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Research Article

Extraction and Alignment of Vegetation astride Road Network in Ward 19 & 20 of KMCA: A Micro Spatial Study

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Abstract:

It is a common apprehension among the researcher that micro-level planning for the plantation of various types of trees at suitable sites of the urban spots may reduce the surface heat fluxes of those urban heat islands. A comprehensive study has done to find out the relation between present alignment of road and vegetation covered land of ward no. 19 and 20 of Kolkata Municipal Corporation. Digitized remote sensing images (LISS IV, 2008) and geographical information system together have supported the scientific analysis of the carriage width of the roads, vegetation density, vegetation quality in response to DN values in different pixels and NDVI values, spatial vegetated land in different buffer distance from road network etc. Result between road network and vegetation distribution shows that vegetation concentration is irrespective of carriage width of the network but concentration of vegetation is more alongside the roads and gradually become sparse outwards.

Introduction:

It is a well known fact that sustainable urban planning gives consideration to the environment and to the quality of life of the inhabitants. High rise buildings, industries, even growing volume of motor vehicles are the direct sources of heating as well as indirect sources of noxious pollutants to the atmosphere. Now a day a common apprehension among the researchers is that the higher urban temperature has direct effect on global climate change.

In fact it has been reported that higher urban temperature increases the electricity demand for cooling and production of carbon dioxide and other pollutants (Santamouris et al, 2000). So a micro level planning for plantation of various types of trees, adjusting to the complicated

geometry of the streets and tall building, may affect the micro climatic condition as well as the overall ecological development of the urban spots. The mission mainly depends upon the information of the extension of transport network along with the density and clusterization of the trees.

Satellite images of LISS III, LISS IV, P6 etc. have potential to provide comprehensive information on transport network and various facts of vegetations (Ray, 2002). GIS is complementary technology as well as a tool for spatial representation of information obtained from remotely sensed data, which are essential as management input (Milliar & Shaw, 2001). The aim of the present study is to find out relationship between road network and vegetation of Ward number 19 and 20 of Kolkata Municipality and to promote the concept in louder voice that road side plantation not only aids for urban greenery or beautification but also help to reduce direct vehicular pollutants.

Kolkata has witnessed urban growth and expansion over the centuries which has taken toll of green areas of and around the city and has dire consequences on its environment. Roadside tree planting probably was initiated in 1727 after the establishment of Calcutta Municipal Corporation. But this programme was officially sanctioned for the first time in 1869,later it was discontinued as the expenditure on such purpose was not authorized by law(Goode,S.W. 1916).In 1911 Calcutta Improvement Trust (CIT) gave some importance to the creation of parks and open spaces. Rapid expansion of the city to meet increasing needs of the population the open spaces and parks are converted into built up land, particularly since 1980's (Sivaramakrishnan, 2010). Avenue plantation is the most popular of urban greening which may increase the level of planted area to a significant scale and raise the status of ecological environment.

Study Area:

Kolkata city, one of the four metropolitan cities in India has a history of no more than 300 years. The city, formerly known by the name of Calcutta has undergone a change in a very short span of time. Kolkata as it stands today is the largest metropolitan city of India. The city has the distinction of being the precursor of many important movements encompassing politics, arts, literature, theatre, cinema, science and technology in India.

The city is divided into 141 administrative wards that are grouped into 15 boroughs which altogether carry 187.33 sq.km. of area. An ancillary civic body is the Kolkata Metropolitan Development Authority (KMDA) responsible for the statutory planning and development of the Kolkata Metropolitan Area (KMA). The KMA includes a large suburban hinterland around the urban centre of Kolkata.

