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*Research Paper*

# Impacts of urbanization on land-use and land-cover change in Baranagar Municipality of 24 Parganas North, West Bengal using Geospatial techniques

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## *Abstract*

Urbanization is one of the serious issues at present because uncontrolled urbanization and land-use land-cover changes raises many issues, which might have both positive and negative impacts in the urban ecosystem. The present research work aims to analyze the changes that occurred in land-use /land-cover (LU/LC) over twenty-nine years (1990-2019) using modern technology like remote sensing and Geographical Information System in Baranagar municipality in North 24 Pargana District of West Bengal. There are 34 wards in Baranagar Municipality spreading in 7.12 sq km area with a population of 245213 (Census 2011). The land-use and land-cover change detection were carried out by using LANDSAT 5 TM and LANDSAT 8 OLI. Through hybrid classification method for interpretation and on-field validation, it is found that the built-up area of Baranagar Municipality has increased from 1991 to 2019 by 15 per cent. The areas under water bodies and bare land have been decreased very significantly in the study period to accommodate the population within the limited area, which is not increasing in the last thirty years. The relationship between urbanization and growth of population is highly positive at the eastern part of Baranagar whereas the rate of urbanization reduces at the western portion of the study area with a sharp decrease of population. So, the present research finds that urbanization at the eastern part is more accelerated than the western part with significant changing Land use and Landcover and it also

invites many environmental problems like changing micro climate, depletion of groundwater resource, loss of productive agricultural land, forest, and water bodies etc. in this urban area. The research concludes that there is a need for systematic and comprehensive planning for sustainable development with a healthy urban environment and proper conservation of natural resources.

**Keywords:** GIS, Land-use/Land-cover, Remote Sensing, Urbanization.

## Introduction

Urbanization is one of the important components in changing the demographic characteristics and plays an eminent role in transforming the physical landscape of a region. The developing countries, located within tropics are currently undergoing urbanization at a rapid pace (Gupta 1999). Urbanization is a process to know the growth of urban areas, which results in population growth, increase in built areas, and a high density of population and change in way of life of the population and economic activities. A detailed understanding of the dynamics of urbanization is very much essential for the sustainability of the environment.

Urbanization is one of the serious issues at present because uncontrolled urbanization and land-use land-cover changes raises many issues which might have both positive and negative impacts like unauthorized urban sprawl, loss of productive agricultural land, forest, and water bodies and other related problems (Bhagat 2005, 2011). The monitoring of urbanization is very much essential for local and regional planning and management of cities for implementing policies to optimize the use of natural resources and play important role in minimizing the impact on the environment and helps to assess the urban growth trends.

Land-use and land-cover changes (LU/LC) has recognized as an important force of environmental change on all spatial and temporal scales (Tuner 1994). The planning studies should be based on accurate and up to date land-use and land-cover information of a region. Therefore proper urban planning is necessary for detecting the change in land-use, the land-cover pattern for minimizing the environmental degradation.

Urban areas absorb most of the global energy, cause various environmental problems, and result in a serious threat to the existing ecosystems. The problem of urbanization is very much critical in India as in India 16 % of the World's population lives in 2.5% of the geographical area (Elmqvist et al. 2013; Nagendra, Sudhira, Katti, & Schewenius 2013). The degree of urbanization in India has increased magnificently over the years. It has increased from 27.7 per cent to 31.1 per cent, with a growth of 3.3 per cent points during 2001–2011 as compared to an increase of 2.1 per cent during 1991–2001 (Bhagat 2011). It is projected that the urban population of India will nearly double reaching 600 million by 2031(Heilig 2012).

Such rapid urbanization in the country can modify the urban landscape leading to changes in land-use and land-cover considerably and causing severe pressure on various natural resources. It is expected that with a degree of urbanization, Indian cities will suffer from local environmental problems and unhealthy living conditions (Kantakumar, Kumar, and Schneider 2016; Mohan, Pathan, Narendra Reddy, Kandya, and Pandey 2011). Rapid urbanization and

changing environment in developing countries like India raise two important research questions:

How does urbanization relate to spatiotemporal changes in LULC?

What are the impacts of such changes in urban areas?

Many studies have attempted to show the land-use and land-cover changes with urbanization and population growth **(**Patra, Sahoo, Mishra and Mahapatra 2018). Many of them have attempted to study urban growth by using remote sensing and GIS techniques (Kantakumar, Kumar, and Schneider 2016). It is found that anthropogenic activities influence the urban environment considerably (Alberti et al. 2003; Andersson 2006; Lundholm et al. 2010), and hence greater attention is required towards monitoring the changes in land-use and land-cover in urban areas. Urbanization is taking place at a faster rate in the last thirty years in the study area as it is very close to Kolkata Metropolis and it serves the service cum trading centre of the Metropolis. However, not much research has been done in this area to focus the impact of urbanization and population growth in changing land-use and land-cover. So, this present research is a maiden attempt to find out the impact of population growth and urbanization in Baranagar Municipality on land-use and land-cover changes between 1990-2019.

