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DESTRUCTION OF URBAN GREENARY OF INDIAN CITIES – A STUDY OF THE TWO WARDS OF KOLKATA THROUGH GIS AND REMOTE SENSING

Biraj Kanti Mondal *[1]
* Netaji Subhas Open University, West Bengal, India

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Abstract: At present the rampant construction and poor compensatory plantation are taking a heavy toll on Kolkata's environment. Now, Kolkata's green cover stands at a dismal 5%, which is below the requirement of 15% for the Indian Metros. Last year Kolkata and its adjoining area have lost more than 5,000 trees to development projects, unauthorized chapping and natural causes. This has pushed up the carbon count by an alarming 5,500,000 kg. per year. The environmentalists feel that, the impact of this loss would be felt in the coming years. Thus, the rapid destruction of the urban greenery from the Indian city's environs affects the urban ecology and causes environmental degradation. Therefore, an attempt has been made here to analyze the urban greenery or vegetation profile of Kolkata at micro level. Vegetation covers of ward 19 and 20 of Kolkata Municipal Corporation Area along with the search of its low existence (KMCA) has been worked for the study. To speed up mapping and decision making, remotely sensed satellite data have been advocated and GIS technology has been used to represent the research work more advanced.

Key words: Vegetation Cover, Geographic Information System, Remote Sensing

Introduction

India has very rich repository of flora and fauna, but the rapid decline of green cover and threat to its habitat has become a serious cause of concern today. In Kolkata, green coverage plays a pivotal role in improving urban environment, such as preserving water and soil, controlling temperature and humidity of air, preventing pollution, flood prevention, functioning as buffers between incompatible land uses, preserving natural habitat and providing space for recreation. But due to our consumption nature, we forgot the importance of that life partner. Though, The Forest Department of India said that India's 23.04% area of India covered by vegetation but recent Satellite Picture argued that only 19.14% of area is forested.

[1] Correspondence to: m_biraj@yahoo.com

According to The National Commission on Urbanization, open spaces in Kolkata have been vanishing as well. Less than 1% of city space now remains vacant. In North Kolkata, urban greenery has dipped to 4.79% which is extremely unhealthy for the city's population (Roy, 1901). In comparison to Kolkata, the green cover in Delhi (19.09%) and Mumbai (18%) are much higher, whereas the national average stands at 19.49%. The erosion of greenery in Kolkata has also led to a loss of biodiversity along with some other serious problems related to them. In that circumstance, compensatory plantation may help to maintain the overall greenery but the loss of biodiversity is permanent.

The present work concentrate in analyzing the green cover of Kolkata's ward 19 and ward 20. Due to lack of ground information, some known features have been used as reference categories to classify the study area. Classification of the whole map has been done to get the buildup area, road area, open space and the vegetation cover. Some possible remedies of the problems related to the shortening of green cover in Kolkata are suggested at the end of the study.

Kolkata or Calcutta, city in eastern India and the capital of West Bengal State, situated on the bank of the Hooghly River (Bagchi, 1939). It is the hub of India's second most populous metropolitan area (after Mumbai, 2001's census) and is the chief commercial, financial, and manufacturing center of eastern India. It served as the capital of British India from 1773 through 1911. Now Kolkata has become a Metropolitan city. It is now known as Kolkata Metropolitan Development Authority (KMDA). KMDA is the statutory planning and development authority for the Kolkata Metropolitan Area (KMA) under provision of the West Bengal Town and Country (Planning & Development) Act, 1979. In January 2001 the spelling of the city's name officially changed to Kolkata from Calcutta (Bose,1958). Kolkata is located only about 1° south far from the Tropic of Cancer and it is on the banks of the Hooghly River, a branch of the great river Ganges. The latitude: 22 o 33' North; longitude: 88 o 30' East and the total area of Kolkata is 1,480 sq. km.

The attempt was made to extract the information about vegetation coverage and also to derive the amount of vegetation area in ward no. 19 and 20 in Kolkata Municipal Area through GIS and remote sensing. The main objectives of the study are:

- To find out how much vegetation areas have been occupied in each of the wards.
- To evaluate vegetation density.
- To find out the decreasing status of vegetation cover.
- To evaluate built-up area.

- To find out the relation between Built up area and decreasing nature of vegetation cover.
- To evaluate open space area.
- To evaluate the network connectivity of road width.
- To evaluate road cover area and road density.
- To assess the population density and its effect on vegetation cover.