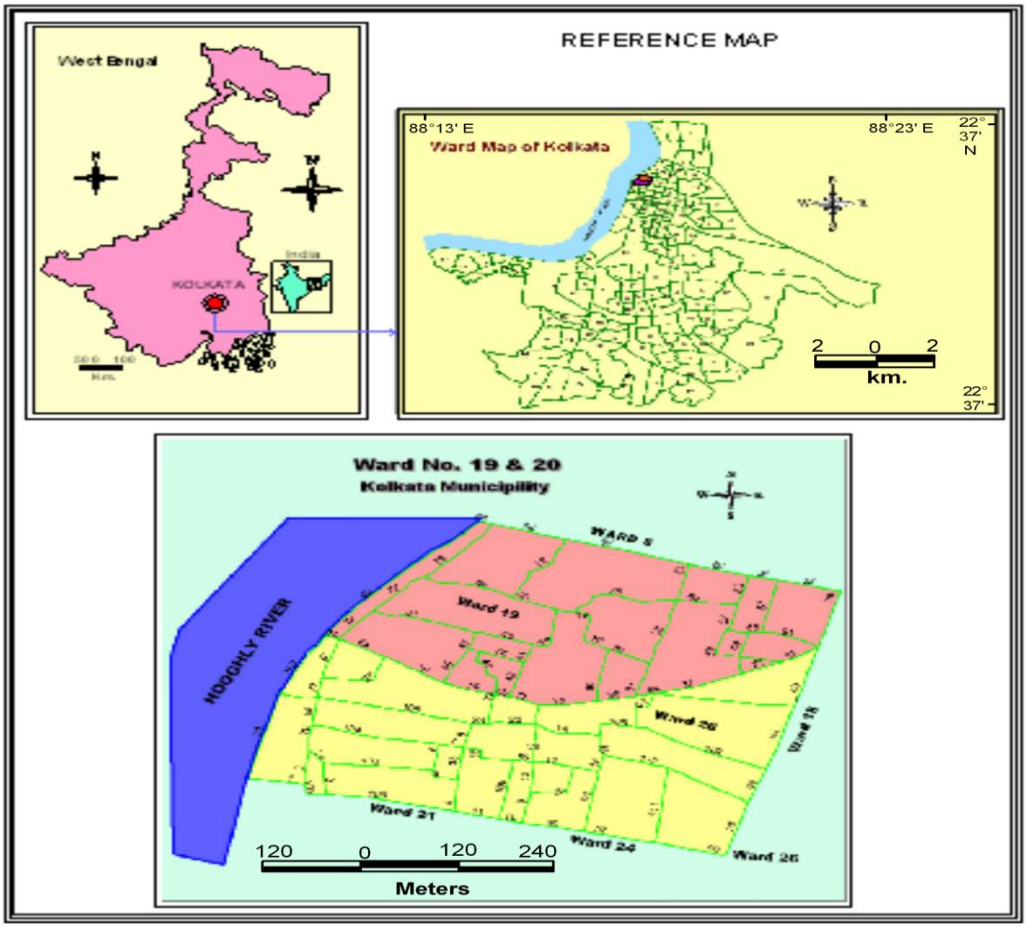

Fig. 1 Reference map of the study area

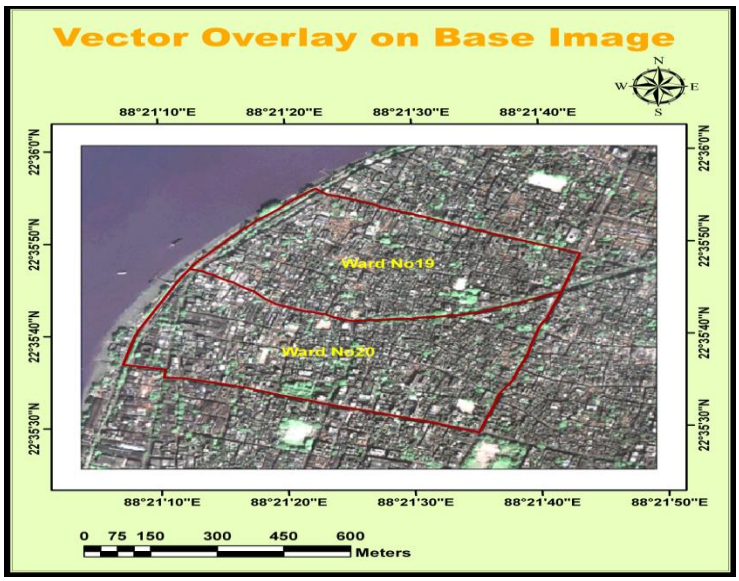

Fig. 2 Ward map on base image

Database and Methodology:

Image of LISS III of IRS 1C satellite series (Nov.,2009) has used for extracting road and vegetation pattern. For extraction vegetation quantity supervised classification in 4, 3, 2 band combination has done collecting adequate spectral and spatial signature of vegetation and using *non parrellipiped* rules. GPS survey has done for field checking regarding vegetation alignment and road distribution. For vegetation quality assessment Normalized Differential Vegetation Index (NDVI) has implied (Chrysoulakis, 2002). Simple equation of NDVI is as follows.

$$NDVI = \frac{IR - R}{IR + R}$$

Where, IR = Infrared (Band 4; wave length 0.77µm. to 0.86µm.); R= Red (Band 3; wave length 0.62 µm. to 0.68 µm.).

On the basis of resultant NDVI values, entire image has again classified into four vegetation quality classes in order to define greater the value and better the quality of vegetation and vice versa.

For extracting road network some useful image enhancement techniques like brightness and contrast enhancement etc. have used. On the basis of the buffer zone map of road network in different distances the relational alignment of vegetation and road network has established.

Result and Discussion:

Road Extraction:

In order to obtain the knowledge of road network pattern the network carriage width has calculated from the digitized road network map (Fig. 3).
In ward no. 19 there are 55 road links with different names and on the other ward (no. 20) the number is 56 and the common boundary roads are 12. Average road density is about 450 m./ 100 sq. m. area. Road density is relatively high where settlement concentration is high but roads are narrow on those places.
Table 1: Carriage width category in different wards

Ward No.	Carriage width in m.				
	<2m.	**>2m.**	**>4m.**	**>8m.**	**>12m.**
19	1	36	59	7	10
20	0	16	35	10	18

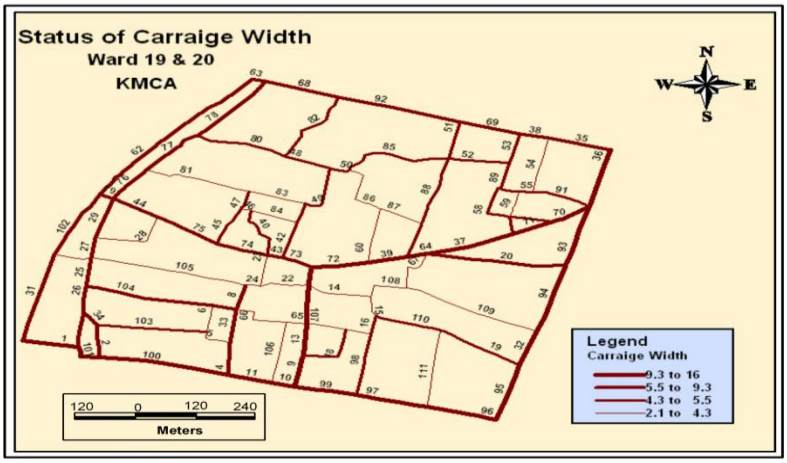

Fig. 3 Status of road width in different road segments

Vegetation Extraction:

Spectral value or digital number (DN) actually varies from object to object and vegetation type to type. But on an average in 16 bit image DN value for vegetation varies from 60 to 86. If DN value is more than the vegetation density or quality will be good and vice-versa. Within a vegetation patch the variation of vegetation status can be assumed using the surface variation of the spectral value. In general if the quality of vegetation is same the possibility to DN value status will be uniform. Therefore, change of spectral value means variation of vegetation quality.

A tiny vegetation patch has been selected and surfaced which is showing the significant variation. Surface value also constructed on the basis of spectral values but displays in 3D format. The variation Z (pixel) value within each patch makes it clear that there is variation of reflectance value of the vegetations and vegetations are of different qualities or types (see fig. 4).