**Study area**

Baranagar Municipality, one of the oldest municipalities in India was established in 1869. The municipality of Baranagar is located at 22.64ºN and 88.37ºE and has an elevation of 12 meters (39feet) from Mean sea Level. Baranagar Municipality situated on both sides of Barackpur Trunk Road is one of the pivotal regions of KMA (Kolkata Metropolitan Region) as it connects three important districts of West Bengal namely Hooghly, North 24 Parganas, and Kolkata (Human Development Report 2010). There are 34 wards in Baranagar Municipality spreading in 7.12 sq km area with a population of 245213 (Census 2011). The Municipality is bounded by KMC in its south, Kamarhati Municipality in the east, River Hooghly in its west (Fig.1).

Baranagar Municipality located on the eastern bank of the River Hooghly is one of the oldest urban centers within the greater Calcutta region (Census 1991). From the mid-18th century, Baranagar Municipality had gained its importance with the establishment of the Baranagar Jute Mill (1859) and other factories in the area (Guha & Dey 2016). Apart from the mills and warehouses, this industrial area was very famous because of the presence of many ghats (river banks) of the Ganges, and the many temples and maths like Alambazar Math. The economic and social life of this town revolved around its jute mill and the many temples and ghats (Mukherjee 2016).

During the two world wars, many engineering factories were set up in Baranagar and the town became famous as an Industrial city (Paul 2014). To provide the civic amenities North Suburban Municipality was formed in 1869 consisting of Chitpur and Cassipore (presently under KMC), all mouzas of present Baranagar Municipal area along with Kamarhati, Ariadaha, and Dakshineshwar Mouzas of present Kamarhati Municipality. In 1881

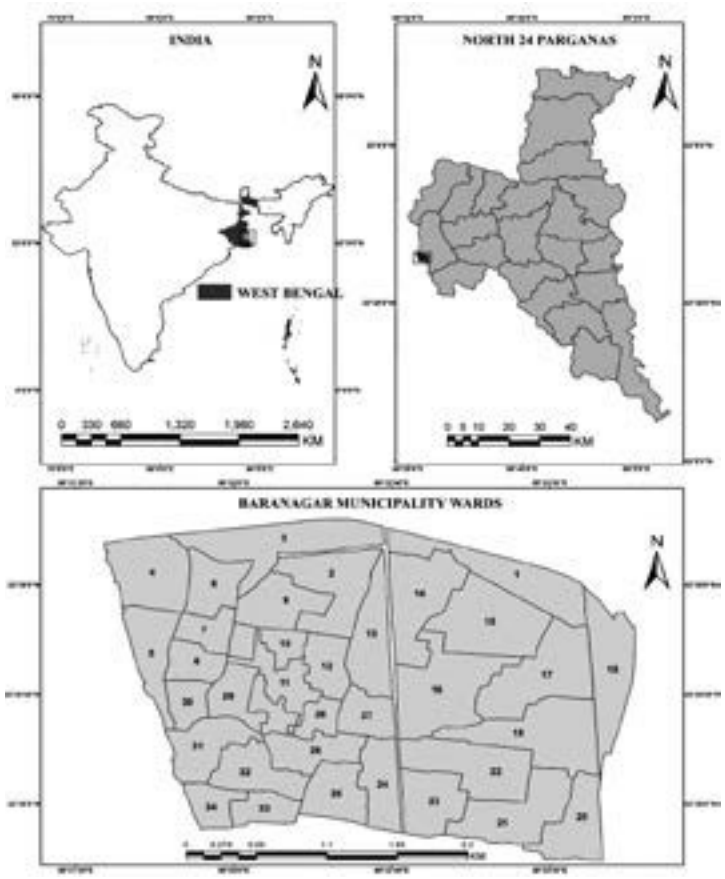


Fig. 1: Location Map of the study area

North Suburban Municipality was divided into two parts 1. Cassipur-Chitpur Municipality 2. Baranagar Municipality. On 1st August, 1899 Kamarhati Municipality was formed parting Kamarhati and Ariadaha Mouzas from Baranagar. In 1949 Dakhneswar Mouzas was parted from Baranagar and merged with Kamarhati Municipality (Guha 2016; Guin 2016). So, the research area exhibits a unique character of its historical growth and development

**Materials and methods**

The studied urban area is characterized by a significant temporal increase of urban infrastructures and as well as population density with rapid environmental degradations. The data relating to areal and population growth of the area has been collected from Baranagar Municipality. The land-use and land-cover change detection were carried out by the satellite images acquired from Landsat sensors including LANDSAT 5 TM (1990, 2000, 2010) and LANDSAT 8 Operational Land Imager (OLI) for 2019. All the images were downloaded from the USGS website. To make an analytical description based on (LULC) changes by some empirical remote sensing approaches like normalized difference built-up index (NDBI) and normalized difference vegetation index

(NDVI), for instance, ENVI and ARC-GIS software has been used. Analysis of LULC changes is carried out by supervised classification and the accuracy assessment was done by 'Kappa Co-efficient'. Normalized Difference Vegetation Index or NDVI ascertains vegetation by estimating the contrast between close infrared (which vegetation unequivocally reflects) and red light (which vegetation retains). The formula for calculating NDVI is (NEAR INFRARED – VISIBLE RED) / (NEAR INFRARED + VISIBLE RED). A negative NDVI value represents water, and values close to zero represents soil, bare land or rocks (Lillesand, Kiefer and Chapmon 2015), values belonging in 0.2 to 0.4 represent grass, shrubs or crops while a higher and value represents temperate or tropical forest. Produced NDVI maps are density sliced based on the Jenks natural classification.

