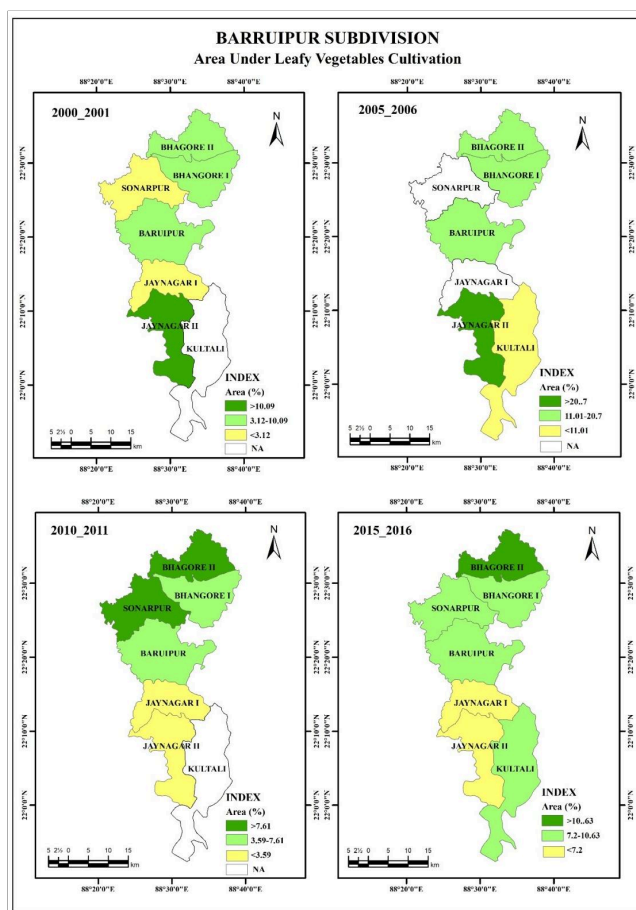


Figure 3. Area under leafy vegetables (2000-2001 to 2015-2016)