Materials and methods

The present study report has been prepared using the information already provided by KMC through some spatial and attribute data. The paper has done using the GIS software (ARC GIS 9.2) and REMOTE SENSING software (ERDAS 9.2) and MS Access for database creation. Various Cartographic techniques like bar graph and pie graphs were prepared, analyzed and interpreted. The analysis of data is made with the help of representative maps and diagrams. The following graphical representation is given to show the steps involved in carrying out the work:-

Remote Sensing also provides the spatial location and attribute data which contributes a good number of advantages, as detailed below, about vegetation cover of ward 19 and 20 :

- Rectification of un-rectified map.
- Fusion of Multispectral and PAN image has been done for better visualization.
- Making of False Natural Colour Image also for better visualization and visual interpretation.
- Determinate the objects/classes for image classification through use Interpretation Key (from multispectral image, fused false natural colour image), Transect Extraction (from multispectral image), and seeing Spectral Reflection value of the bands (from multispectral image).
- Classification (supervise or unsupervised) has been done to get details about the study area. There are two satellite images used for the present work. One image is geo referenced Multispectral image and another image is non-geo referenced Panchromatic (PAN) image. These two images cover the area of ward no 19 & 20 and also give some attribute data were used for the study.

Multispectral Image: Multispectral Image is the collection of reflected, emitted, or back scattered energy from an object or area of interest in multiple bands (regions) of the electromagnetic spectrum. For the work one rectified

multispectral image, naming “ms_ward.img” was collected from the CAD Centre, Jadevpur. Projection system of this image is WGS 1984 UTM Zone 45N and datum is D WGS 1984, which have 4 bands. It was taken by Quickbird satellite in 21 November, 2002. This image has 388 rows 465 columns and it’s pixel size (spatial resolution) is 2.80 meters. It is an Unsigned 16-bit image.

Panchromatic Image: PAN image is the collection of reflected, emitted or back-scattered energy from an object or area of interest in a single band of the electromagnetic spectrum (normally 0.4μm to 0.7μm) with a radiometric resolution of 8 bit grayscale. The unrectified pan image, naming “pan_ward.img”, was taken by Quickbird satellite in 21 November, 2002. This image has 1549 rows 1858 columns and it’s pixel size is not available because it is not rectified.

Results and discussion

Study Area: The present study occurs in Ward no. 19 and 20 of Kolkata (West Bengal, India), located in the north-western part of Kolkata, and on the left bank of Hooghly River (Figure 1).

Geographical Location: This study area’s Latitude is from northern $22^{o}35’55.933”$ north to southern $22^{o}35’29.328”$ north and Longitude is from western $88^{o}21’6.772”$ east to eastern $88^{o}21’43”$ east.

Area: Total area of the Ward no.19 is 233900.4009 sq. mt. and Ward no. 20 is 285126.1529 sq. mt.

Climate: The city enjoys fairly stable, warm and humid climate throughout the year.

Temperature: Kolkata has a tropical wet-and-dry climate (according to Koppen’s climatic classification). The annual mean temperature is 26.8° C (80° F); monthly mean temperatures range from 19° C to 30° C (67° F to 86° F). Though winters are mild, with an average January temperature of 19°C (67°F), the temperature sometimes dips to 10° C (50° F). From March through September, Kolkata is hot and humid, with an average July temperature of 29° C (85° F); in the months of May and June the temperature may rise as high as 38° C (100° F).

Rainfall: Rains brought by the South-West Monsoon and its average annual rainfall of 1625 mm (64 inches) falling from June through September. The highest rainfall occurs during the monsoon in August 306 mm.

Soil: Kolkata is folded with alluvial soil.

Topography: Built on flat sedimentary marshy land, Kolkata is dotted with moist deciduous groves and tropical wetlands, most of which has been converted for fish farming use.

Altitude: Kolkata is close to sea level in a formerly swampy area. Its altitude is 20 feet above the mean sea level.

River: Hooghly is the only river in Kolkata which is a tributary of the Ganges River and this river is situated western side of these two wards.

Population: According to the 2001 census, population of Ward no. 19 is 24,467 and Ward no. 20 is 19,486. Population density of these two wards is 104604.5319 person/sq. km. of ward 19 and 68341.71559 person/sq. km. of ward 20.

Connectivity: These two wards are connected all over Kolkata with road and railway. Main roads of these two wards are Sovabazar Street, B.K. Pal Avenue, Rabindra Sarani, Ahiritola Street, Stand Bank Road etc. Circular railway and Metro railway has present of these both ward.

Created Image: Rectified PAN Image: When a digital image was taken by camera at that time it is not geographically referenced. To remove these errors there are some processes between which one is known as geometric correction or rectification or image registration or geo referencing (Sarkar, 2003). It has two processes –

- Image to Ground Geo-correction (Geo referencing).
- Image to Image Geo-correction (Registration).

Fused Image: Increasing spatial resolution of a multispectral image using a co-registered higher resolution panchromatic image of same area and time. Through this process visualization ability of the image, which will help us to Digital Image Processing (DIP) and Visual interpretation can be increased (Jensen, 1990).

