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An Appraisal Of Urban Growth Pattern Of Berhampore Town In Murshidabad District (West Bengal)

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Abstract

By displacing areas of vegetation with residential and commercial sectors, as well as the associated infrastructure, the expansion of urban areas has a substantial impact on land use, which raises adverse impact on urban ecology. The goal of this study is to look into how changes in land use and land cover in Berhampore town over the past two decades have been impacted by urban growth. The normalised difference vegetation index (NDVI), and normalised difference water index (NDWI) maps were additionally made using Landsat8 Operational Land Imager. The spatial expansion of built-up areas of Berhampore town is estimated as 26.46%, 37.46% and 57.16% in 2000, 2020 and 2023 respectively of the total geographical area. The case study presented in this research would help urban planners estimate urban expansion under various land cover features and, as a result, prepare appropriate strategic actions.

Keywords: Urban growth, Multi-temporal Satellite Data, Land use/land cover, Berhampore town

Introduction

Due to ongoing urbanisation, land covers in metropolitan areas can change dramatically more quickly than elsewhere. Due to the country's fast economic expansion, peri-urban regions in China were particularly troubled by urbanisation and saw frequent land cover changes. As remote sensing photos are often current and provide a panoramic perspective, they are perfect for monitoring and detecting these changes. Researchers have been more interested in employing remotely sensed imaging to solve urban and suburban challenges during the past 20 years (Jacquinetal, 2008). Several methods for autonomously mapping urban land cover using satellite images have been developed, put into use, and assessed. These methods can be broadly divided into two categories: (1) those based on the categorization of the input data, which include

object- and pixel-based classifications (Guindonetal, 2004, Cleveetal, 2008); and (2) those based on the direct segmentation of the indices, such as the widely used normalised difference vegetation index (NDVI). But obtaining precise remote-sensing-based products for urban regions is fundamentally difficult due to the spatial and spectral variabilities of the urban environment (Powell et al., 2007). Therefore, it is still important to make improvements to automated mapping of urban land use using satellite imagery.

In the early 20th century, West Bengal was one of the largest and most populated states in the nation and was largely centred on Kolkata. West Bengal now has an urbanisation rate of 31.87 percent, which is somewhat higher than the national average. The application of satellite data and Geographical Information Systems (GIS) for evaluating city expansion and sprawl development patterns has been the subject of extensive research in recent years. In a thorough investigation of the dynamics of urban land cover, Herold et al., (2003) used remote sensing data to create spatial (landscape) metrics that were then examined and interpreted in combination with the outcomes of spatial modelling of urban expansion. According to several reports (Kong et al. 2016; Zhao et al. 2017), time series NDVI shows seasonal variations in plant cover. In NDVI time series, characteristics with the same or similar spectral signatures correspond to the same type of land cover, according to an analogy. In metropolitan environments, where there are more enduring elements, this presumption is more plausible. The urban setup and its surroundings are a heterogeneous environment that occupy the lower portion of the NDVI scale with extremely narrow width for determining distinctive land-cover types, in contrast to vegetated regions with broad range of NDVI value, usually between 0.3 and +1, to classify vegetation into numerous groups (Kinthada 2014; Zhao et al. 2017). According to Dewan and Yamaguchi (2009) and Boori and Amaro (2010), remote sensing is important because it provides a "unique view" of the spatial and temporal dynamics underlying phenomena such as urban expansion and land use change.

Despite having a significant impact on urban growth, small and medium-sized cities and towns are frequently disregarded. Therefore, Berhampore Town, a tiny city in West Bengal, has been selected as the research location for a better understanding of the urban dynamicity in small size towns/cities of India, even though the nature of urban dynamicity and magnitude of city growth differs on several aspects from area to area.

Study Area

City of Berhampur, also known as Baharampur, is located in West Bengal's Murshidabad district. The Bhagirathi River, a significant Ganga River tributary, passes by the city of Berhampore on its eastern bank (Figure 1). According to physiography, the entire study area lies in a plain area. The south west monsoon season brings with it well-distributed rainfall, an oppressively hot summer, and excessive humidity almost the entire year. The soil is grey or reddish, with iron oxide and nodular lime ghutting strewn about (kankar).