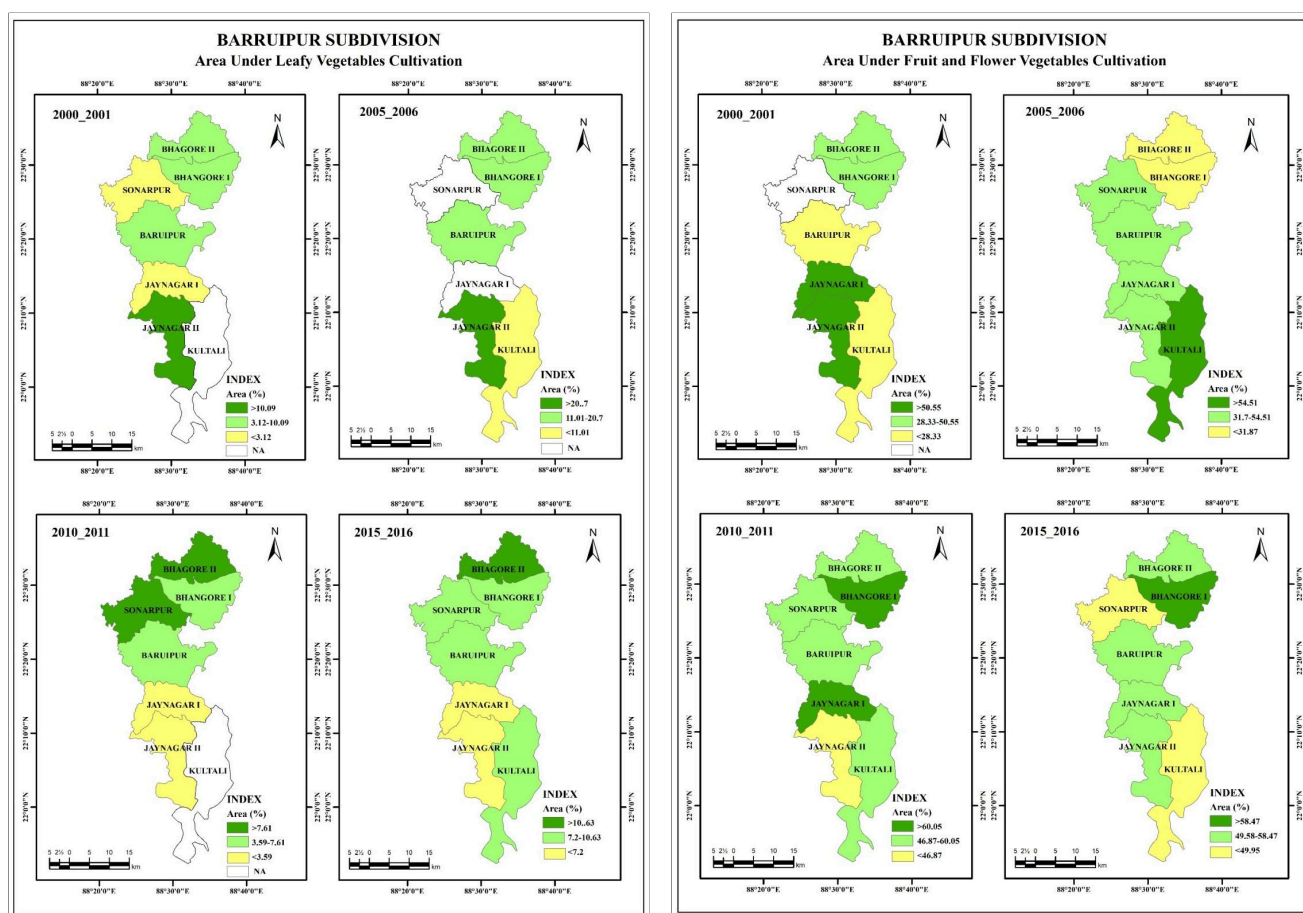


Figure 4. Area under Fruit and Flower vegetables (2000-2001 to 2015-16)

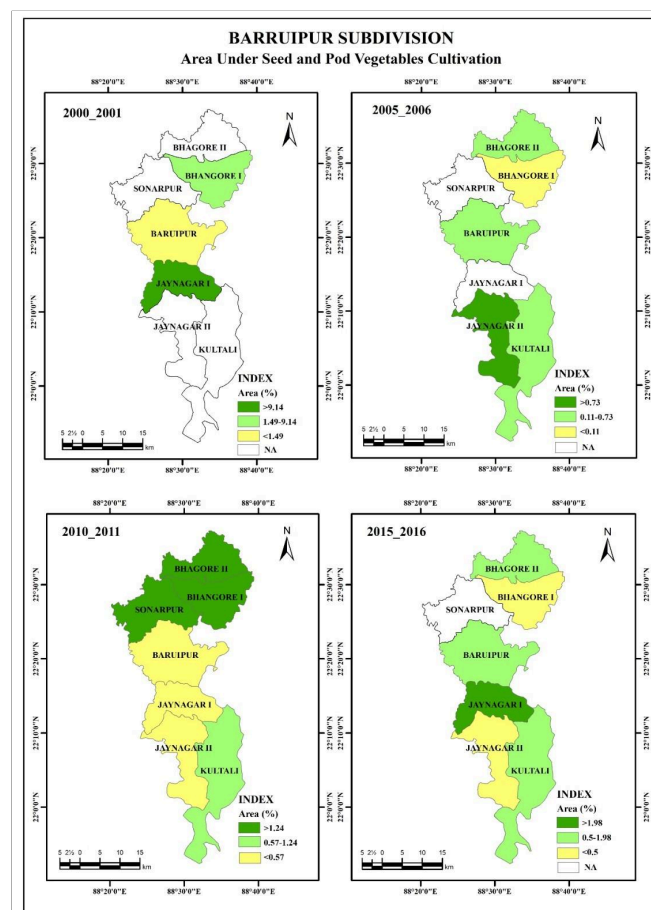


Figure 5. Area under Seed and Pod vegetables (2000-2001 to 2015-16)