Fused False Natural Colour Image: For the present work a fused false natural colour image has also been used for better visualization. In this image all entities are shown in their own natural colour.

Raster to Vector Conversion: After doing this classification convert that classified image from raster to vector (R2V) and convert all classes in different layers and remove errors from these layers.

Identification of the Objects*:* For identifying the different objects present in an image there are some particular key features by the help of which we can detect the objects in an image. There are four major types of object is identified here –i. Vegetated area, ii. Built-up area, iii. Open space area, iv. Water bodies.

Classified Image: Sorting pixels into a finite number of individual classes, or categories of data, based on their DN values. The classifications are two types:

- Supervised (Information Class): Information classes are those categories of interest that the analyst is actually trying to identify in the imagery, such as different kinds of crops, different forest types or tree species, different geologic units or rock types, etc. (Fig. 2).
- Unsupervised (Spectral Class): Spectral classes are groups of pixels that are uniform (or near-similar) with respect to their brightness values in the different spectral channels of the data (Fig. 3).

In the present work, a Supervise Classification and four signature classes was done to classify the multispectral image. These are – a. Vegetation area, b. Built-up area c. Open space area and d. Water bodies.

- Vegetated Area: The vegetated area is detectable from the image through some processes. These processes are Vegetation has higher reflectance value in band 4 or NIR band. If multispectral image is open with 4, 3, 2 band combinations using RGB colour then vegetated area are shown in red colour due to the higher reflectance of vegetation in band 4 or NIR band. Transect Extraction is one of the methods which are applied to detect the vegetated area (Fig. 4).
- Built-up Area: The built up class consist of the buildings and the roads in the image. These objects can be identified primarily from their shapes from both the multispectral and panchromatic image.
- Open Space Area: The open space in the multispectral image by its association but mainly because of the tone, since the open space gives a higher spectral reflectance and so it seems white or white to yellowish.

Micro- Level Analysis: In the present study area there are two wards, these are shown in green colour in *DIGITIZED WARD MAP* picture (Fig. 1). Road network has also been shown in red colour in "DIGITIZED ROAD MAP" picture (Fig. 1). The Ward 19 is present in the northern part or upper portion and

the Ward 20 is present southern side or lower portion of the study area. According to the given data in these two wards there are 111 important roads, in spite of, having so many roads there are still some lanes and bi-lanes are present but due to their lower impotency their data has not been given.

According to this map and attribute data it can be understand that, Ward 19 has one heritage building, no market complex and no underground hydrant. On the other hand, Ward 20 has two heritage buildings, one market complex and underground hydrant. Respect to this data Ward 19 is less developed than Ward 20 since it poses no market complex or no underground hydrant. It is being realized that urban area need to upgrade its 'grey-infrastructure' (roads, metro railways, flyovers, etc.), along with the expansion of 'green infrastructure' (avenue trees, parks etc.).

Analysis of Road Network: Kolkata, being one of the most important metropolitan cities of India, is well connected by the entire transportation mode. The two study wards (19 and 20) are situated in the north-western side of Kolkata (KMC) beside the left side of the river Hugli. These two wards are also well connected through roads, circular and metro railways.

Table 1. Roads of The study area:

Ward No.	North	South	East	West
No.-19	Sovabazar Street.	B.K. Pal Avenue, Ahiritola Street and its continuation up to the River Hooghly.	Rabindra Sarani.	Circular railway
No.-20	B.K. Pal Avenue, Ahiritola Street and its continuation up to the River Hooghly.	Nimtala Ghat Street and Port Trust Road leading to Nimtala Ghat.	Rabindra Sarani.	Circular railway

Source: http://kolkataonline.in/profile

According to the attribute data, ward 19 has 55 roads and ward 20 has 56 roads, a total of 111 roads, most of which are very important for communication throughout the Kolkata. Based upon the calculated attribute data, layouts of buffer of the roads are drawn using the formula:-

Road buffer= Half of carriage width. From the study, it can be observed that-

- Road area is larger in ward 20 (53%) than 19 (47%),
- Ward 20's area is larger than 19,
- Road buffer area is larger in ward 20 than 19.
- Among these 111 roads, the two main types, i.e. bituminous (99 roads) and stone set (12 roads) are observed.

- Among the studied 111 roads, various carriage widths are present which have been represents through a table (Table 3).

But all these roads are segments of one single road and 'Botto Kristo Paul Avenue' is the only road with the highest carriage width (16 meters) between the two wards under study. It can easily be understood that the road coverage area in ward 19 is less than the ward 20 (Fig. 5). For in-depth study, road area density was calculated through the process:

Road area density=Road Area/ Ward Area.
(Road Area= Carriage Width x Shape length).

The impact of road area density is important in several aspects. The first and most significant is fragmentation of the landscapes and habitats. When road is being constructed then huge number of trees are cut down so far Kolkata is concern. The road area density in ward 19 is higher than ward 20, though the road area and ward area is less in ward 19.