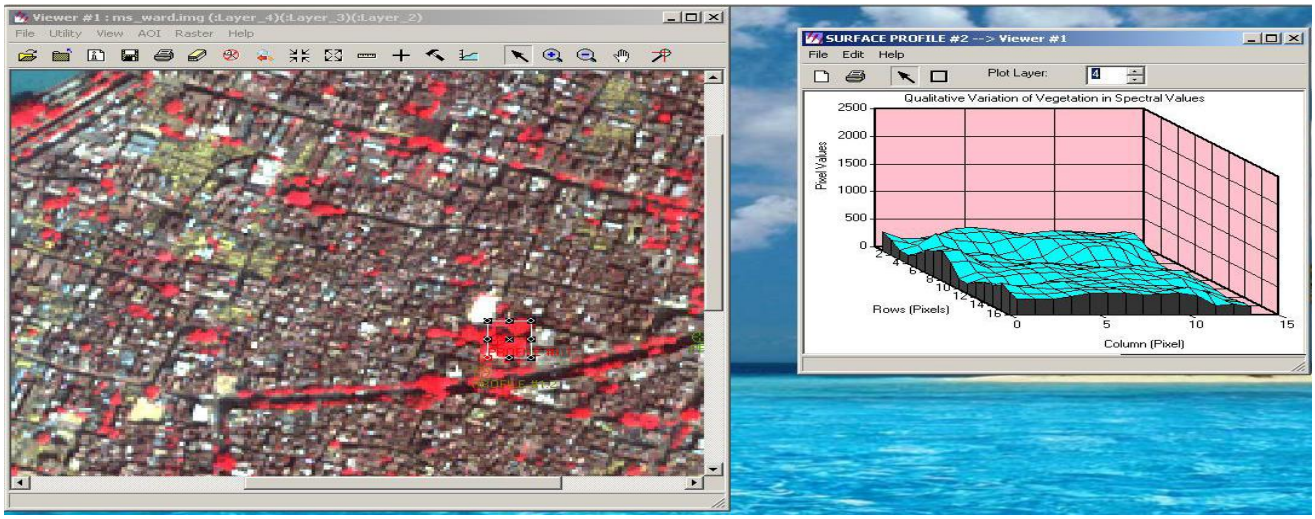

Fig. 4 Intra vegetation patch DN value disparity

Quantity Assessment:

Following a long, systematic and scientific techniques vegetation area has been extracted and highlighted with green colour. A small glimpse of image classification has shown in the following print screen images (fig. 5).