Table 3. Block-wise growth rate of various vegetables in Baruipur Subdivision

BARUIPUR	GROWTH (%)			
	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	-13.53	606.70	-75.81	47.83
Leafy	481.25	61.29	80.67	1593.75
Fruit and flower	624.24	484.94	3.72	4293.94
Seed & pod	0.00	1300.00	64.29	2200.00
Other vegetables	-94.87	1012.50	715.73	365.38
BHAGORE-1	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	368.11	169.11	-92.00	0.81
Leafy	2872.31	-53.11	-25.72	935.38
Fruit and flower	388.30	243.89	-45.83	809.72
Seed & pod	-78.95	5350.00	-98.17	-78.95
Other vegetables	1790.91	-82.03	140.53	717.48
BHAGORE-2	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	42.42	94.47	17.72	226.06
Leafy	185.71	187.27	197.15	2338.96
Fruit and flower	5.30	773.02	177.34	2449.62
Seed & pod	4.00	1925.00	85.19	150.00
Other vegetables	9000.00	130.77	184.60	59666.67
JAYNAGAR-1	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	706.41	-99.74	6050.00	31.32
Leafy	-100.00	10.00	2440.00	2209.09
Fruit and flower	278.50	-74.51	260.92	248.16
Seed & pod	-100.00	2.00	9150.00	2.78
Other vegetables	-100.00	185.00	596.22	938.71
JAYNAGAR-2	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	-90.23	1283.72	-100.00	-100.00

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GROWTH (%)				
Leafy	-95.64	-44.12	426.32	-87.18
Fruit and flower	-98.46	641.86	257.05	-59.12
Seed & pod	2.00	-50.00	600.00	7.00
Other vegetables	-61.54	-100.00	839.00	3126.92
KULTALI	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	258.33	-62.13	331.58	485.71
Leafy	4.00	-100.00	220.00	220.00
Fruit and flower	7670.37	-97.02	787.20	1953.70
Seed & pod	5.00	-60.00	950.00	21.00
Other vegetables	215.66	-100.00	703.00	746.99
SONARPUR	2000-01 to 2005-06	2005-06 to 2010-11	2010-11 to 2015-16	2000-01 to 2015-16
Root	77.00	827.27	-62.04	271.00
Leafy	-100.00	151.00	90.73	28700.00
Fruit and flower	9009.00	-87.71	37.13	1518.00
Seed & pod	0.00	36.00	-100.00	0.00
Other vegetables	18644.55	-99.94	8216.67	888.12

Source: Calculated by the author based on agriculture census data (2000-2001 to 2015-16)