Population: According to the 2001 census, population of ward 19 is 24,467 and ward 20 is 19,486, whereas the population densities of these two wards are 10460.5319 and 68341.71559 persons per sq. k. m. respectively.

Land Cover: The important and typical application of remote Sensing data is to represent the land cover. Land cover refers to features of land surface; which may be natural, semi-natural, managed or man-made. From the tabulated data, it can be stated that, the vegetated area, Built-up area and open space area in ward 19 are less than the ward 20.

Analysis of Vegetation Cover: The vegetation cover of Kolkata is decreasing day by day due to over population and to make the city more modern to accommodate them and pollution. The main motto of the present work is to extracting the information about the amount of vegetated area of the two study wards (Fig. 6). According to the acquired data, ward 19 has 42% and ward 20 has 58% vegetation area. For in detail layout of the study area, vegetation density is calculated. Vegetation density is a measurement of vegetation coverage per unit of area usually per square k. m. or mile.

(*Formula: Vegetation Density= Vegetation Cover/ Ward Area*. Here vegetation covers and ward area calculated from Arc GIS after doing Raster to Vector (R to V) conversion.) (Fig. 7).

Table 2. Road area of the study wards

Ward No	Road area (sq.mts)	Road area (in %)	Ward area (sq.mts)
19	36195.75	47	233900.4009
20	41459.92	53	285126.1529

Table 3. Carriage width of the study wards

Carriage Width (in Meters)	No. of Roads
2.100000 - 4.880000	38
4.880001 - 7.660000	32
7.660001 - 10.440000	24
10.440001 - 13.220000	7
13.220001 - 16.000000	10

Table 4. Ward area and road area

Ward No.	Ward area (sq.km)	Road area (sq.km)	Road area density/ sq. k.m.	Ward area (sq.mts)	Road area (sq.mts)
19	0.2339	0.036195687	0.154748559	233900.4009	36195.75
20	0.28512	0.041459897	0.145409039	285126.1529	41459.92

Table 5. Land covers data (in sq. meter)

Ward No.	Vegetation	Built-up Area	Open Space Area	Ward area
19	23765	208502	1633.69	233900.4009
20	32678.5	248250	4197.23	285126.1529

Table 6. Ward area and vegetated area

Ward No.	Ward area (In sq.mts.)	Vegetation Cover (In sq.mts.)	Vegetation Density/sq. km.
19	233900.4009	23765	0.101603249
20	285126.1529	32678.5	0.114610734

Table 7. Population, vegetation and built-up area densities (in sq. km.)

Ward No.	Vegetation density	Population density	Built-up area density
19	0.101603249	104604.5319	0.891415135
20	0.114610734	68341.71559	0.870667705

Source: All the data are obtained by the author from the Satellite Imagery

The impact of vegetation density is important in several aspects, like-fragmentation of landscapes, human and habitats. Due to decrease of vegetation density increase of the environmental risks (pollution, global warming etc.) occurs. The study reveals that the vegetation density is higher in ward 20 than ward 19 (Fig. 7). The ward area, vegetated area and vegetation density of the study area have been shown in this layout (Fig. 2). From the column graph and tabular data, we can understand clearly that that ward area, vegetated area along with the vegetation density of ward 19 are lower than ward 20 (Fig. 8).

Analysis of some relationships

The relationship between *population density and vegetation density* of both wards is expressed (Fig. 5) and it is observed that, there is always an inversely proportional relationship between population density and vegetation density. If population density increases then vegetation density will surely decrease and vice versa. Based on the above layout and the evaluated tabular data three graphs were drawn. Here, Ward 19 both built-up area density and population density are high than the Ward 20 (Table 7). So it can be said that an environmentally misbalanced situation exists in Ward 19. Because if population density increases then proportionally built-up area have to increase with it then at the same time the vegetation density have to decrease and this has only happened here. It also reveals that vegetation density of Ward 20 is higher than Ward 19, but it is to be remembered this is not the case for our study area only. This is evident for the whole world. Through a layout, it can be stated that the comparison between *road area density and vegetation density* of each ward expressed a different relationship (Fig. 9).

There has always been an inversely proportional relationship between *road area density* and *vegetation density* (Fig. 8). But before discussing this topic, it is needed to know why the road area density will increase? Because if population density is increased then it is very obvious that they will not be accumulated in one place instead they would disperse themselves over a wide area. So the built up area will increase simultaneously this has been shown in graph ‘A’. Now it is

in the human nature that man cannot live alone. So to move around in different places we need roads and in today's world road seem to be a symbol of modernizing. The construction of roads is for better transportation, communication, etc. So to increase the number of road density and road area density the trees are cut down, in turn road density and road area density will increase than the vegetation density. It is stated that, in Ward 19 both built-up area density and road area density are higher than Ward 20, so vegetation density in Ward19 is lower than Ward 20. Built-up area density and road area density are directly proportional to each other.

