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Land Use and Land Cover Change and Its Environmental Implications in Berhampore Municipality, West Bengal

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Abstract: Rapid urbanization in small and medium cities of India is causing significant changes in land use and land cover (LULC) in rapid ways. The current study analyses land use changes in Berhampore Municipality of Murshidabad district of West Bengal between 2016, 2020 and 2025 using Sentinel-2 satellite imagery with spatial resolution of 10m. Only four LULC categories were identified e.g. water bodies, vegetation cover, built-up areas and open land from respective images. To achieve better classification accuracy, we have considered all the reflective bands along with some index oriented classification output. The results show that built-up area has increased from 41.81% in 2016 to 53.93% in 2025. On the contrary, open land has decreased from 27.85% to 16.61%. There has also been a steady decline in water bodies and vegetation cover over the study area due to growing inflow of rural urban migration. These changes are posing serious environmental challenges in terms of wetland health, urban heat island effect (UHI), waterlogging, and sustainable urban development. Lastly, this study emphasizes the need of integrated land use planning discission considering the environmental conservation and also for forecasting possible future change in growth pattern.

Keywords: Land Use Land Cover, Urbanization, GIS, Remote Sensing, Berhampore Municipality, Sustainable Development

Introduction

Urbanization process in India is not restricted merely to the major metropolitan cities but is largely determined by Census defined Class-I towns, of which there are more than 468 across the country [1]. As a result, the urbanization process is shaped predominantly by Class-I towns, statutory towns and functional (including market and food-based) towns, besides large cities [2].

In India, the leap of urban growth in small and medium-sized cities has been particularly noticeable, with significant implications for land resources, ecological balance, and environmental sustainability [3-4]. Land use and land cover (LULC) change studies provide critical insights into the spatial dynamics of urban expansion, helping policymakers anticipate future challenges and opportunities.

Berhampore Municipality, the district headquarters of Murshidabad in West Bengal, has undergone rapid growth over the past decade. The conversion of open land and vegetation into built-up areas has intensified pressure on natural resources, leading to challenges such as waterlogging, biodiversity loss, and reduced liveability [5]. Understanding these changes is crucial for planning sustainable urban development in the region.

Urbanization is considered to be one of the major land cover transformation processes worldwide, but its magnitude has gone beyond the threshold in the last 2-3 decades. In India, urban sprawl has been observed to the greatest extent in recent decades in small and medium cities, which has a profound impact on natural resources, ecological balance and sustainable urban development [3-4]. Research on land use and land cover (LULC) changes is very useful in understanding the spatial dynamics of urban expansion.

Berhampore Municipality, headquarters of Murshidabad, has witnessed rapid changes in recent years. The conversion of open land and vegetation cover into built-up areas is increasing creating a problems such as waterlogging, loss of biodiversity, heat island effect and degradation of the quality of liveability etc. [5]. For this reason, Understanding LULC changes is crucial for planning sustainable urban development in the class-1 towns.

This study aims to (i) assess the spatial and temporal changes in LULC between 2016, 2020, and 2025, (ii) identify major trends in urban sprawl, and (iii) discuss the environmental implications of these changes.

Materials and Methods

Study Area

Berhampore, is the district headquarters of Murshidabad in West Bengal, located on the left bank of the Bhagirathi River. According to Census of India, this town has been identified as Class I city [6-7] that creating a nodal centre of road network between North and South Bengal. The municipality covers approximately 13.61 sq. km, comprising low inter building distance, growing commercial hubs, numerous water bodies, and fragmented vegetation patches (Figure 1). Its strategic location has made it an transport and trade canter, and it attracting continuous population influxes that result into urban sprawl. Over the past few decades, rapid urban growth of this town has led to huge encroachment of natural wetlands, open space, and agricultural land. Locating at the lower Gangetic plains, this town experiences a humid tropical climate with annual rainfall ranging from 130 to 160 cm, and the temperatures vary from 10°C in winter to 40°C in the summer months which aggravates drainage related issues like urban flood, drainage clogging and so may hygienic issues. The morphology of this urban settlement exhibits sharp contrasts where Khagra, Indra Prastha Gorabazar are densely populated and have high impervious surface, while the outlying urban areas have sub-urban characteristics with open land and informal settlements. This spatial diversity of urban density and lack of open space affects building density and urban infrastructure. Socio-economic vulnerability amalgams this problem, as low-income households existing in the urban fringe often lack access to formal waste services and option to open disposal of waste next to drains. These factors make the Berhampore municipality an important case to examine how growth of settlement interconnect with green space, blue scape and open area, creating spatial vulnerabilities that directly impact public health and environmental sustainability.