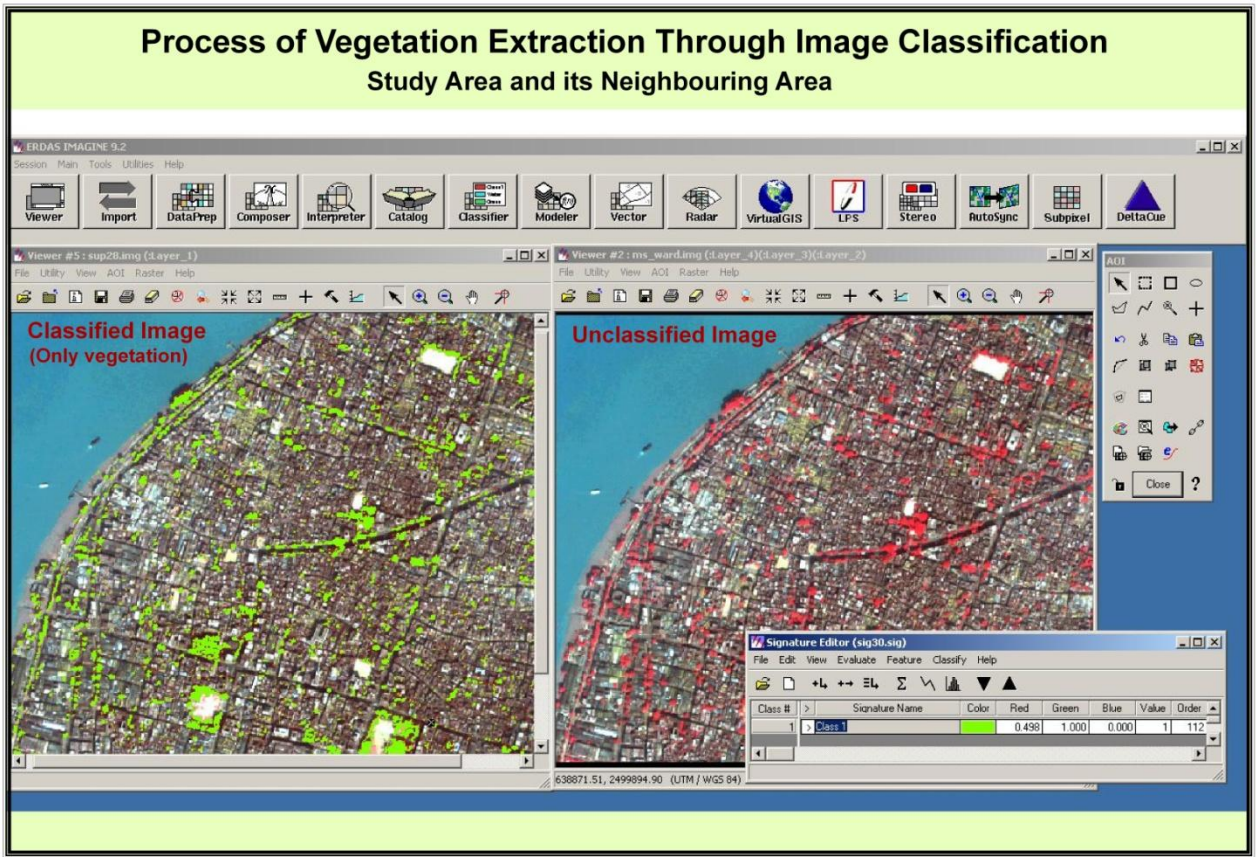

Fig. 5 Classification of vegetation from raw image

Total geographical area of the ward no. 19 & 20 is 37.30 ha. and 52.04 ha. respectively. Classified image shows that out of total area, 2.08936 ha. in ward no. 19 and 2.63423 ha. in ward no. 20 is covered under vegetation. Table 2 shows the quantitative details of vegetation distribution.

Table 2: Vegetation cover and vegetation density

Ward No.	Total area in ha.	Vegetation cover area (in hectare)	Vegetation density/ hectare
19	37.3019	2.08936	0.056
20	52.0404	2.63424	0.050

Quality assessment:

Vegetation quality can be assessed in response to DN value. The differences of DN value over a vegetation patch is happened due variation of chlorophyll content in plant's tissues. It again varies due to a set of factors like change of rainfall and temperature in different seasons, pest infestation, type of vegetation, availability of plant's sap for their nutrition etc. There are different advanced remote sensing techniques to measure vegetation quality, like Normalized Differential Vegetation Index (NDVI), Vegetation Index, Tassel Cap analysis etc.

Normalized Differential Vegetation Index (NDVI) technique is very much effective to assess the health of vegetation, chlorophyll content etc. The output image is a grey scale in looks and gives vegetation quality. Vegetation quality in NDVI varies from 0 to 1. More the intensity of value more is the qualitative of vegetation health. The bright white portion indicates healthy vegetation and relatively white grey portion indicates poor health vegetation **(vide fig. 6 & 7).** In the study area the variation of vegetation health is not state worthy because most of the vegetation is planted and of same category and same age.