Major Findings

Towards the end of the study a result of the present work can be stated that, the vegetation of the study area is at verge. Compared to any other aspect (road area, population, built-up area density) of the area it is observed that the vegetation density is lower than those. The affects of that could be happened in the following ways- **i.** Lose of biodiversity, ii. Climate changes, iii. Increase Pollutions, iv. Ecological imbalances, v. Decrease water level, vi. Misbalance situation in environment, vii. Green house gasses will be increased.

Therefore, it can be said that this is an imbalanced situation which is needed to be taken care of and if not the adverse results are very near to us. It is to be hoped to see a better and *GREENER KOLKATA* in near future. Kolkata is facing excessive population pressure along with the presence of unplanned economic development, industrialization and vehicular emissions leading to a steady decrease in urban greens (Shekhar, 2004). Needless to say the main contributors to India's high pollution level has been its growing metropolitan cities, Kolkata being an important one.

Over the years, Kolkata has grown in an unplanned manner. In the post-independence years of latter half of twentieth century, the city has grown in the southern part. After partition and refugee influx- the informal sector in service, commerce and industry have experienced a spiraling growth in the city. The arrival of refugees left no time or opportunity for any land-use planning. Consequently the green space distribution in the study area is largely disparate. In recent times, the entire North and Central Kolkata has become covered with residential, commercial and mixed residential-commercial land use leaving very little room for any significant amount of urban greens. These areas are the oldest parts of the city which have developed from the time of its growth and development under British rule. Spatially at the time of the study the southern, south eastern and eastern fringes of the city have a more generous share of green

space. These areas are new additions to the city, which have been incorporated from surrounding non-built up areas and so have not been invaded by built-up space in the proportion the older parts of the city have witnessed.

Based on per cent of ward green area and using GIS as a tool, the study area of Kolkata Municipal Corporation has been identified in four green zones. Maximum parts of the city have been identified in the *Very Low Green Zone* (0-5% ward green area). Parts of bordering areas on the western parts of the study area have been identified as *Low Green Zone* (5%-10% ward green area). This part is the areas which have lesser built up area compared to the core city. The *Moderate Green Zone* (10%-20% ward green area) is observed around eastern part. The main concentration of the High green zone has been around boundary of the two study wards. Finally a small area and patches in south of both wards recorded formed the *High Green Zone* (>20% ward green area).

The study gauged the environmental perception of urban green space of Kolkata's citizens. Considering the 'fluid' nature of the environmental image, the study has made attempts to analyze the citizens' perception in both qualitative and quantitative manner. A novel approach integrating collaborative GIS techniques and informal interviews generated complementary insights about the spatial and non-spatial factors influencing attitude towards urban green spaces.

Conclusion

From the present study, it can be stated that the study area of Kolkata is highly signified with very low urban greenery or vegetation density, thus causing acute problem which is need to be taken care. Thus it is conclude that the vegetation cover of the study area as well as Kolkata is insufficient and is decreasing day by day and huge carbon (about 95 lakh tones) are generated in Kolkata from vehicular emission every year which has become a matter of immense concern. Therefore, the urban ecology of Kolkata has been affected adversely. GIS and Remote Sensing help in detecting the affected area. Today, there are several instances where GIS incorporated with other data sources which are providing innovative and alternative solutions in the management and monitoring of urban greenery. GIS is widely accepted in urban landscape planning as it can provide better understanding on the spatial pattern and changes of land use in an area. So, it is expected that the city will spend money and detect the affected area and will try to improve it by planting trees as much as possible. At the same time Government and many others private authority should be implement to aforesaid

approaches. In that purpose GIS can be an effective tool in preserving and monitoring urban greenery and open spaces in an urban area.

At the end of the present study, there are some suggestions which is if not taken care of the lives in Kolkata would be in danger in the near future, like-