NDBI or Normalized Difference Built-up Index is a measure to identify built up from the satellite images. Built-up and soils reflect more short-wave infrared than near infrared. Using the difference between these two bands value NDBI is calculated. The formula of NDBI is (SHORT WAVE INFRARED - NEAR INFRARED) / (SHORT WAVE INFRARED + NEAR INFRARED). Produced maps show some identical changes in LULC categories, such changes were verified by field visit, which is the Ground truth verification of the problem areas. The relation among the areas of different LULC categories was analyzed by regression analysis; the value of the co-relation co-efficient helps us to assess the quantitative relations.

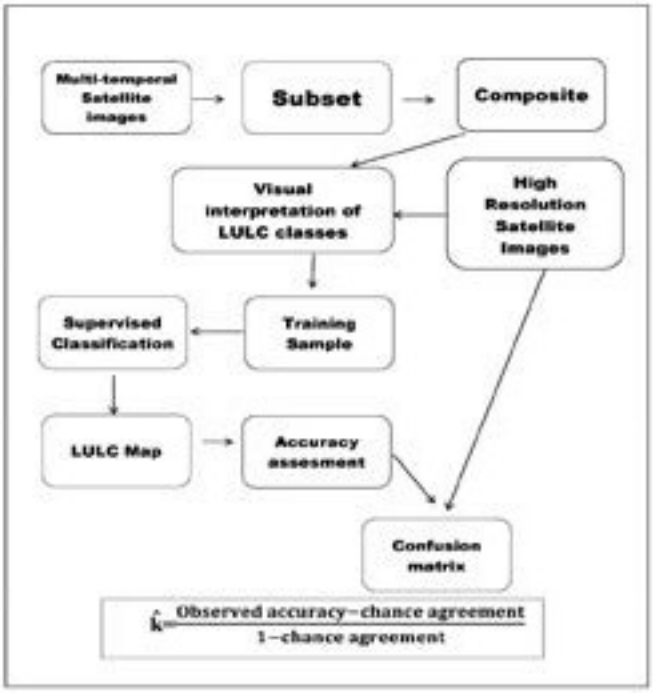


Fig. 2: Methodology for obtaining data from satellite imagery

## Results and Discussions

*Population Growth and Urban Expansion*

In 1901, Baranagar had a population of 25,435 persons, which was increased to 37,050 in 1931, 77,126 in 1951 and 136,842 in 1971 (Fig. 3). Between 1901 and 1971 the population of Baranagar increased by more than five times. According to West Bengal District Gazeteer in the decade of 1951-61, the inflow of refugees from East Pakistan was the main reason to increase the huge growth of the population in the Baranagar area (Som 1989). According to West Bengal District Gazeteer, the demographic growth of the North 24 Parganas along with Calcutta began to attract immigrants from the distant parts of India. It highlights the beginning of the large scale of manufacturing units and newly created employment opportunities encouraged the huge inflow from all over India. Immigration from East Pakistan and an increase in birth rate over death rate pushed up the population growth in the region.

The western part of the area had the population and it was home to wealthy Bengali households. The Barrackpore Trunk Road running north-south through the middle of the municipality has divided it into two sides. Towards the east, the land drastically sloped down into marshes and water bodies and was less densely populated. The landscape of eastern Baranagar started changing with the partition in 1947 and the ensuing refugee influx. Due to its industrial nature and vicinity to Calcutta, Baranagar attracted Hindu Bengali migrants coming from East Pakistan. But by mid-1949 the East Bengalis came to Baranagar occupied all the eastern part and housing crisis had reached a bursting point. From this time onwards, the topography of the area started changing with the creation of numerous refugee squatters' colonies on low marsh lands which had been lying vacant on the east of the BT road.