Table 4. Determinant factors of vegetable cultivation

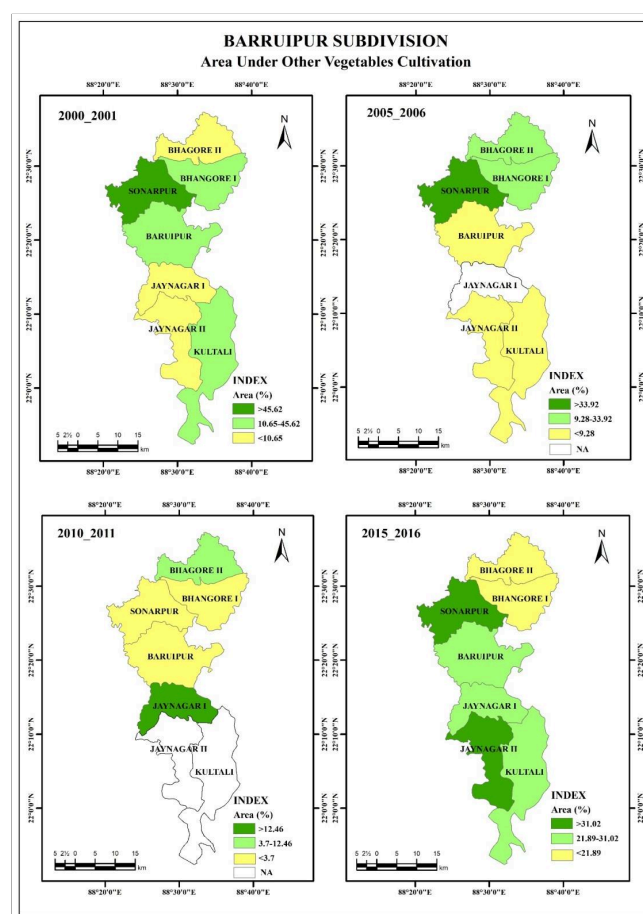


Figure 6. Area under Other vegetables (2000-2001 to 2015-16)

Table 3. clearly shows that growth patterns vary significantly across blocks and time periods. For instance, root vegetables recorded the highest growth in Jaynagar-1 during 2010–11 to 2015–16 (6050%) Similarly, leafy vegetables exhibited the highest growth in Bhagore-1 during 2000–01 to 2005–06 (2872.31%), fruit and flower vegetables, shows consistently high growth across most blocks (e.g., 4293.94% in Baruipur, 2449.62% in Bhagore-2, and 1953.70% in Kultali) during the overall period of 2001-02 to 2015-16. Seed and pod show the highest growth rate (9150%) in Jaynagar-1 during 2010-11 to 2015-16. Other vegetables show very high growth rates in Bhagore-2 (59666.67%) followed by Jaynagar-2 (3126.92%) during the overall period of 2001-02 to 2015-16. This is largely due to very low initial base values and does not indicate real dominance in the cropping structure. Vegetables also show negative growth trends across several blocks during different periods. For root vegetables, Baruipur recorded a decline of –13.53% (2000–01 to 2005–06) and –75.81% (2010–11 to 2015–16), while Bhagore-1 experienced a sharp fall of –92.00% from 2010–11 to 2015–16. Similarly, Jaynagar-2 shows a continuous decline of –90.23% (2000–01 to 2005–06) and –100.00% during both 2010–11 to 2015–16 and the overall period, indicating a complete reduction in the area under root vegetables. Leafy veg

(continued on next page)

etables also show notable negative growth in certain phases. For instance, Bhagore-1 shows declines of –53.11% and –25.72% in successive periods, while Jaynagar-2 records declines of –95.64% and –44.12% in the initial periods. Sonarpur also experienced a –100% decline in the early period (2000–01 to 2005–06). These fluctuations indicate that leafy vegetable cultivation is highly unstable and varies over time. Fruit and flower vegetables, although generally showing high overall growth, also experienced notable declines in several blocks. Bhagore-1 recorded a –45.83% decline, Jaynagar-1 recorded a –74.51% decline, Jaynagar-2 recorded a –98.46% decline, and Kultali experienced a sharp fall of –97.02% during 2005–06 to 2010–11. This indicates that, despite long-term expansion, short-term declines are quite pronounced. Seed and pod vegetables also demonstrate negative growth rates. Bhagore-1 shows –78.95% and –98.17%; Jaynagar-1 records –100% in the initial period; Jaynagar-2 shows –50%; and Sonarpur also experienced a –100% decline during 2010–11 to 2015–16. These drastic reductions suggest irregular cultivation patterns and possible crop substitution over time. Other vegetables also reveal strong negative growth in certain phases, such as –94.87% in Baruipur, –82.03% in Bhagore-1, –100% in Jaynagar-2, and –100% in Kultali during 2005–06 to 2010–11.

