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URBAN GREEN SPACES: A CHANGE DETECTION ANALYSIS OF THE KOLKATA MUNICIPAL REGION

Maansi Malik and Prem Prakash

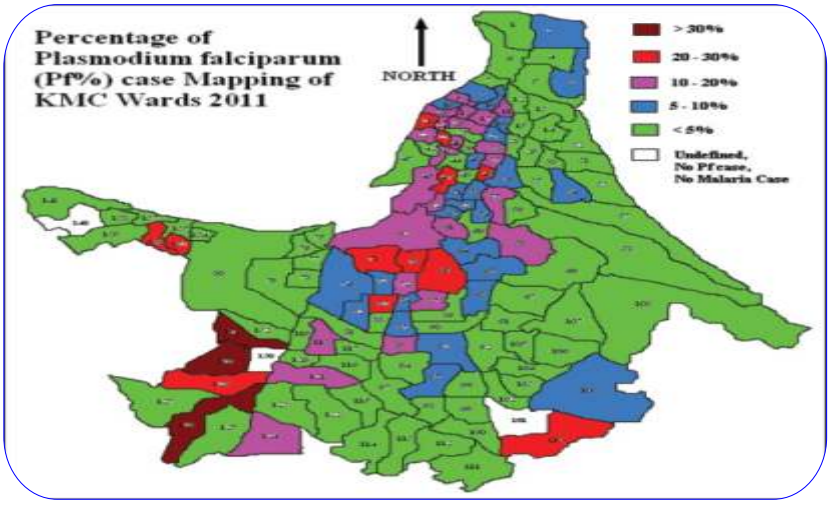
ABSTRACT

Kolkata is a comparatively congested city as compared to Delhi since the rate of migration is very high and the area of the city is not enough to accommodate such a large population. The area of Kolkata is approximately half of the area of Delhi and the region experiences large scale migration from the surrounding regions. This is because Kolkata is the economic centre of the eastern region due to concentration of industries, financial services and commercial activities in the city. Rapid development has taken a toll of the open and green spaces in the region and these have diminished to a great extent. The water bodies have also declined.

KEYWORDS :Urban Green Spaces , Detection Analysis , financial services and commercial activities .

STUDY AREA

Kolkata is located in the eastern part of India between the geographical coordinates of 88º 30'E - 22º 33' N longitudes. The city has been divided into different topographical regions. There are mainly five geographical units including east, west, north, south and central Kolkata. The adjoining regions include Howrah, Hooghly, North 24



Parganas, South 24 Parganas and Nadia. Kolkata is situated on the outskirts of the Sundarban Delta (145 km to the south of Kolkata). It's on the eastern bank of the river Hoogly. The topography of Sundarban is also typical as it the largest mangrove delta in the world. The city's soil type is mainly alluvial similar to the soil of Indo-Gangetic plains. Quaternary sediments consisting of clay, silt, various grades of sand and gravel underlie the city. These sediments are sandwiched between two clay beds, the lower one at depths between 250 and 650 m and the upper one ranging between 10 and 40 m in thickness.The Maidan (literally open field) is the largest urban park in Kolkata in the Indian state of West Bengal. Kolkata lies in the tropical zone and hence the climate in Kolkata is also of tropical type.

During summer season the climate becomes very hot and humid The city's average minimum annual temperature is 26.8 °C and monthly minimum temperature varies from 19 °C to 30 °C. The maximum temperature of the city during summer (April-June) exceeds 40°C while minimum temperature during winter (December and January) reaches 12°C. Kolkata experiences an annual rainfall of about 160 mm. October and November Kolkata evenings become very pleasant. The highest temperature recorded is 43°C and the lowest is 5°C.he city experiences the southern monsoon between June and September during which heavy rains lash the city. This is the season when the city gets most of its annual rainfall. Kolkata is among the most polluted cities of the world with high level of Suspended Particulate Matter (SPM) in the atmosphere creating a major health hazard. The best time to visit the city is between September and March. During this period the sky is clear and the climatic condition is favorable for the tourists.