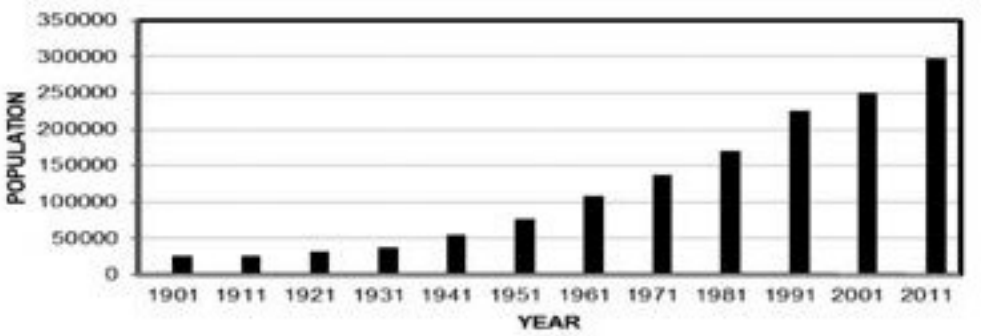


Fig. 3: Population growth in Baranagar Municipality 1901-2011

Between 1950-65 the population of Baranagar Municipality was increasing highly by immigration than that of by birth. From Fig. 3 it is observed that population growth in Baranagar Municipality was inconsistent over the century. After the Partition in 1947 and Bangladesh war in 1971, there was a very huge influx of refugees in the Municipality (Ahmed 2006). Secondly, the proximity of this Municipality in the KMC area is another reason for high population growth. In the early twentieth century, some areas (Ward no. 12,14,17) of the municipality had a low marshy land-covered with hogla forest. Dr B C. Roy, Chief Minister of West Bengal had planned to reclaim this marshy low land for settling refugees from East Bengal in 1960 (Guha 2016).

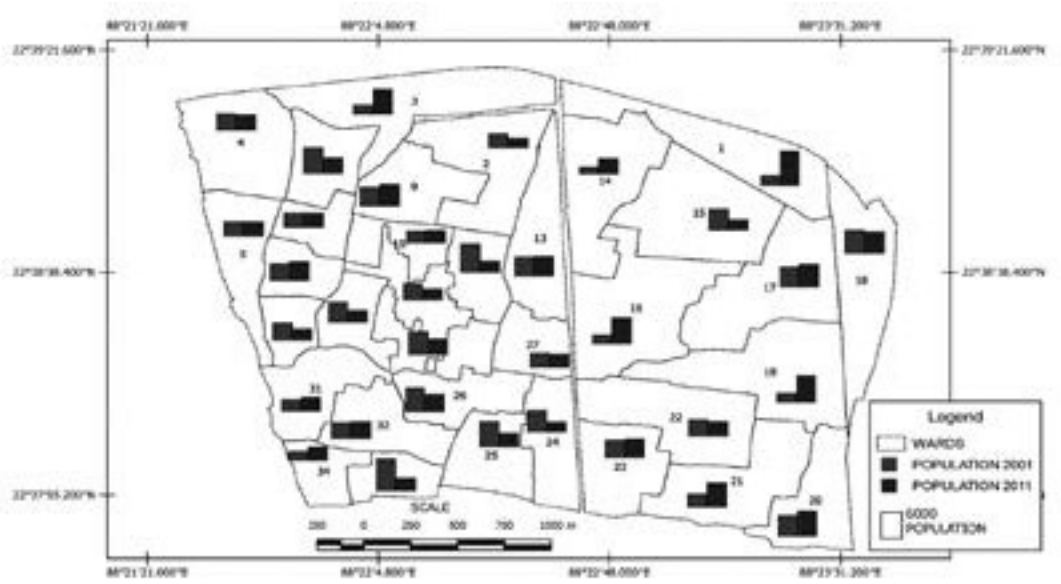


Fig. 4: Ward wise population in Baranagar Municipality 2001&2011

It was then developed very haphazardly to accommodate large refugee population and government-built Refugee industrial complex, hospitals, tents by filing up this marshy land under Refugee Rehabilitation Programme. The region became popularly known as Refugee Colony in the district until 1990 but in the second half of the twentieth century the extension of Metro railway Projects from Dumdum to Barrackpur via Baranagar area and Urban Renewal Programme by West Bengal Govt. has widened the scope of Urbanization in this area.

According to the 1991census, the total population of Baranagar Municipality was 2,24,821 of which the male population was 120134 (53.44%) and the female population was 104687 (46.56%). The highest population was found in ward number 29 followed by ward number 26. Ward no 14, 01, 03 and 10 were under the low population category.

According to the 2001census, the total population increased to 2,50,768 among which male and female population was 132559 and 118209 respectively (Census 2001, 2011). The highest population was found in ward 33 followed by ward 12, 25 and 8 and ward 14,1, 03, etc. are considered under a smaller number of populations. In the 2011Census, the total population in Baranagar Municipality is 2,45,213 of which the male population was 126187 (53.44%) and the female population was 119026 (46.56%). The highest population was found in ward 1 followed by ward 19, 16 and 20 and ward 34,11,12 &15 etc. are considered under less number of population (Fig. 4).

The urban growth in the study area has been greatly stimulated by Industrialization and Commercialization. The establishment of different manufacturing plants especially Baranagar Jute Mill in Baranagar and the concentration of workers in and around the area has triggered the urbanization in Baranagar Municipality (Guha 2016). Development of Transport and

Communication is the key factor for the urbanization in the Baranagar Municipality as it is well connected not only with Kolkata City but also through developed means of local transportation the different parts of the districts of West Bengal namely Hooghly and North 24 Parganas. At the time the factory was introduced, local transportation facilities were poor. The factory workers were compelled to live near their place of employment. Congestion of housing resulted. The development in modes of transportation and communication and the facilities that cities offer for satisfying the desire for communication also explain urban growth. Industrialization depends upon transportation so that raw material and manufactured goods can be carried in large volumes. Baranagar area is well connected with railways, roadways, metro railways and ferry services with other districts of West Bengal. Baranagar Road Railway Station is one of the oldest railway stations and Belgharia Expressway and Barrackpur Trunk road pass through the Baranagar area, which connects Kolkata with northern suburban areas and Howrah and Hooghly.