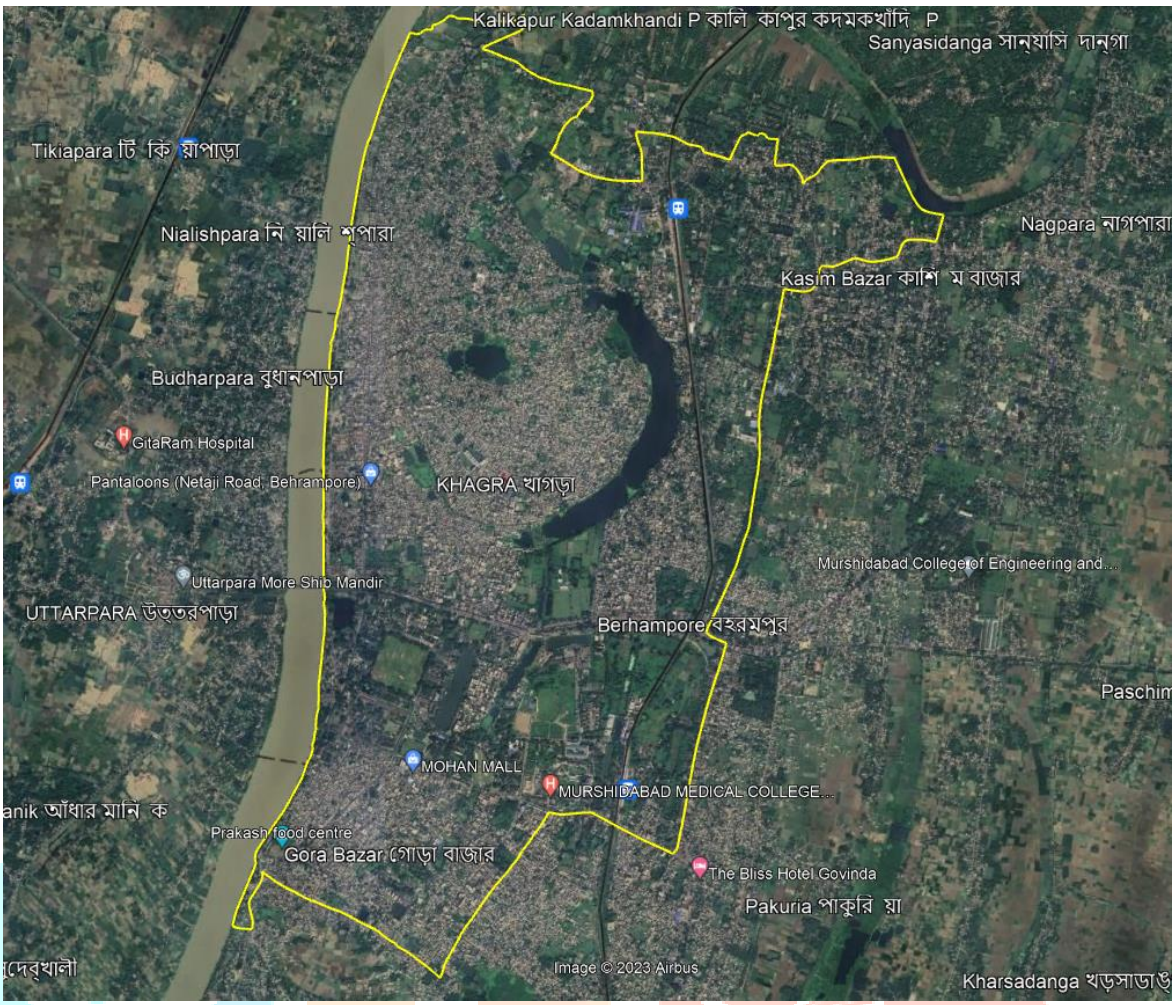

Figure 1: Location map of Berhampore town in Murshidabad district in West Bengal (India)

In the regions of Berhampore, Islampur, and Beldanga, which are known for their sericulture operations, mulberry farming is prevalent. Mango enthusiasts adore kinds including Shadulla, Himsagar, Ranipasand (the queen's favourite), Begumpasand (the Begum's favourite), Sharanga, Mulayamjam, and Kohitur (the king of mangoes). According to the 2011 Census India data, there are 195,223 people living in the Berhampore Municipality, of which 100,247 are men and 94,976 are women. Berhampore Municipality has a sex ratio of 947. Male literacy rates in Berhampore are at 92.25%, while female rates are 87.74%.