Fig 1: Administrative Divisions, Kolkata (2011)

OBJECTIVES

The objective of this study is to assess the change in green cover in the Kolkata municipal region temporally. The study is an attempt to investigate the underlying reasons behind the change in land-use pattern of the capital city.

DATABASE AND METHODOLOGY

The study is based on use of GIS-based methods. For the study satellite imagery for the year 2002 and 2012 has been used. The satellite imagery for 2000 is an ETM+ (Landsat 7) image and 2012 is a LISS IV (Resourcesat 2) image. Two methods have been used. The first method is the Normalised Difference Vegetation Index used to assess the vigour of vegetation cover to estimate the percentage change in area and the second methods is the Land-use/cover analysis based on which a change detection analysis has been conducted. The second method is a tool to identify theunderlying causes of change in the green cover of Delhi.

NDVI

The main aim of calculating NDVI was to distinguish the green cover from the other areas. NDVI was calculated on the basis of 50 samples of vegetation. The NDVI values in Kolkata were much less as compared to Delhi. For the year 2002 the threshold value was 0.102 while the value for the year 2012 was 0.124. This indicates that the green cover density in Kolkata has increased over time. The increased threshold value may be due to increase in area of green cover or also due to the fact that the physiognomy of the trees and vegetation cover in these regions must be much healthier as compared to 2002 i.e. the area under vegetation must have remained same but spectral reflectance would have increased as a result of increased photosynthetic activity due to a much greener vegetal cover. NDVI values not only depend on the density but also on the health of the green cover. Pale brown leaves have much lower NDVI as compared to green healthy leaves.However, the threshold value for Kolkata is less

compared to Delhi for both areas. This explains that the green cover in the city has already been removed due to rampant development.

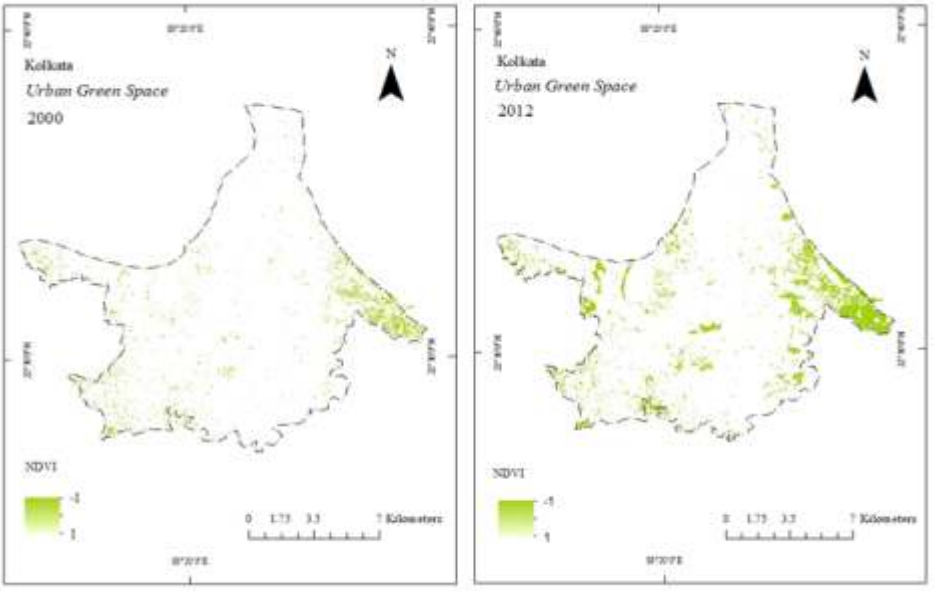


Fig 2: Demarcation of green spaces using NDVI (2002, 2012)

LANDUSE CLASSIFICATION

The total area of Kolkata Metropolitan Area nears to about 850 sq kms. The aim of classification is to divide the area into suitable landuse and assess the area under a particular landuse as a percentage of total area. This can then be compared on a temporal scale. Landuse classification of Kolkata was done into three classes: vegetation, water bodies and built up.

