# The Changing face of Dhaka City Seen through the Eyes of Satellite

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## Abstract

There is no doubt that Dhaka city is growing but in which direction and what rate that is the main concern. There is also the question how urban growth is influencing the different land uses. This study was initiated to find the answer to these questions. In today's fast growing pace, one of the best available options to understand the phenomenon of urban growth is the application of Remote Sensing techniques in amalgamation of GIS methods. In this paper the spatial and temporal distribution of urbanization and vegetation of Dhaka Metropolitan area, examined through the use of satellite imagery, has been presented to understand the phenomenon of urban growth.

## Introduction

Dhaka, the capital city of Bangladesh is the outcome of spontaneous growth without any prior or systematic planning. The present population of Dhaka city (under the jurisdiction of the Dhaka City Corporation) stands at approximately 6.7 million and metropolitan area, is 12.3 million as of 2007 (Source: BBS, 2008). Dhaka has one of the highest population growth rate i.e. 4.7% per annum in whole of Asia (Source: BBS, 2008). The annual growth rate of Dhaka City's population during the last three decades on an average has been over 7 percent, with doubling of its population every decade. Dhaka is going to be the second most populated city by 2015, next to Tokyo (with a growth rate of urban population at 3.1 percent per year) according to the UN projections.

There is no denying the fact that Dhaka is growing. The main issue of concern is to identify the trend of this growth. Satellite data is very effective for evaluating the rapidly changing land use pattern both spatially and temporally. In this paper the spatial and temporal distribution of urbanization and vegetation of Dhaka Metropolitan area examined through the use of satellite imagery and remote sensing techniques has been presented to understand the phenomenon of urban growth.

### The Study Area

The Dhaka Metropolitan Area (DMA) comprising of 130 wards with a total area of 360 sq.km. has been selected as the study area shown in the map 1.1. DMA area is surrounded by RAJUK (DMDP) area as shown in the map. DMA area is located in the center of Bangladesh between 23.68'N (BTM 533233.91 m), 90.33' E (BTM 619052.83 m) and 23.90'N (BTM 550952.57 m), 90.50' E (BTM 642511.56 m), respectively.

Dhaka city is surrounded by Buriganga River and DND embankment in the south, Balu River in the east, Tongi khal in the north and Turag River in the west. Dhaka city based on flood control infrastructure is divided into two parts: Dhaka West and Dhaka East. The area is gradually sloping towards the east. Topographically, the area is flat with a surface elevation ranging from 1 to 14 m, with most urban areas located at elevations ranging from 6 to 8 m (FAP 8A, 1991).

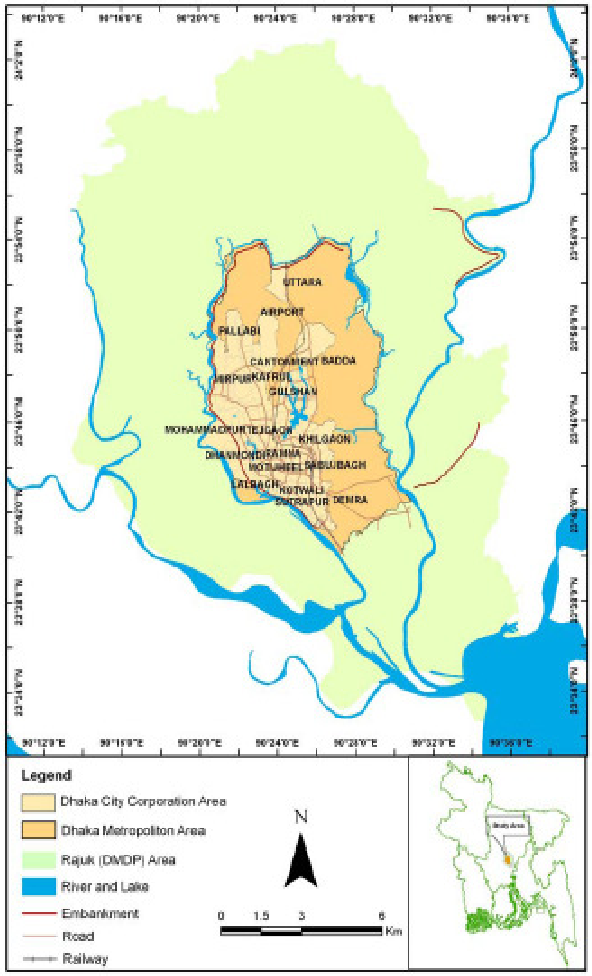


Figure 1: Map of study area (Dhaka Metropolitan Area)

## Maximum Likelihood and NDVI Classification Methods

Among the supervised classification techniques, Maximum Likelihood is one of the most used methods. NDVI has a wide range of applications. This technique is used mainly to delineate the vegetated and non-vegetated area. Several applications of these two methods in various studies have been demonstrated in the previous section. Therefore, in this study the 'Maximum Likelihood' and 'NDVI' methods have been applied to identify the different land use classes, especially urban area and vegetation area and later on, the results have been compared to see the effectiveness of both methods.