Materials & Methods

Data collection and processing

The study area boundary was collected from the Berhampore municipality office. The Census of India, Berhampore Municipality, the Ministry of Urban Affairs (Govt. of West Bengal), and numerous publications and magazines are the sources of population data. Three cloud-free Landsat8 – Operational Land Imager satellite images (2000, 2010 and 2023) measuring 138 paths and 43 rows were freely acquired from the United States Geological Survey website in order to study the urban growth of Berhampore town. Geometric and radiometric adjustments were made to the resulting images. The peri-urban regions around the urban agglomeration of Berhampur are shown on the administrative map. Zone 45N and WGS-84 datum UTM coordinates were used to register the administrative map of Berhampore. The processed images were selected using the corrected map. subsequently the clipped images were used for LULC change detection and urban expansion illustrating

Delineation of Built-up areas

The remote-sensing (satellite)-derived normalised difference vegetation index (NDVI), which measures vegetation vigour, is closely related to each other. The varied colours (wavelengths) of the reflected visible and near-infrared sunlight from the plants are examined to estimate the density of green on a piece of land. The difference between near-infrared (NIR, $Band_4$) and Red ($Band_3$) reflectance divided by their sum is used to calculate the NDVI (Reid et al., 2018).

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

where RED and NIR are abbreviations for measurements of spectral reflectance made in the red (visible) and near-infrared bands, respectively. NDVI scales from 1 to 1, with lower values denoting a lack of vegetation (such as water) and higher values denoting a large amount of healthy vegetation (Idrees et al., 2022). The index was created using remote-sensing satellite photos with a resolution of 30 m from Landsat5 - Thematic Mapper data in 2011 with a cloud cover of less than 2%.

The Normalised Difference Water Index (NDWI), which uses reflected near-infrared light and visible green light to distinguish between open water features and highlight their existence in remotely sensed images, was created. Remote sensing data from water bodies may be used to assess their turbidity thanks to NDWI (Mc Feeters, 1996). Changes in the liquid water content of plant canopies might affect NDWI. Equation is used to compute the NDWI.

$$NDWI = \frac{Green - SWIR}{Green + SWIR}$$

While built-up areas and barren terrain significantly increase in reflectance from $band_4$ to $band_5$, vegetation has a slightly larger or smaller DN value on $band_5$ than on $band_4$. This pace of growth is notably quicker than other coverings. $Band_4$ has much lower minimum and maximum DNs than $band_5$ for the same cover. When these two bands are standardly discriminated, the result will be values close to 0, negative values for waterbodies, and positive values for built-up pixels, allowing the latter to be separated from the remaining cover. Built-up index is a binary image that only shows built-up and barren areas with larger positive values, allowing BU to identify built-up areas automatically.

$$BU = NDWI - NDVI$$

Trend analysis

The geographic distribution of built-up areas is seen from a three-dimensional viewpoint by using the Trend Analysis tool (Zhang et al., 2021; Dinda et al., 2019). Plotting of built-up area distribution sites takes place on the x,y plane. The region above each point is determined by the stick's height in the z-dimension. The built-up area is subsequently displayed as scatterplots onto the x, z, and y, z planes, which is a special feature of the Trend Analysis tool.

Results

Estimation of growth rate

According to the 2011 census, the town has 305,609 residents and an overall population density of 18,332 people per square kilometre. It is predominantly a service town. Table 1 illustrates the growth rate of Berhampore town during the period between 1901 and 2021. Over the past five decades, the decadal growth rate has ranged from +26.63 (1971) to +38.84 (2001). The lowest growth rate is calculated in 1911 (+2.02) and the highest decadal growth rate is calculated in 2001 (+39.10), followed by 1951 (33.82) and 1971 (+26.63).