Data Sources and preparation

Sentinel-2 satellite imagery for the years 2016, 2020, and 2025 were acquired and used to assess the LULC maps and urban growth of Berhampore town. The spatial resolution of sentinel-2 images are 10m and it provides multispectral bands across the visible, near-infrared, and shortwave infrared regions which is suitable for any land use studies related to small urban areas [6]. The pre-processing, geometric and atmospheric correction and classification of the images were performed using QGIS 3.40.5 and ArcGIS 10.5 software's. In the analysis, all the reflective bands along with some index oriented classification results were utilized as separate bands to achieve better classification accuracy. Specifically, to predict the urban green space, the Normalized Difference Vegetation Index (NDVI) [11] and on the other hand to achieve precious measurement of the blue spaces the Normalized Difference Water Index (NDWI) [10] have been used. After that, this staked of both original spectral bands and vegetation/water indices give precious discrimination between built-up, vegetation, open area, and water body classes, similar to methods applied in previous urban LULC studies [7]. The images were co-registered to a common projection system and municipal vector overt boundary has been used to clipping of raster images.

Finally, supervised image classification with maximum likelihood classifier algorithm has been carried out using training samples collected from the vast study area for the representative of the four LULC categories: built-up area, vegetation, water bodies, and open area. About 150 training sites were collected for each land use categories through visual interpretation of high-resolution Google Earth images and GPS based field investigation with ground knowledge, ensuring accurate representation of the spectral variability of each class. After accomplishment the all results the classified maps were further refined by visual inspection and recoding of misclassified pixels.