### Methodology

The study approach applied general image processing functions which are usually followed in any image classification study. At preliminary stage, after the images were collected then the images were preprocessed using Geometric and Radiometric correction. This was followed by image enhancement to aid better visual interpretation. Two methods were applied for classification of images: A supervised classification technique "Maximum Likelihood

Classification" method and Vegetation Index "Modified Normalized Difference Vegetation Index". The methodological framework is detailed out step by step in Figure 2.

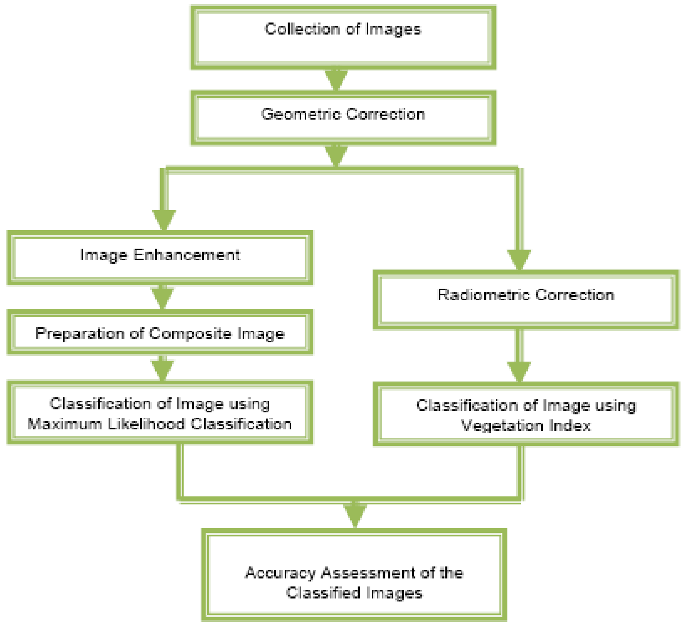


Fig. 2: Methodological framework of the study

***Collection of Data and Images***

Landsat Thematic Mapper (TM) images of Dhaka Metropolitan city have been acquired to study the urbanization and vegetation cover. Vegetation naturally changes according to an annual cyclical pattern. So it is necessary to study images from the same season to detect changes in the vegetation pattern over the years. Based on expert's knowledge, it was determined that images from December till March are most suitable for analysis of land use patterns and changes are examined for every 3-4 year period within a span of 15 years from 1993 to 2007.

Low resolution satellite data of Landsat Thematic Mapper (TM) image (30 m resolution) of 1993, 1996, 1999, 2003 and LISS III image (24 m resolution) of 2007 has been used, because it is very useful for gathering land use and land cover information, for land use change detection and growth analysis.

***Image Processing***

The image rectification process consisted of identification of GCPs and geo-referencing. Potential GCPs were identified on image before the field survey of the coordinates. The raw image was geo-referenced and projected into Bangladesh Transverse Mercator (BTM) projection system using a polynomial equation and nearest neighbor re-sampling technique. The average RMS error using 14 points was found 1.2827, where error in X was 0.7587 and Y was 1.0343. The average RMS error using 8 GCPs was found 1.116, where error in X was 0.722 and error in Y was 0.851.

Radiometric correction on the raw images were carried out in order to correct or calibrate aberrations in data values due to specific distortions from such things as atmosphere effects (such as haze). The 'dark object subtraction' method was used for haze reduction. The geo-referenced images were enhanced to aid in visual interpretation. Linear with saturation technique was applied in order to enhance the images.

***Image Classification***

The 'Maximum Likelihood' classification has been used to classify the image of Dhaka City. This technique uses the training data as a means of estimating means and variances of the classes, which are then used to estimate the probabilities for membership in each class. The training sets were selected keeping in mind that that they are uniformly distributed representing / covering the study area. The images were classified into seven spectrally distinct classes namely water body, builtup area, bare soil, grassland, trees, crops and wetland.

Vegetated areas have a relatively high near IR (Infrared) reflectance and low visible reflectance. Due to this property of the vegetation, various mathematical combinations of the NIR and the Red band have been found to be sensitive indicators of the presence and condition of green vegetation. These mathematical quantities are thus referred to as vegetation indices. The most commonly used of these indices is the NDVI (Normalized Difference Vegetation Index) that is computed using the formula (NIR RED)/ (NIR+RED). The Normalized Vegetation Index (NDVI) is used to assess the vegetation condition of Dhaka city as it represents the natural environment of an urban area. The Maximum Likelihood classified Landsat image was overlayed with the NDVI image to produce the final classified image for better results.

***Analysis of Spectral Signatures***

Spectral signatures have been studied for the classified features using scatter diagram. In the scatter plot the mean values of reflectance in the Near Infrared bands (TM 4) and Red band (TM 3) are plotted in the feature space defined by red band as X axis and near infrared band as Y axis. The linear distribution of the mean values of different land cover classes in the scatter plot shows that the spectral signatures of water body, urban area, bare soil is very distinct. The wetland and water bodies are located very close to each other and wetland has a spectral signature similar to water body. Therefore, the wetland areas may have been misclassified as water bodies.