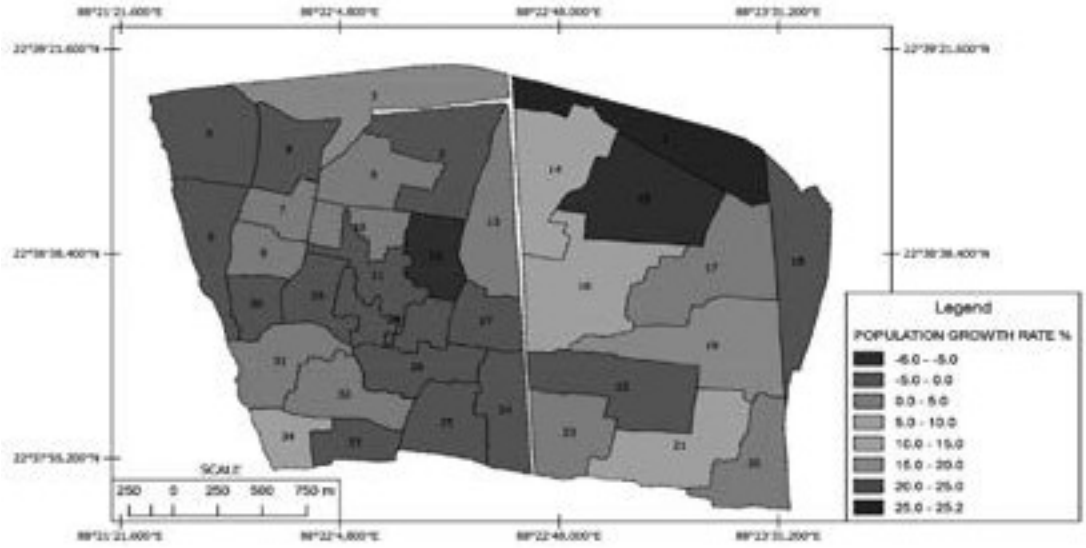


Fig. 5: Decadal growth of population (in %) among the municipal wards of Baranagar Municipality

Two data sets (census data 2001& 2011) have been used to find out the decadal growth rates of the population of different wards in Baranagar Municipality. Among 34 wards 17 wards (2, 4, 5,8,11,12,15,18,22,24,25,26,27,28,29,30,33) have negative growth of population whereas rest of the 17 wards(1,3,6,7,9,10,13,14,16,17,19,20,21,23,31,32,34) have positive growth of population (Fig. 5). The lowest growth rate is in ward no 12(-5.95%) and highest growth rate is in ward no 1 (25.19%). Entire Baranagar Municipality is divided into two separate zones, eastern and western. Eastern zone comprises 11 wards (1,14,15,16,17,18,19,20,21,22,23) and western zone comprises 23 wards (2,3,4,5,6,7,8,9,10,11,12,13,24,25,26,27,28,29,30,31,32,33,34). Modern business and commerce pull young men to Baranagar Area where they are paid munificent salaries. People live here not because they like it as a place of residence but because they can get jobs there. Employment opportunities are one of the main factors that led to urbanization in the study

area. Moreover, the Baranagar area is also home to many schools, colleges, educational institutes of national importance, libraries, recreational centers, and health and these have attracted the population to settle here and results in high population growth.

Among 11 wards of eastern zone 8 wards have positive growth rates (1,14,16,17,19,20,21,23) where rest of the 3 wards (15,18,22) have negative growth rates. Ward no 1, 14 and 19 have very high growth rates. Among 23 wards of western zone only 9 wards have positive growth rates (3,6,7,9,10,13,31,32,34) where rest of the 14 wards(2,4,5,8,11,12,24,25,26,27,28,29,30,33) have negative growth rates. Ward no 3 have very high growth rates (20-25%).

The present research shows that rapid growth of population with positive growth rates, near about 73% of the municipal wards is present at the eastern zone, whereas only 39 % municipal wards in the western part have positive growth rates. The rapid growth of population in the eastern zone is due to rapid urbanization at the bare lands. The refugees of Eastern Pakistan mainly occupied the western zone at the post-independence time. Now with the closing of industrial activities, the settlement of the labours at the western zone becomes less dense. Only one ward (ward no 3) have the same character of urbanization and population growth as the wards of the eastern zone.