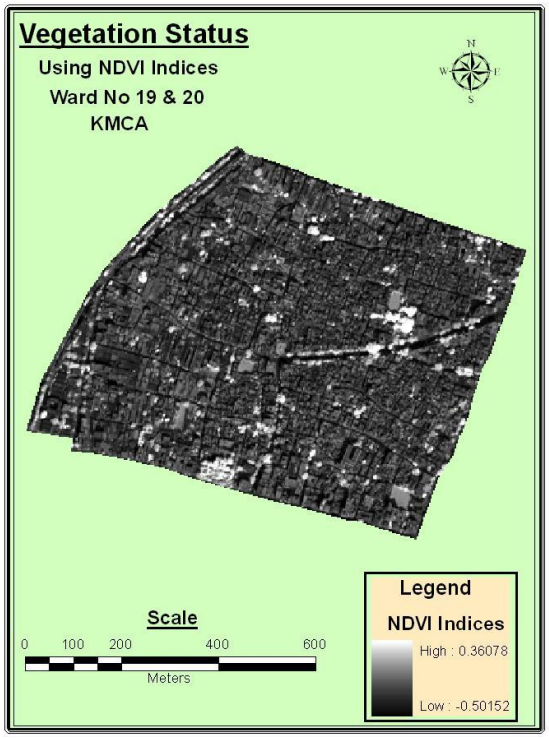

Fig. 6: Status of vegetation indices

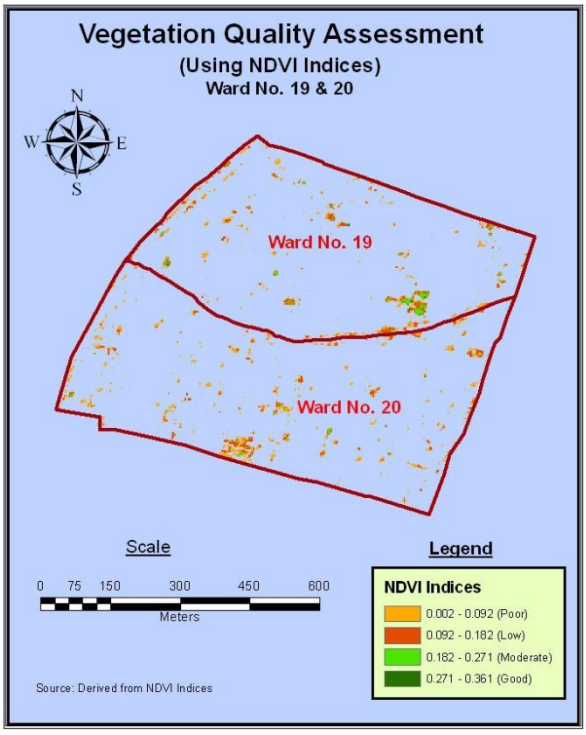

Fig. 7: Classification of vegetation based on NDVI

Vegetation Spatiality along Network:

The birth, growth and death of vegetation follow the nature. But extension of road network of an urban spot disturbs the vegetation alignment. To make a study on the spatial distribution pattern of the vegetation in response to road network three buffer distances have been selected at 15m., 25m. and 40m. distance from road line(Fig. 9a, 9b, 9c).

From the vegetation alignment, it is clear to mention that there is definite tendency to align vegetation along roadsides where there is possibility of plantation (Fig. 8.a). Form figure 8.b it is also clear that there is no definite relationship between carriage width of road and vegetation concentration i.e. in both the wards the pattern of vegetation concentration is almost uniform both along sides of narrow and wide road.