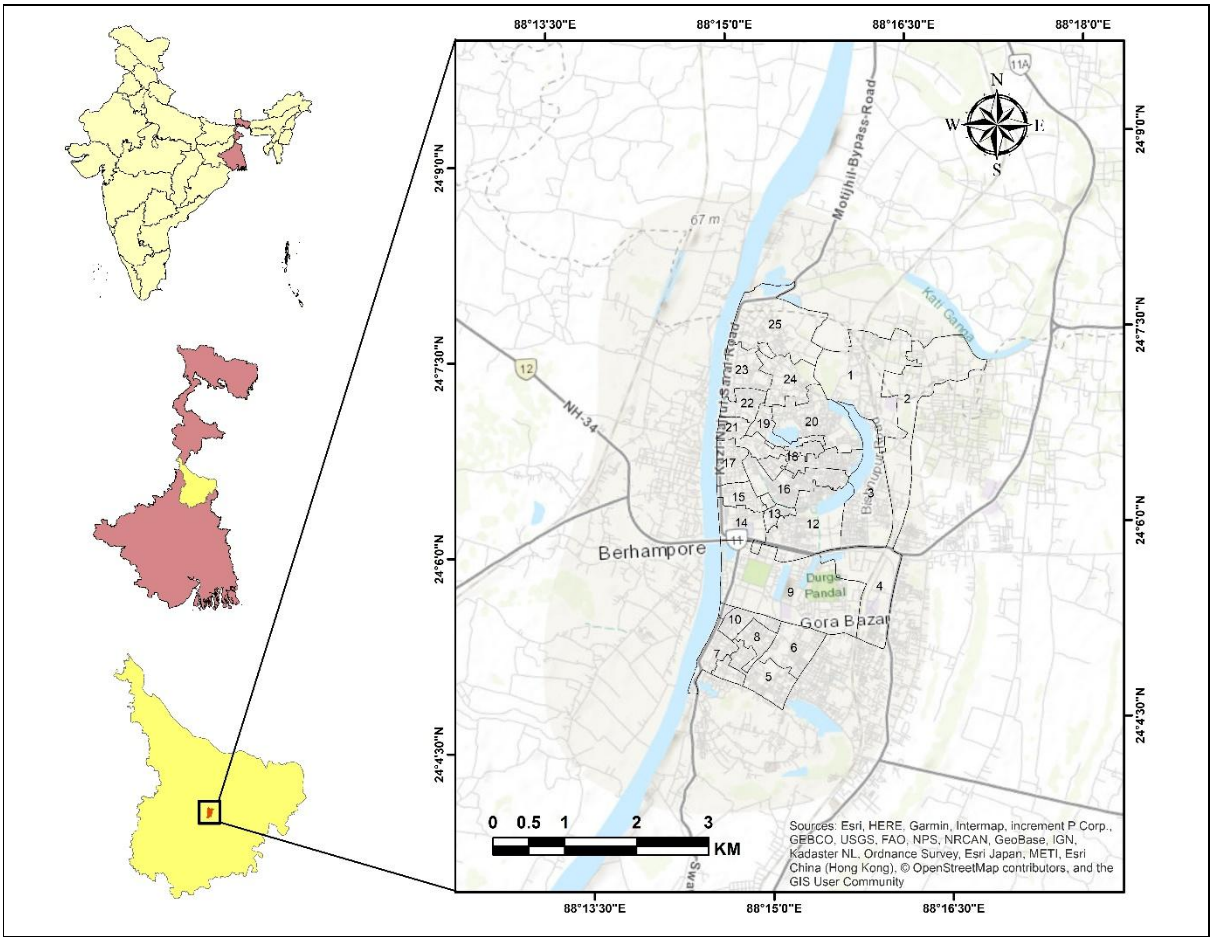

Figure 1. Location map of the study area

Classification and Accuracy Assessment

The accuracy assessment has been conducted using confusion matrices and Kappa statistics. The classification results achieved overall accuracies of 88.6% for the year 2016, 90.5% for 2020, and 90.6% for the year 2025, with corresponding Kappa coefficients of 0.836, 0.862, and 0.857, respectively. Both the user's and producer's accuracies for the individual classes were generally high, with built-up and water body classes showing greater than 90% accuracy in all years, that is due to vegetation and water indices whereas the open area exhibited slightly lower performance due to spectral similarity with old buildings and grass and bushes patches.

These findings confirmed that the applied methodology generated reliable LULC maps suitable for analysing urbanization trends. All the classification accuracy exceeds the threshold recommended (85%) for land use studies, providing confidence in the subsequent spatial and temporal change detection analysis.

Results

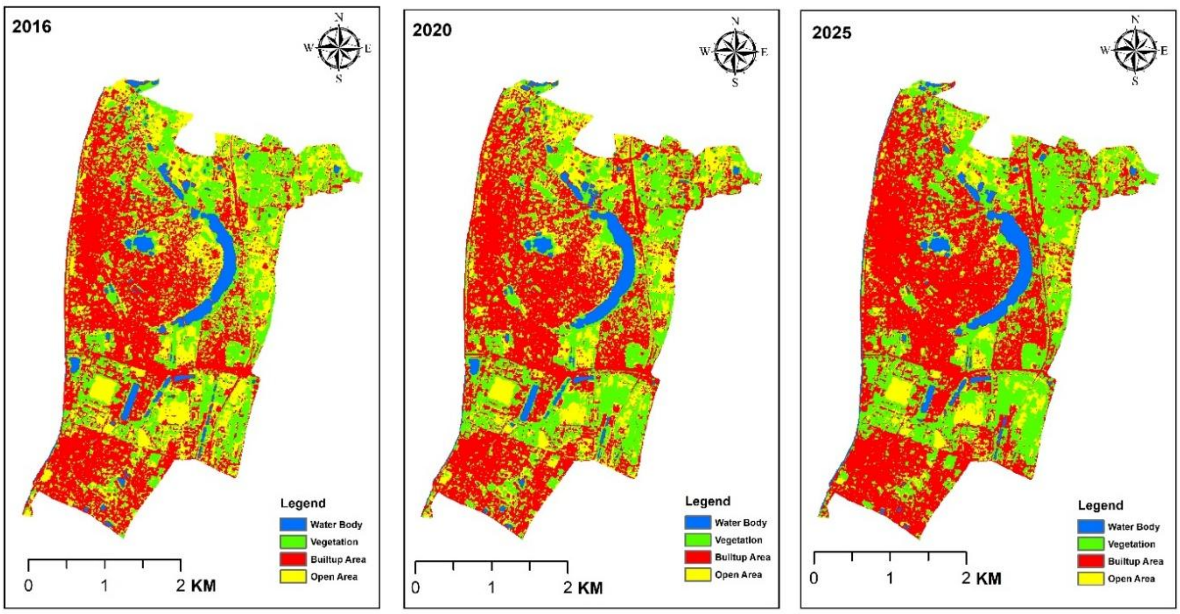

Figure 2. LULC map of the study area

Table 1. Area calculation of the study area

LULC Classification	2016		2020		2025	
	Area (sq.km)	Percentage	Area (sq.km)	Percentage	Area (sq.km)	Percentage
Water Body	0.68	5.00	0.67	4.92	0.65	4.78
Vegetation	3.45	25.35	3.39	24.91	3.36	24.69
Built-up Area	5.69	41.81	6.25	45.92	7.34	53.93
Open Area	3.79	27.85	3.30	24.25	2.26	16.61
Total	**13.61**	**100.00**	**13.61**	**100.00**	**13.61**	**100.00**

Source: Prepared by Authors

The maps prepared show the built-up area of Berhampore Municipality in 2016, 2020 and 2025 along with the dynamics of urban sprawl. Here, an attempt has been made to briefly illustrate how the urban infrastructure of the municipality has changed over time, thereby trying to understand the rate of change within a one decade time span (Figure 2).