*Change in Land-use/ Landcover*

Produced land-use and land-cover maps show changes over 29 years (Table 1, Fig. 6a). As seen on the land-use and land-cover map of 1990 eastern part of the map has a high percentage of fallow land, vegetation and water bodies. At the northwestern part of the map, there was the presence of fallow land and vegetation and a large water body. While the rest of the study area was already covered in built-up. In 1990, bare land was 1.68 sq km (20.4%), urban was 5 sq km (60.8), vegetation was 1.3 sq km (15.1%) and water body was 0.29 sq km (3.5%). As seen on the map in 2000 the 3 other types of land-use and land-cover classes reduced due to an increase in built-up (5.5 sq km/66.8%). There observed a decrease in bare land (1.13 sq km/13.8%) and water bodies (0.26 sq km/3.2%). However, vegetation slightly increased (1.3 sq km/16.2%). In 2010, the urban (5.7 sq km/69.1%) expansion continued to increase and resulted in reducing bare land (0.98 sq km/12%) and water bodies (0.99 sq km/2.7%). As seen on the map in 1990 the eastern part of the study has a significant amount of vegetation in the form of both shrubs and trees, they also appear much healthier than the present time. But over the years (1990 - 2019) the vegetation of the eastern side of the study area was the victim of urban expansion and overall health also deteriorated. The following map also reveals the presence of agriculture in the eastern part. But there is observed an increase in vegetation in the southern part of the study area. Unlike NDVI (Fig 6b), negative values of NDBI (Fig 6c), represent vegetation and higher positive values represent built up. As seen on the map the 1990 map has low built upon the eastern part of the study area. But over the year (1990- 2019) built up in the eastern part significantly increased and occupied bare land and water bodies along with agricultural land.

Vegetation cover slightly decreased to 1.32 sq km (16.2%). in recent times of the year, 2019 urban expansion is at its peak covering 6.1 sq km (74.6%) of area. Bare land (0.44 sq km/5.4%) and water bodies (0.16 sq km/2%) reduced further. Vegetation increased to 1.5 sq

km (17.94%). The Eastern part of the study area is now almost covered by built-up as a result of urban expansion (Fig.7)

Table 1: Change of area (in %) in land-use and land-coverage categories (1991-2019)

| YEAR | % OF BARE LAND | % OF BUILT-UP AREA | % OF VEGETATION | % OF WATER BODIES |
|---|---|---|---|---|
| 1991 | 20.4 | 60.8 | 15.3 | 3.5 |
| 2000 | 13.8 | 66.8 | 16.2 | 3.2 |
| 2010 | 12 | 69.1 | 16.2 | 2.7 |
| 2019 | 5.4 | 74.6 | 17.94 | 2 |

Source: Data calculated from satellite imageries.

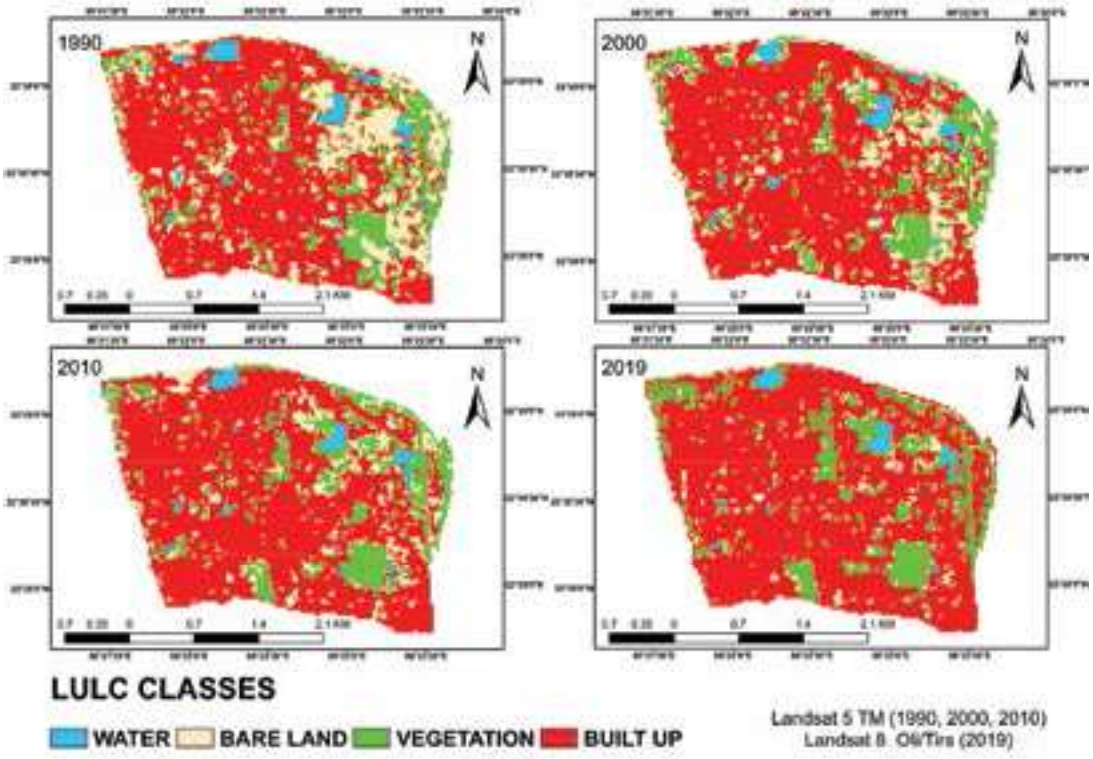


Fig. 6a: land-use and Land-coverage map of the study area

Source: Data calculated from satellite imageries.