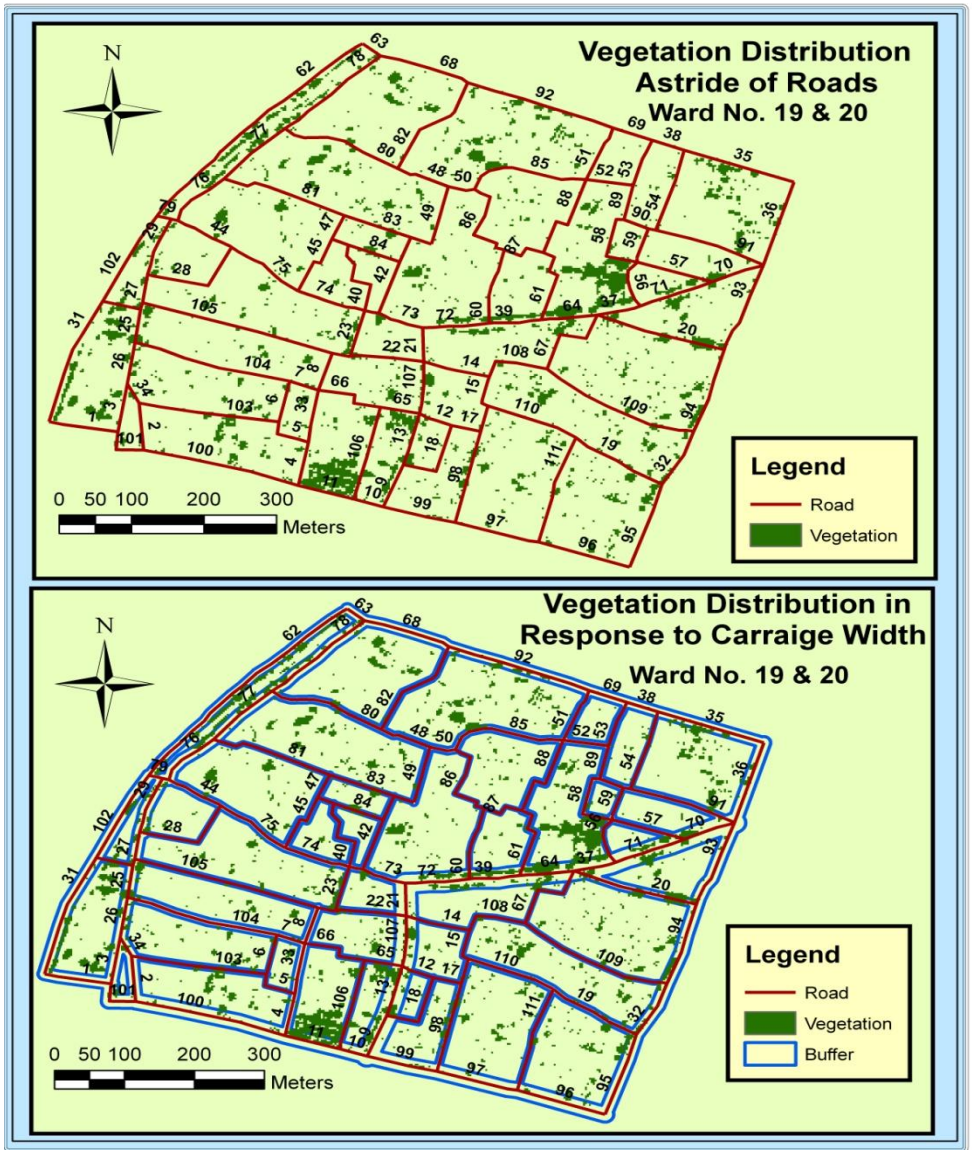

Fig. 8a & 8b Vegetation distribution along road side in response to width of road

At 15 m. buffer distance vegetation cover area is 2.83494 hectare while from 15 to 25 m. buffer distance the vegetation cover area is 1.57563 hectare and between 25m. to 40 m. distance it is only 0.19 hectare. So, about 90% vegetation cover land is noticed within 25 m. distance from road.