- People should be made aware of the importance of the trees particularly in the case of Kolkata.
- Need to plant trees beside houses, roadside, railway tracks.
- Pollution should be kept in control.
- Some rules should be enforced so that no more buildings or malls are made by cutting down trees.
- Householders can be tempted by allowing a certain amount of money if they plant a certain number of trees around their houses.
- People should be supplied with seedlings from the corporation.
- People should be more aware of their surroundings.
- Proper maintenance of trees is needed, only planting them will not be sufficient.
- The slogan of "ONE MAN ONE TREE" should be rejuvenated among youngsters so that the result is achieved quickly.
- People should be stopped from cutting down immature plants and trees and if extremely needed then re-plantation should be done.
- NGOs and other organizations should be also welcomed to increase the green coverage of the city and its environs.
- Number of Eco Club and NSS centre should be increase to enhance the green area.
- The individual green assets must be encouraged and enhanced in a large scale in the Very Low, Low Green Zone and Medium Green Zone. In these zones it is difficult to plant new tree saplings. Hence the focus has to shift to the household green assets. Detailed environmental policy must be formulated and implemented for the household level. This exercise may be emulated in the entire Kolkata as well as other Indian Metropolitan cities.
- The maintenance of parks and gardens should receive much more attention with active participation from the citizens themselves. One of the greatest factors is active participation from the residents themselves.
- Apart from residents, students from educational institutions in the neighborhood may be truly encouraged to play an active role in the maintenance of the green space. Environmental policies may be formulated which actually join hands with the educational

institutions and make these activities a joyful yet compulsory activity for the students.

- Last but not the least the Government should take some serious steps to maintain the Kolkata's greenery.