Table 1: Urban population growth rate in Berhampore town by decade from 1901 to 2011

Year	Urban Population	Growth Rate
1901	24397	-
1911	26141	+7.16
1921	26670	+2.02
1931	27403	+2.75
1941	41558	+5.65
1951	55613	+33.82
1961	62317	+12.05
1971	78909	+26.63
1981	92889	+17.72
1991	115144	+23.95
2001	160168	+39.10
2011	195223	+21.89
2021	240515	+23.20

Expansion of built-up area

Figure 2a portrays the geographical expansion of built-up areas of Berhampore town in 2000, covers approximately 26.46% of the entire study area. The results also showed, the built-up areas are mostly expanded in west and south of the Berhampore town. In the Berhampore town, the maximum built-up areas are observed in Ward no. 22, 21, 17, 15, 23, 13, and 10. The medium areal coverage of built-up area are observed in ward no. 7, 8, 12, 14, 16 and 23. The low areal coverage of built-up area are found in ward no. 1, 6 and 25. The areal coverage of built-up areas are negligible in ward no. 3 and 4.

Figure 2b illustrates the geographical distribution of built-up areas in Berhampore town in 2010, covers approximately 37.46% of the entire study area (Table 2). Results showed the areal distribution built-up in Berhampore town is expanded in the study area. More than 90% of the area is covered with built-up area in ward no. 7, 8, 10, 16, 17, 18, 21 and 22. Medium dense built-up areas are mostly covered in ward no. 5, 11,

15, 19 and 23. Low areal coverage built-up areas are observed in Ward no. 3, 6, 9 and 25. Very low coverage of built-up areas in the Berhampore town are observed in Ward no. 1, 2, 3 and 4.

Figure 2c portrays the areal coverage of built-up area in Berhampore town in 2023, covers approximately 57.16% of the entire study area (Table 2). Areal coverage of built-up areas is mostly observed in the west, south and central part of the town. Most of the areal coverage of built-up areas are found in ward no. 7, 8, 10, 13, 15, 18, 21 and 22. Medium coverage of built-up areas are found in ward no. 5, 6, 16, 19, 20, 23 and 24. Low coverage of built-up areas are observed in ward no. 3, 9, and 25. Very low coverage of built-up areas are mostly observed in ward no. 1, 2 and 4.