The red patches on the maps represents the built-up areas, which mostly include residential areas, commercial canters, industrial areas, transport infrastructure (such as roads) and other inadequate surfaces associated with urban development. Together, these elements make clear the true extent and nature of rapid urban growth. Looking at the 2016 map, it is seen that the built-up areas were mainly concentrated in the central part of the municipality. But in the 2020 map, urbanization has intensified in the outskirts of the municipality. The trend of urban sprawl has increased in the south and northeast. The land cover and land use of Berhampore Municipality have clearly changed between 2016 and 2025. The biggest transformation during this period has been in the built-up area. In 2016, about 5.69 sq km (41.81%) of the total area of the municipality was built-up. In a span of ten years, this has increased to 7.34 sq km (53.93%) in 2025. That is, more than half of the area of the municipality has now become built-up area. This continuous increase clearly indicates the rapid pace of urbanization (Figure 3).

The built-up area is now not limited to the center or periphery; rather, it is spread across the entire geographical spread of the municipality. Areas that were previously in the form of separate built-up areas have now joined together to form larger, contiguous and continuous urban areas. Thus, the expansion of urban infrastructure has gradually lost its concentricity and taken on a multifaceted and extensive form, which is a familiar feature of urban sprawl. These changes are mainly a reflection of Horizontal Urban Sprawl.

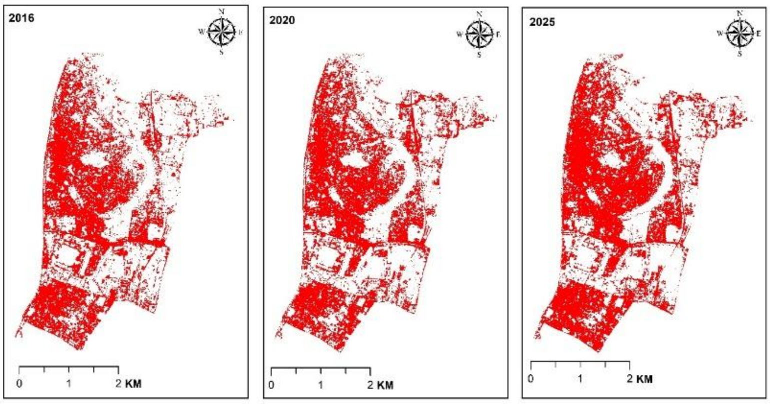

Figure 3. Temporal changes in LULC in Berhampore municipal area

It is clearly observed that areas that were previously open land, or covered by agricultural land or partial green cover, have gradually been converted into built-up areas. This indicates not only residential demand, but also the growth of infrastructure due to commercial expansion. The open land area was about 3.79 sq km (27.85%) in 2016 while this picture is even more dramatic in the 2025 map where it reduced to only 2.26 sq km (16.61%) in 2025. This deficit in open area is mainly the result of land conversion to meet the needs of residential and commercial infrastructure. Previously fallow land, vacant plots or cultivable agricultural land have been gradually converted into built-up areas (Figure 4).

Figure 4. Temporal changes of open space Berhampore municipal area

A gradual decline in green cover is also observed over the study area. In 2016, green space, the most crucial part of city was 3.45 km^2 that covers 25.35% of the total municipal area, that transform into 3.36 km^2 (24.69%) in 2025. Although the rate of change is relatively low, this trend may have a negative impact on the environmental quality of the city in the long term. Fragmentation of plant cover is particularly noticeable in the central and southern parts of the municipality. As a result, shaded areas are decreasing and the microclimate of the city is gradually changing (Figure 5).