1. Vegetation: The main green areas of Kolkata lie in the Southern part of the city near the Rabindra Sarovar Lake and the Maidan. Rabindra Sarobar is the artificial lake of South Kolkata. Initial this lake had marshy jungles but was converted to a lake earlier called Dhakuria Lake in the 1920s. It was renamed to Rabindra Sarobar in 1958. The area around this region was used for recreational purposes – parks, gardens and auditoria. It is also one of the most densely populated area of the city.

Maidan is another green area in the city. This is referred to as the city lungs. The Maidan was created by clearing of a jungle and cuts of the settlement in the South. It is the property of the army and hosts the Indian Army's Eastern High Command in Fort William. It is a vast stretch of about 400 hectares from River Hooghly in the west to Chowringhee and Park Street in the east.

2.Water bodies: Kolkata is located at the bank of River Hooghly. The water bodies include ponds, tanks, wetlands and marshes, the Rabindra Sarobar lake. The East Calcutta Wetlands are the wetlands of international significance. They lie to the east of Kolkata and are a complex of natural and human wetlands. The wetlands cover 125 square kilometers, and include salt marshes and salt meadows, as well as sewage farms and settling ponds. The wetlands are used to treat Kolkata's sewage, and the nutrients contained in the waste water sustain fish farms and agriculture.

3.Built up: The built up area comprises of all the urban settlement of the metropolitan area as well as roads. Kolkata is a congested city owing to the fact that the area is comparatively much less and the population growth in the city is very high as well as migration rates. As a result, the city has swollen beyond municipal limits and the expansion of built up area has been rapid to meet the increasing needs

of the population. The city comprises of both authorized and unauthorized settlements along with a large number of industrial and commercial establishments.

Analysis

Analysis of the imagery is based on landuse classification on the basis of pixel count. The pixel count for each class has been used to calculate the percentage of area occupied by that particular class in the imagery. Then, this percentage has been used to calculate the area occupied by the landuse feature in terms of absolute area.

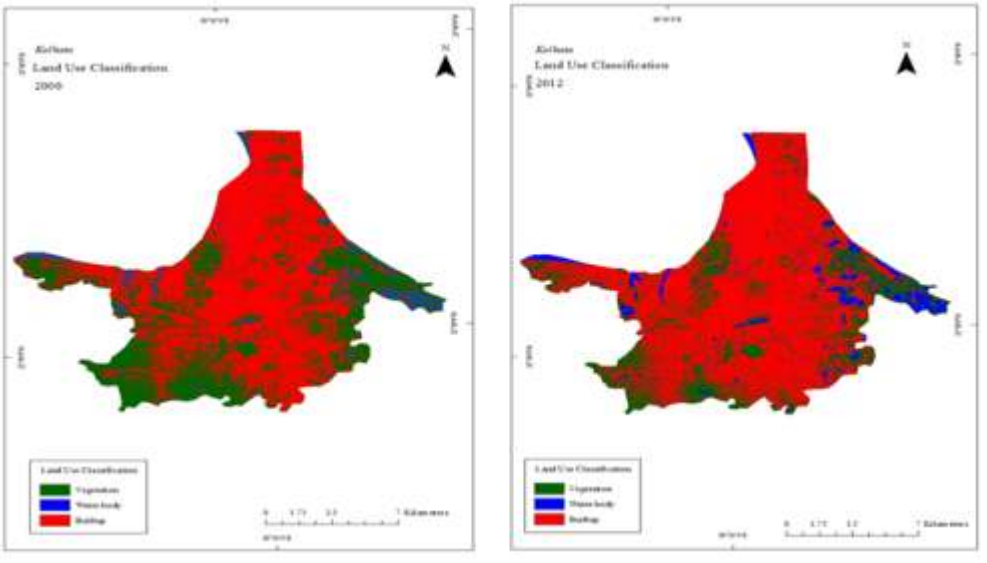


Fig 3: Land-use/cover Classification of Kolkata Municipal Region (2002, 2012)

Table 1: Landuse Classification in Kolkata (in terms of pixel count)