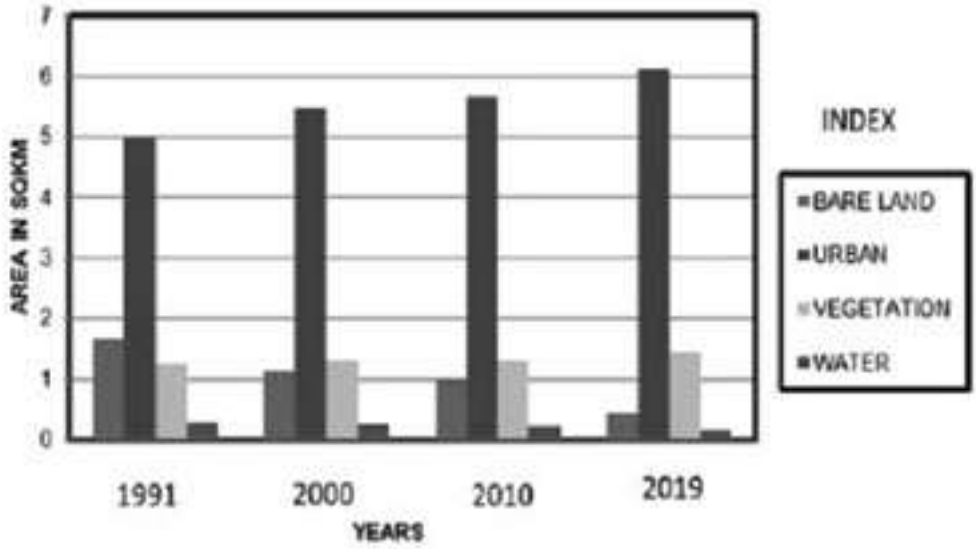


Fig. 7: Change of area in different land-use and land-coverages (1991-2019)

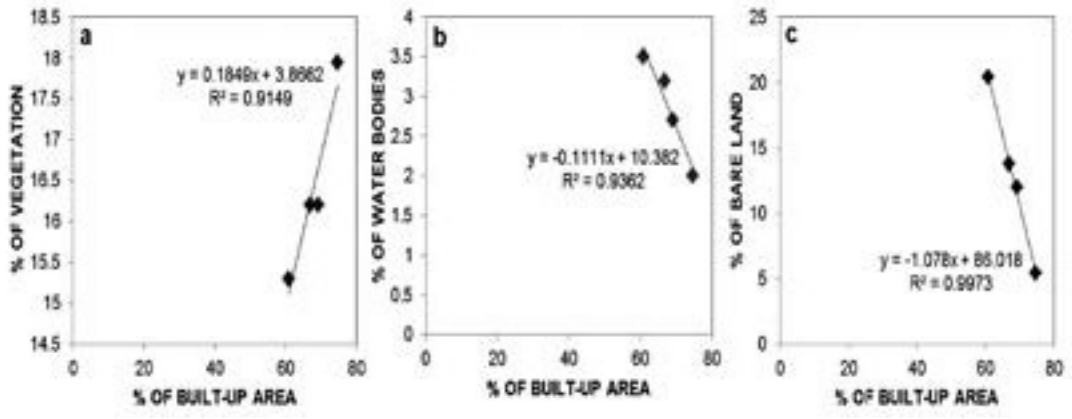


Fig 8. Linear regressions between a). Urban area and vegetation coverage, b). Urban area and area of water bodies, and c). Urban area and Bare land

The drawn scatter diagrams (Fig. 8 a, b and c) are showing the relationship between the urban area with water bodies, bare lands and vegetation coverage of the area under study. There is a positive relationship between urban land and vegetation coverage. This relation has a very high positive (+0.95) relation. It indicates that the increase of the built-up area also results of an increase in vegetation coverage. It is due to the growth of scrub vegetation at the abandoned RIC industrial complex at the eastern portion of the Bon Hooghly Lake. Whereas there is a negative relationship between the built-up area and water bodies and bare lands. With the increase of the built-up area bare land and water bodies are decreasing. The rapid growth of the urban region results in the reduction of wetlands and marshy lands. The value of the correlation coefficient is

-0.96 which highly negative, reflects inverse relation between build-up area and area of wetlands. Ongoing building projects are mainly developed at the bare lands. The correlation coefficient value between these two variables is -0.99 which is highly negative. The geographical area reduces with increasing the build-up areas. Siddha Lake views an ongoing building project at the southern portion of Bon Hooghly lake is mainly developed at marshy low land (Fig:9).