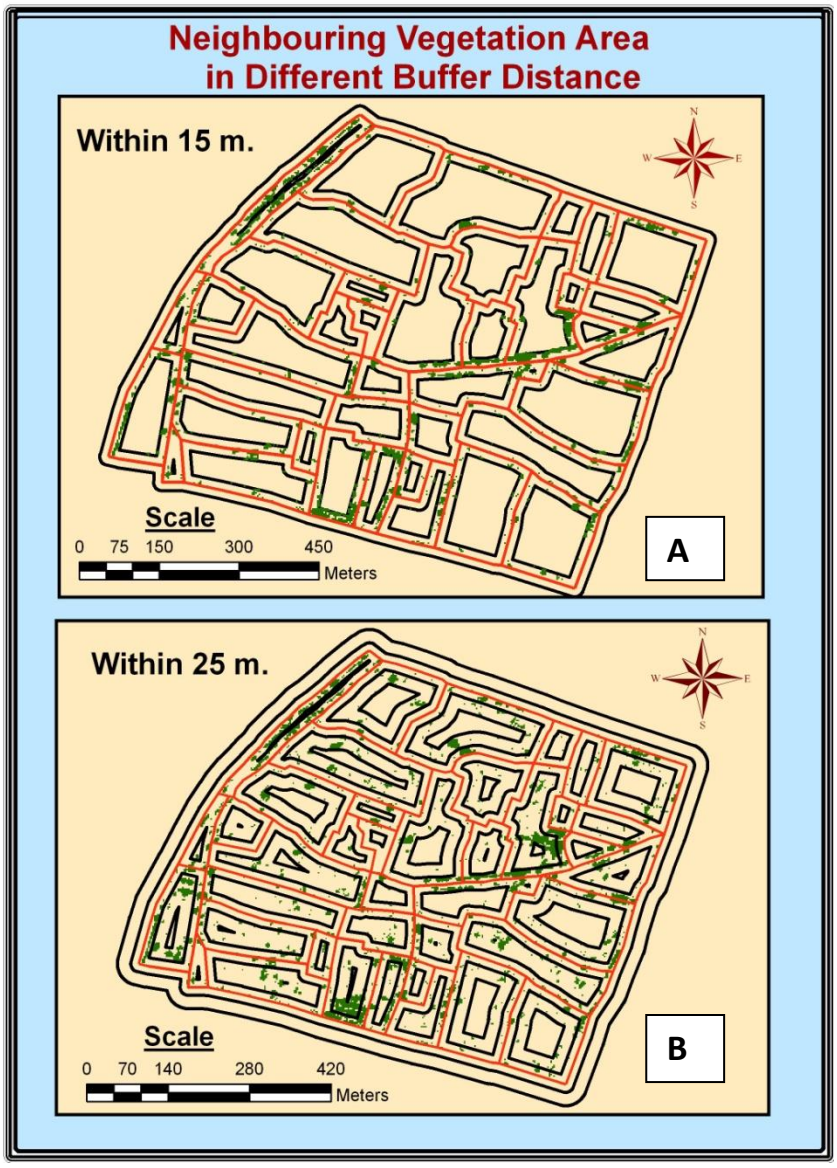

Fig. 9 a & b Vegetation cover in different buffer distance from road

Table 3 shows the distribution of vegetation in different buffer zones and cumulative pattern of vegetation in the same buffers. The analysis depicts that vegetation concentration is high in the road side and sparse toward far offset distance from road.

Fig. 9c Vegetation cover in 40 m. buffer distanc

Table 3: Vegetation area along side road

Buffer distance from road (in m.)	Vegetation area in hectare	Cumulative vegetation area
0- 15 m.	2.83494	2.83494
15-25 m.	1.57563	4.41057
25-40 m.	0.19193	4.6025

Source: Derived from classified image

Summary and Conclusion:

In the present study, digitized remote sensing images along with GIS packages have established the relationship between the road network and vegetation cover of two sample wards of Kolkata Municipality Corporation by supporting the micro level information. Sustainable urban planning demands micro level investigation and application of this knowledge to improve the urban

ecosystem. On the basis of above discussion it may be suggested that the extension of vegetative covered land is necessary in the urban spots which have great effect on the reduction of pollution level. So, government and private level plantation programmes should be installed according to demand. Large number of spacious road sides of these two wards can ensure more than double times vegetation covered areas than as present. Road segments 32, 68, 69, 70, 72, 74, 75, 76, 94, 95, 96, 97, 99, 100, 102, 105 etc. have potentials to make space for vegetation. Plantation of shrubs and climbers along boulevards, road dividers must be included in the Kolkata greening project. Moreover, when new roads will be established in the newly builtup areas, space for plantation should also be ensured.

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