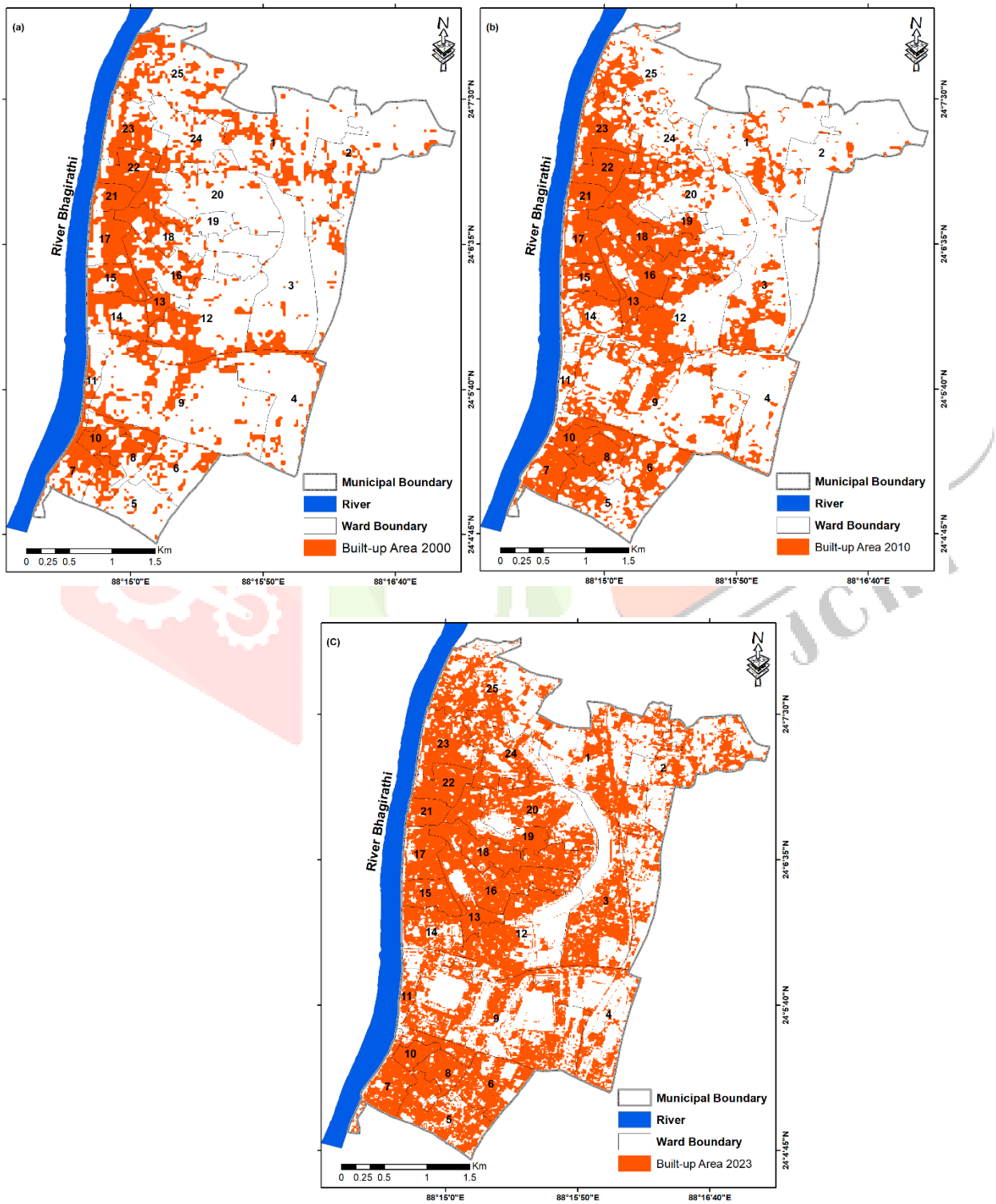

Figure 2: Spatial distribution of built-up area in Berhampur town during the period between 2000 and 2023

Table 2: Areal distribution of built-up areas in Berhampore town during the period between 2000 and 2023

Year	Area (in Sq. km)	Percent
2000	3.595	26.46
2010	5.09	37.46
2023	7.768	57.16

Trend Analysis

A trend exists because the curve across the predicted locations is linear, as the blue line in the image below illustrates (Turok and McGranahan, 2013). It indicates that the trend is emphasised and exhibits a strong upside in west and down east side shape if the polynomial follows a clear pattern, such as a downward curve as seen by the green line in the figure 3a. This indicates that most of the built-up areas were covered in west of the city.