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Appendix

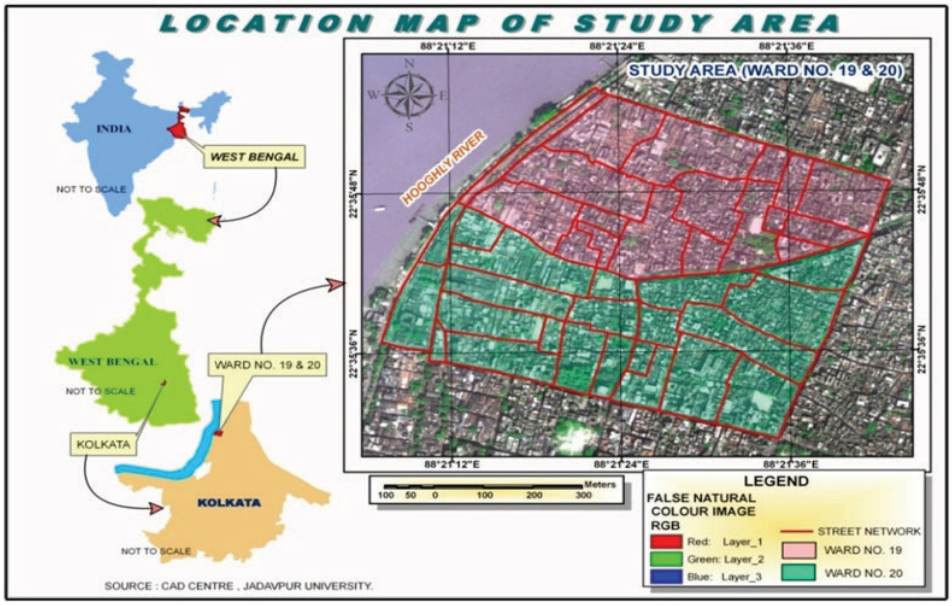

Fig. 1. Map of the location of the area of study

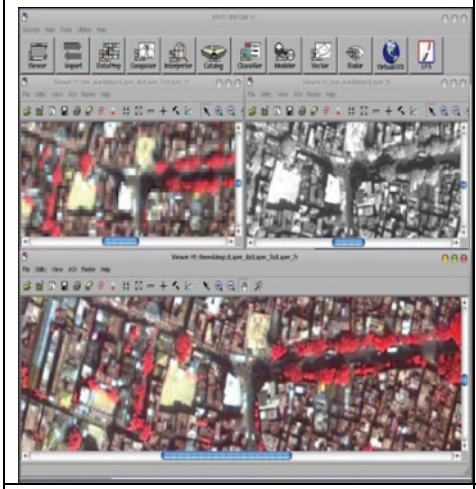

Fig. 2. Rectified PAN Image

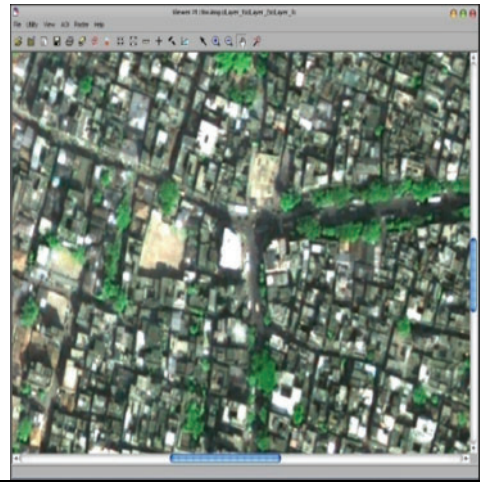

Fig. 3. Fused False Natural Colour Image

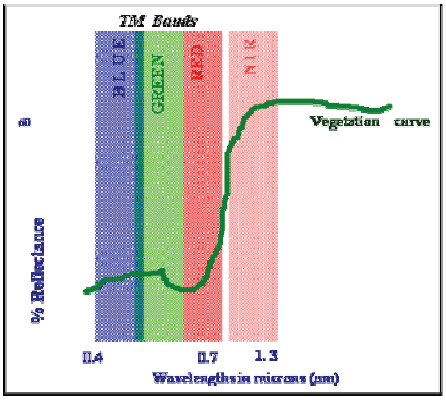

Fig. 4. Graph showing vegetation

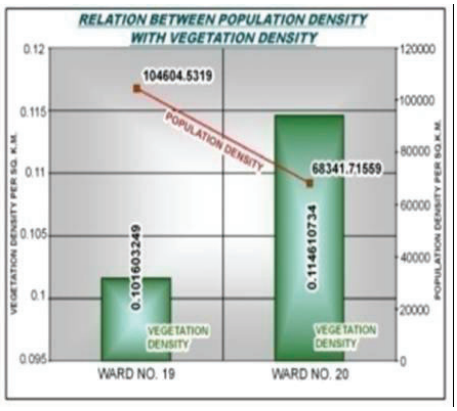

Fig. 5. Relationship between population density and vegetation density, 19 & 20 Ward, Kolkata.

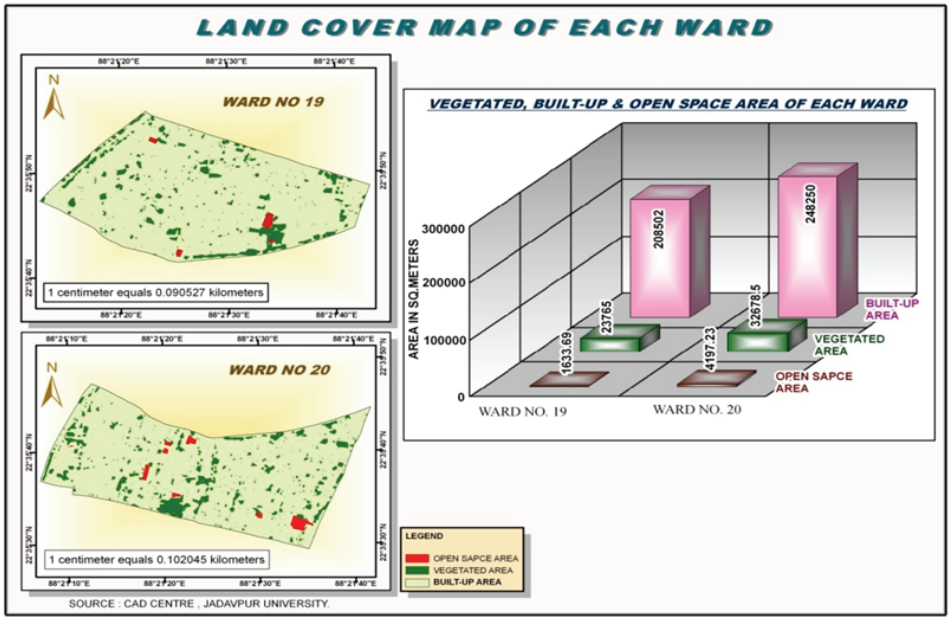

Fig. 6. Land cover of the Ward 19 and 20.