S. No.	Class	Pixel Count 2000	% of total area 2000 (in terms of pixel count)	Pixel Count 2012	% of total area 2012 (in terms of pixel count)
1.	Vegetation	75520	33.79	1659488	22.98
2.	Waterbody	10441	4.6	494292	6.84
3.	Built up	137477	61.52	5066077	70.16
	Total	223438	100	7219837	100

The table states that in terms of pixel count the area under vegetation has decreased from 33.79% in 2000 to 22.98% in 2012. There has been a decline of nearly 10% in these 12 years. Water bodies have increased by a minor percentage in 12 years. Also, the area under built up has increased from 61.52% in 2000 to 70.16% in 2012. There has been an increase of about 10% as well in the built up area as well. Though the increase in area is the same for both vegetation cover and built up but is noteworthy that the area under built up was significantly large in the year 2000. It was already more than half in the year 2000 and has increased by another 10% in 2012. This explains the extent of congestion in the city. Also in the year 2012 the area under built up has increased by nearly three times as compared to vegetation. Thus, the amount of green cover present in the city is not enough to

compensate for such a large population

Table 2: Landuse Classification in Kolkata (in terms of total area)

S.No.	Class	Area In sq. kms (2000)	Area In sq. kms (2012)
1.	Vegetation	287.292	195.372
2.	Built up	522.988	596.433
3.	Water bodies	39.719	58.1934
	Total	849.99	849.99

As a component of total area also we can infer that the area under vegetation has declined by about 90 sq kms in 12 years. The built up on the other hand, has also increased by about 20 sq kms. From the above statement we can note that there is a much rapid decline in vegetation as compared to the increase in built up. From this we can also infer, that besides increase in built up the removal of vegetation not only takes the form of an increase in built up but also degradation of land and formation of wastelands.

The ratio of built up to vegetation for the year 2000 was 1: 0.55 where as the ratio was 1: 0.32 in the year 2012. As we can see, that the denominator has declined, we can infer from the ratio that in area of 1 sq km the presence of vegetation has declined from 0.55 sq km in 2000 to 0.32 sq km in 2012.

Comparing the techniques of NDVI and Landuse Classification we can conclude that results are quite not coherent. Where the technique of NDVI states that green cover has increased over the past 12 years and the NDVI value has increased but the landuse classification shows that area under green cover has declined. However, the point is that both the techniques are based on different primciples. NDVI values can be high due to high spectral reflectance whereas in Landuse Classification collection of optimum training points forms the basis.

CHANGE DETECTION

Besides classification, another technique that can be used to assess the change in landuse is change detection. The change detection matrix helps us to analyse the change in pixel class over a period of time which depicts the change in landuse.The change detection matrix is prepared which shows an overlap of change in landuse over 2000 and 2012.

Table 3: Change Detection Matrix (% of zone)

Class	Unclassified	Vegetation	Water body	Built up
Unclassified	**99.97**	0.88	1.41	0.35
Vegetation	0.01	**47.94**	11.84	9.90
Water body	0.01	3.84	**66.96**	3.86
Built up	0.01	47.33	19.80	**85.90**

In the above matrix, the diagonal values represent the unchanged area under a pixel class. We can see from the table that with reference to the class of vegetation, 9.90 % of the total area has converted to built up. With reference to built up 47.33 % of the area that was previously under built up has now converted to green cover. The significant point to note is that a significant proportion of the

total area is under built up which is almost 85.90 % of the total and remains unchanged.

CONCLUSION

The temporal comparison led us to conclusions which were not that coherent. Different results were obtained using the techniques of NDVI and Landuse Classification. The NDVI reflected an increase in green cover density with an increase in NDVI value from 0.102 in 2000 to 0.124 in 2012. However, the Landuse Classification reflected a decline in green cover by 10.0% in twelve years and an increase in built up by about 9% and as a result more than 70% of the total area is now under built up. The change detection technique showed that 9.9% of the total that was previously under vegetation is now a part of built up and 47.3% of the total area that was previously under built up has undergone a change of pixel class to vegetation.

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