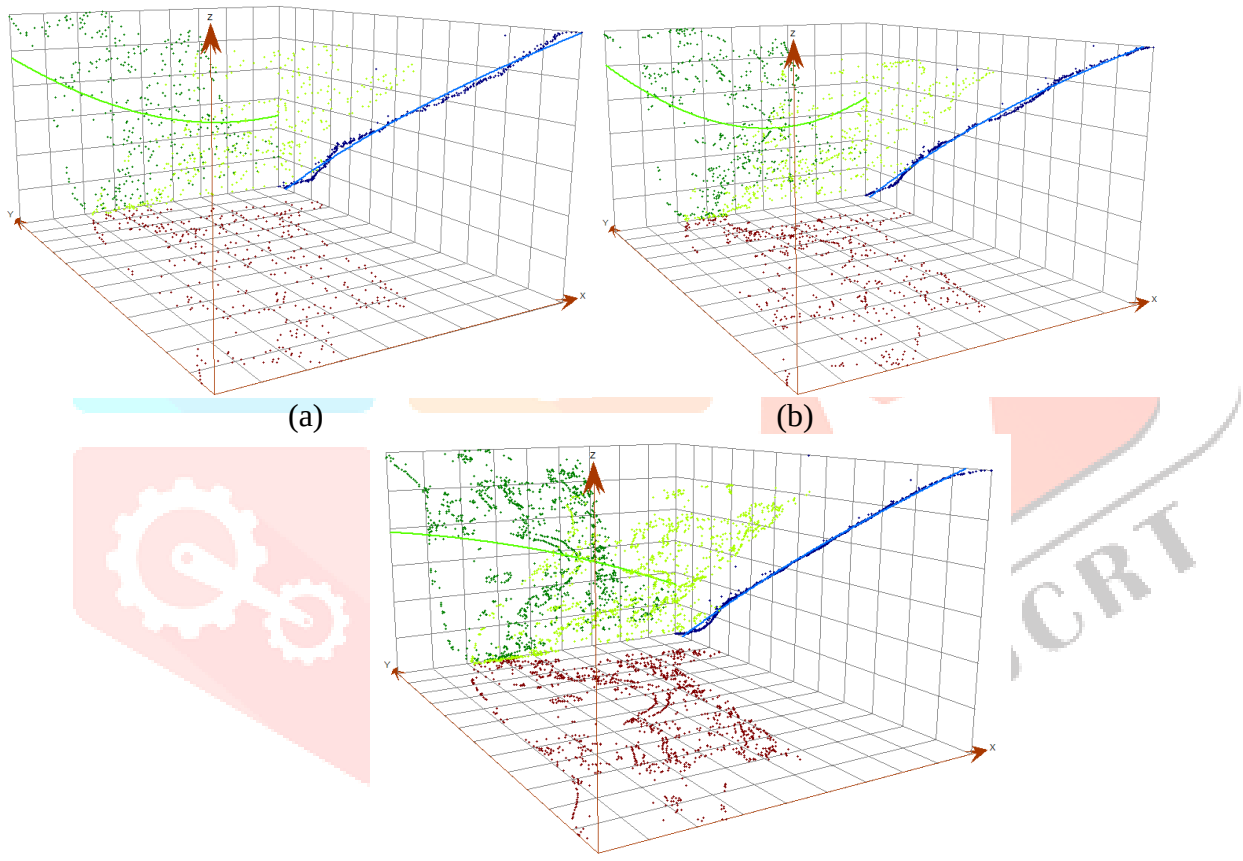

Figure 3: Trend analysis of built-up area in Berhampur town (a) 2000 (b) 2010 and (c) 2023

Figure 3b illustrated the trend analysis of built-up area distribution in 2010. Its greatest effect is felt from the west to the east (that is, the west has the greatest coverage of built-up area, while the east has the least amount of built-up area). A three-dimensional graphic of the town of Berhampore shows the built-up region above the study site plot raised to the height of the areal coverage values in the Trend Analysis of 2023 (Figure 3c).

Summary and Conclusion

Berhampore town is experiencing tremendous population increase. The town has evolved into a commercial hub for an agricultural region, with industries like silk weaving, ivory carving, and other types of home industries, in addition to industries like milling flour, rice, and oil seeds (Roy and Mondal, 2022).

Additionally, this town is highly known for the production of ivory and wood carvings, bell-metal and brass kitchenware, and other household items. West Bengal's Berhampore is a popular destination for tourists. Being the initial headquarters of the East India Company and having a long, rich history with "Nawabs," "Kings," "zamindars," (rulers), and other European colonial forces including the Dutch, Portuguese, English, and French, it attracts both domestic and foreign tourists. Currently, the construction industry is booming, with new financial company branches, apartment buildings, multi-story structures, and other commercial market locations all being built. These are the factors that are attracting immigrants to the town, which has prospered.

For commercial activities, there is dense settlement and linear settlement along the riverbank. On the west side of the Bhagirathi River, a growth pole formed. The Bhagirathi River, which supplies drinking water to densely populated areas, is where the town of Berhampore is situated (Sharma, 2012; Halder, 2014). One major benefit that was acknowledged was the protection provided by the Bhagirathi rivers. The primary modes of transportation and communication were the railway and the Bhagirathi River. Several paleo-courses, which appear to be the remains of the older channels of the river Bhagirathi, may be found on the western side of Berhampore town, according to an analysis of satellite and aerial images. The fact that these paleo-channels cross-cut with subsequent channels suggests that they may not all date from the same time period. The town's expansion was impacted by the river's altered path.

The recently acquired portion of Berhampore makes up the southern and eastern periphery, while the older portion of the town covers the centre and western regions. The inner region is defined by a transitional land use pattern, high land value, proximity to the central business district (CBD), outdated and inadequate urban infrastructure, and increasing commuting as a means of preventing permanent migration. These elements caused the population growth rate in this area to be negative. For instance, the river served as an approach track, or water way, for the establishment of European colonies prior to independence. The settlement is located in a low-lying, frequently flooded location. The town's expansion was impacted by the river's altered path. The town had a surge of refugees following India's independence. The town had a surge of refugees following India's independence. As a result, the Bhagirathi River and railway line have a larger concentration of refugees. Therefore, it can be inferred that the river Bhagiratghi has been crucial to the growth and development of this metropolis as well as to its future extension.

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Conflict of Interest

No Conflict of interest

Funding Agency

No funding Agency

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