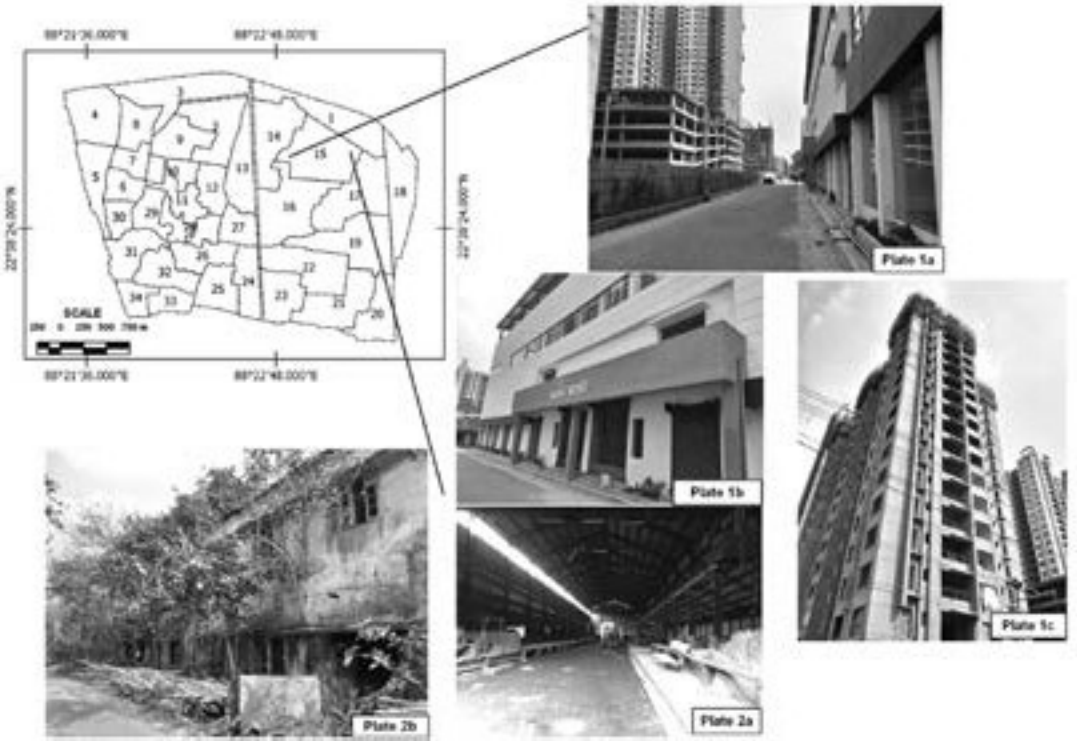


Figure 9. Plate 1a,1b and 1c showing the growth of buildup areas in the eastern part of the study area mainly on the marshy land and Plate 2a,2b showing the present condition of Industrial complexes and growth of shrubs at the abandoned industries.

**Conclusions**

The present research is a maiden attempt to show the impact of urbanization on changing LULC in the last nineteen years (1991-2019) using RS data in the study area. The research finds that Baranagar Municipality has experienced rapid changes in LULC in the last thirty years and it leads to haphazard growth of urbanization and also invites urban problems.

The research reveals that the urban landscape of the eastern part has been changing in the recent years to accommodate huge population within its limited area. The research find that the built-up area has increased by 15 % in the study period by leading to a substantial reduction in the area of water bodies, vegetation, and bare lands. Bare lands and water bodies in this area have decreased to just 5% and 2% respectively in recent years concerning the total areas of Baranagar

Municipality. Vegetation cover has slightly increased to 3% in the given period. It is due to the growth of scrub vegetation at the abandoned industrial complex at the eastern portion of the Bon Hooghly Lake. The LULC shows that the Eastern part of the study area is now almost covered by built-up as a result of urban expansion. The linear regression shows a very strong negative relation between the built-up area and water bodies and vegetation cover in the study area. Whereas the urbanization is less in the western part of the Municipality as it is inhabited by the original population.

The present research shows that rapid growth of population with positive growth rates (near about 73%) of the municipal wards is present at the eastern zone of the Baranagar Municipality and only 39 % of municipal wards have positive growth rates in the western part. The rapid growth of the population in the eastern part had taken place at the bare lands. The study concludes that there is a very strong positive relationship between the change in LULC and the growth of the population in the eastern part of the Baranagar municipality. The LULC map of 1990, 2000, 2009 and 2019 shows that the eastern part has high built-up areas, and also recently developments of high-rise apartments in this area attract new migrants from Kolkata city.

The haphazard urban expansion in the study area especially in the eastern part brings negative consequences to the society and on the natural environment also. It has posed the most serious livelihood challenge to the original populations, fishing communities, and the industrial workers of the area. The massive expansion of urban structures has led to an increase in the surface air temperature, an increase in pollution level, overcrowding, poor sanitation problem, poor road connectivity, unwanted and haphazard development of some areas, and the adverse ratio of public amenities and population. The monitoring of urbanization is very much needed for planning and management purpose by the governmental and non-governmental organizations. It will be helpful for implementing policies to optimize the use of natural resources and accommodate development at the same time minimizing the impact on the environment.

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