Variables	Model 1 Root Vegetable	Model 2 Leafy Vegetable	Model 3 Fruit and Flower	Model 4 Seed and Pod	Model 5 Other Vegetables
Literacy	-3.970944 (1.651924) **	1.140727 (0.3065) ***	1.360 (2.496)	-0.1901 (0.455)	1.660 (2.382)
Irrigation	0.0014926 (.0028059)	0.0027 (0.0005) ***	0.003 (0.0038)	-0.0006 (0.00086)	-.0071 (.00319)
NSA	-0.00233 (.0018887)	0.0003 (0.0003)	-0.0018 (0.0028)	0.000009 (0.0003)	0.0021 (0.002)
Marginal Farmers	0.0016207 (0.000999)	0.00035 (0.0002)	0.0016 (0.0017)	0.0001 (.00025)	-0.0037 (.0020)
Small Farmers	-.0046539 (.0069391)	0.00004 (0.0012)	0.0084 (0.0057)	0.0013 (.0017)	-0.0052 (.0081)
Urban Population	0.0001404 (.0001087)	-0.00003 (0.000022)	-0.00012 (0.00016)	-0.00001 (.00003)	-0.00008 (.00018)
Constant	308.11 (133.78) **	-86.42 (20.04)***	-100.50 (196.02)	9.752 (34.25)	-30.94 (160.48)
F Statistics	0.04	0.001	0.287	0.9827	0.26
F (6,7)	2.96	12.82	1.55	0.15	1.63
R ²	0.57	0.801	0.416	0.1976	0.5595
Root MSE	16.32	3.315	21.79	4.581	22.22
Observation	14	14	14	14	14

Note: Standard errors in parentheses * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Source: Prepared by the authors

Table 4 presents the multiple regression model of vegetable cultivation, accounting for different factors. In Model 1, root vegetable cultivation is negatively associated with the literacy rate at the 5% significance level. Root vegetable cultivation decreases by 3.97 units for each 1-unit increase in literacy rate. This model is statistically significant at the 5% level, with an R (Aynalem *et al.*, 2026) [4] of 0.57. This means that people are more health-conscious. As a result, they consume less at the individual level. Because root vegetables have various negative effects on health, such as increased glucose levels, lipid profiles, and blood pressure (Knez *et al.*, 2022) [6].

In model 2, leafy vegetable cultivation is positively associated with the literacy rate. Leafy vegetable cultivation increases by 1.14 units for a one-unit increase in literacy rate. It is statistically significant at the 1% level. Literate farmers are aware of market demand and have more knowledge regarding crop cultivation. Leafy vegetables are an important source of vitamins C and E and carotenoids, which support metabolism (M. Knez *et al.*, 2024; Nurzyńska-Wierdak, 2025; Thakur *et al.*, 2022). As a result, farmers cultivate more high-value crops. The study also shows a positive association between leafy vegetables and irrigated area, with leafy vegetables increasing by 0.0027 units per 1-unit increase in irrigated area. It is statistically significant at the 1% level. The model is also significant at the 1% level. The remaining three models are not statistically significant.

The study findings carry practical relevance for regional agricultural planning. Identifying the specific blocks where root vegetable cultivation is declining, and where fruit and flower vegetables are expanding, gives policymakers and extension agencies a spatial basis for targeted interventions — whether in irrigation infrastructure, drainage management, or market-

linkage support by the policymaker.

The unavailability of recent data constrains the study, as the latest Agricultural Census data is available only up to 2015–16 and may not reflect current trends. Production data for different vegetable categories were not available. Not all variables have consistent time-series data, limiting detailed comparisons across years.

Conclusion

The study shows that vegetable cultivation in the Baruipur subdivision has changed notably over time. There has been a clear transition from subsistence-based farming to more commercially oriented agriculture, with fruit and flower vegetables emerging as the dominant category across most blocks. The region's proximity to Kolkata mainly drives this shift through better market connectivity, higher profitability, and evolving consumer preferences. Meanwhile, root vegetables have become less important. Root vegetables are highly sensitive to excess water and poor drainage. Heavy rainfall and flooding cause waterlogging, leading to root rot and fungal diseases. High pesticide costs make disease management difficult for small farmers. As a result, repeated crop losses discourage root vegetable cultivation, leading farmers to shift toward more moisture-tolerant crops. Leafy vegetables show moderate yet inconsistent growth, and seed and pod vegetables remain marginal. The findings also suggest that factors such as literacy rate and irrigation significantly influence cropping decisions. Therefore, to ensure the sustainable development of vegetable cultivation, proper planning, updated data, and policy support are essential

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