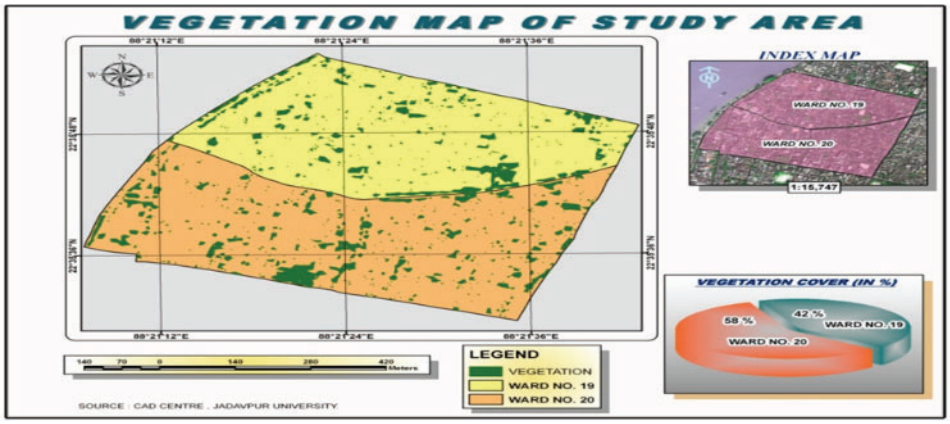

Fig. 7. Vegetation Cover of the Ward 19 and 20

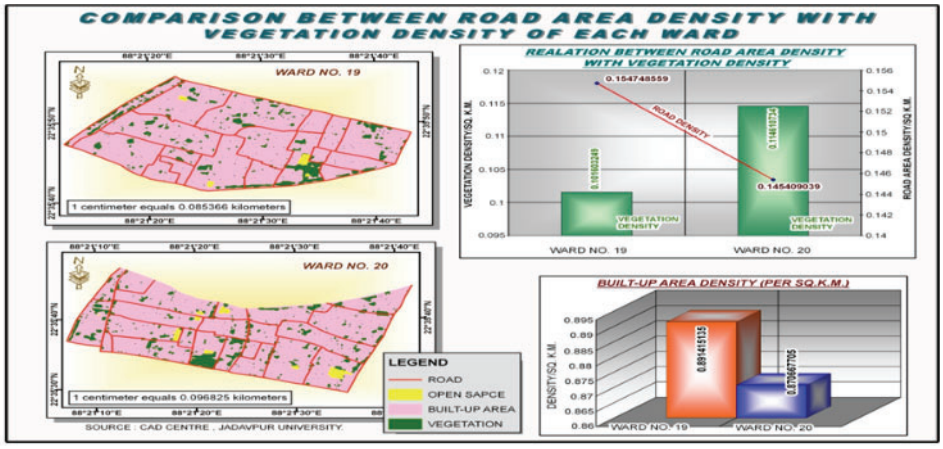

Fig. 8. Comparison of road area and vegetation area of Ward 19 and 20

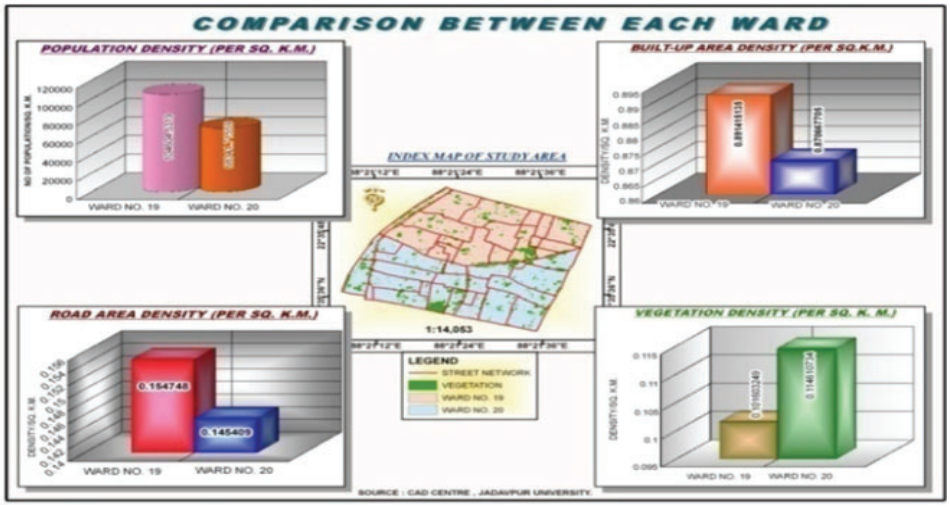

Fig. 9. Comparison between ward 19 and 20, Kolkata

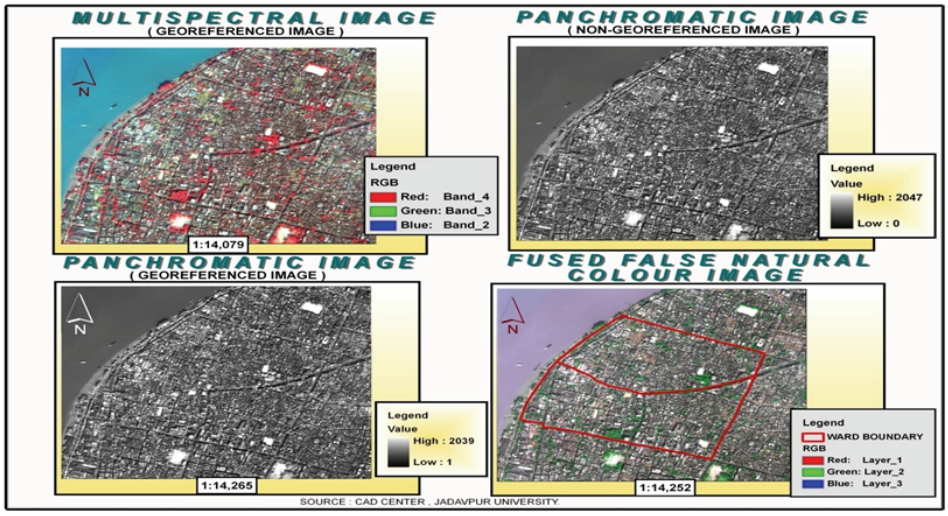

Fig. 10. Classified Base Images