Cities are now gradually spreading over marginal areas, semi-urban areas and agricultural land. As a result, open land, arable land and green cover are being lost. Such uncontrolled or semi-planned urban growth also impacted on a slight change in the area of water bodies. In 2016, 0.68 km^2 (5.00%) of the area was covered by water bodies, which decreased to 0.65 km^2 (4.78%) in 2025. Although the change is small, its impact cannot be ignored, because a decrease in the number and size of water bodies reduces the city's water resource management and rainwater retention capacity. Social pressure and unhealthy environment due to increasing population density. This intensity of urban expansion is not only a result of the housing demand of the population; it is also due to the development of economic activities, establishment of new commercial centers and increase in administrative activities. At the same time, the lack of land use planning, absence of strict zoning policies and unplanned construction are also accelerating this trend (Figure 6).

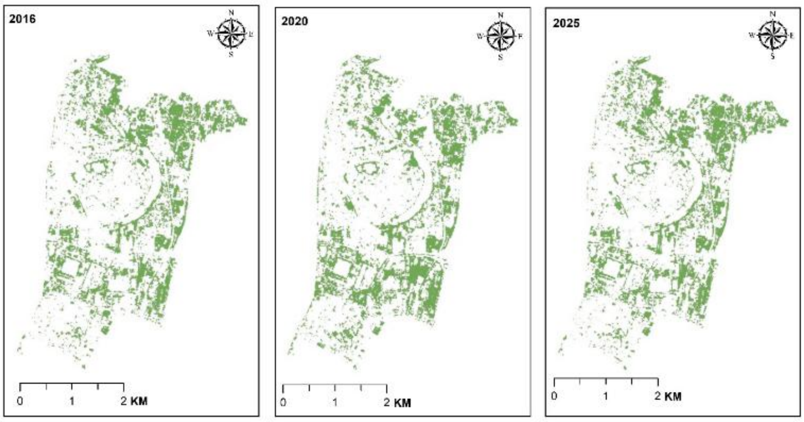

Figure 5. Temporal changes of vegetation cover in Berhampore municipal area

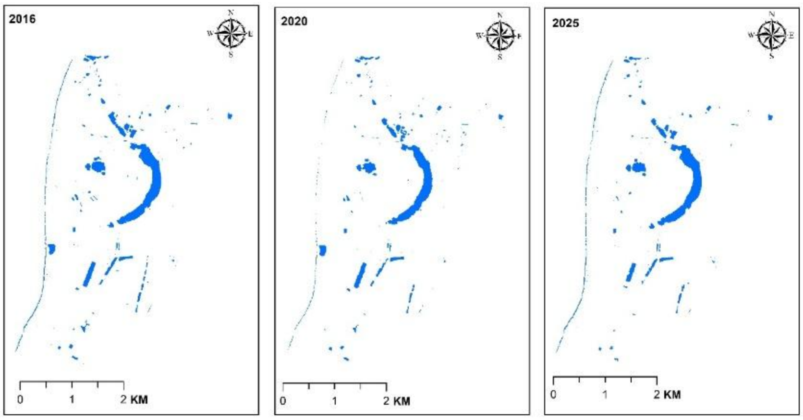

Figure 6. Temporal changes of water body in Berhampore municipal area

The social and environmental impacts of this change are also serious. The reduction in open space is reducing open space in the city, which is damaging the ecological balance on the one hand, and also affecting the quality of life of citizens on the other. The fragmentation of green cover can contribute to the increase in temperature in the city, as a result of which the urban heat island effect can be more intense. The shrinkage of water bodies can exacerbate the problem of water shortage and waterlogging in the city during the rainy season in the future.

Conclusion

This trend of land use change is a reflection of a faster and more extensive urbanization highlights significant LULC changes in Berhampore Municipality between 2016 and 2025, marked by a rapid increase in built-up areas and reduction in open and vegetated spaces. Such kinds of urban expansion, indicates the potential for economic development and infrastructural development of the town, while on the other hand, it also poses major challenges for environmental balance and sustainable development. This gradual reduction of green and blue space areas further threatens ecological status and biodiversity, and urban liveability. Overall, our findings point to a trajectory of unplanned or semi-planned urbanization that may aggravate environmental vulnerabilities over the municipal area if it is left unchecked. For the sustainable urban growth, there is a urgent attention to integrate land use planning with conservation approaches. Protecting green and blue spaces, enforcing zoning regulations, and adopting water-sensitive urban design will support sustainable development needs with environmental resilience. The methodology adopted in this study also demonstrates the value of multi-temporal remote sensing and GIS analysis in monitoring urban dynamics, which can serve as a decision-support tool for planners and policymakers in similar rapidly urbanizing towns.

Consequently, there is a urgent need for sustainable land use policies, emphasis on green area conservation and planned infrastructure management by integrating ecological principles into urban development, Berhampore can achieve a balance between growth and sustainability.

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