***Accuracy Assessment***

The accuracy of the classified images was assessed through generating error matrix. Ground truth data from field were collected for this purpose. The ground truthing was done in 2008 whereas four out of five images (Landsat image of 1993, 1996, 1996 and 2003) were captured quite a long time back. Due to this long time gap, data had to be verified through the information collected from the local people, other secondary sources such as maps, reports etc. The overall accuracy of all the Maximum Likelihood classified images is better than the NDVI images which is 71.26%, 95.5%, 96.19% and 87.36%. In some cases, the lower accuracy results were obtained due to haze effect (cloud cover).

One of reason of Maximum Likelihood method having better results than NDVI method is that the NDVI classified image is a single band output whereas Maximum Likelihood classification output was based upon 3 band composite images. Another reason is that NDVI indexing method uses a certain range to classify a particular class. As a result of this, some overlapping area remains within two classes which are difficult to remove or separate out through NDVI method.

## Land Cover Change Analysis

It is seen from evaluating the classified images that urbanized area has doubled from 23% in 1993 to 47% in 2007. The areas clearly identified as bare soil .i.e. landfill areas or the land cleared up of vegetation for development work changes from year to year as it depends upon the extent of development. It occupies roughly around 4% area in 1993 and 2003.

### Spatial and Temporal Trend of Urbanization

There has been 15% increase in builtup area within a period of ten years between 1993 and 2003. Consequently, within a span of 14 yrs from 1993 to 2007, 24% increase of builtup area was observed. The gradual changes in builtup area have not occurred in a regular or linear pattern rather the growth pattern is sporadic in nature. The city structure has taken its shape due to development of several transportation network encouraging urban growth. Urban growth has intensified specially in the north that is Uttara residential area, Nikunja near the airport, Diabari in north-west, Mohammadpur in west, Badda and Aftabnagar in east. Real estate development has contributed in the urban growth through several private sector initiatives. Intensive urban development has led to decline of wetland, water bodies, agricultural lands, vegetation areas over the years.

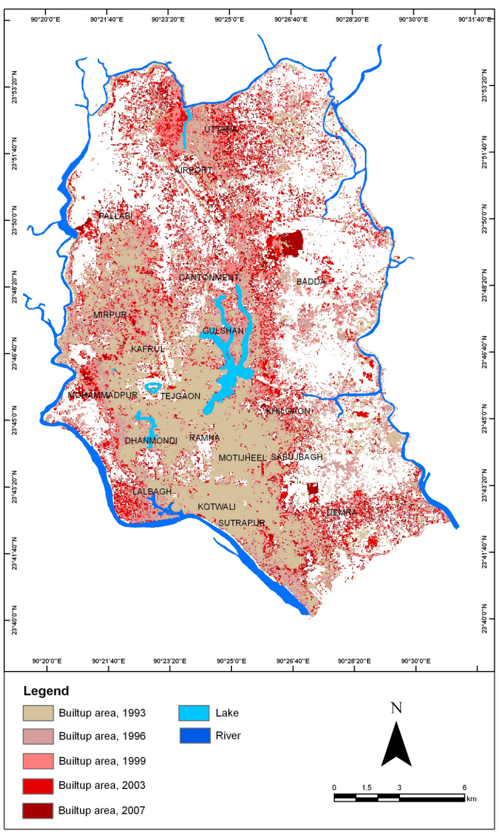


Figure 3: Changes in Builtup area from 1993-2007

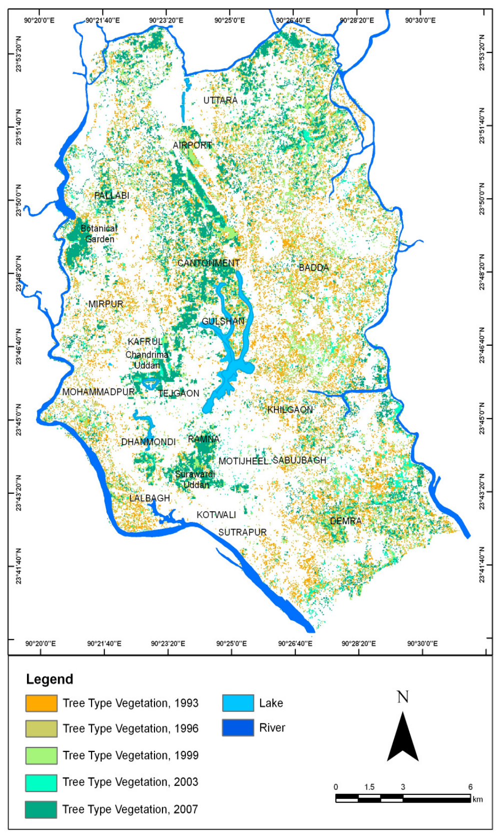


Figure 4: Changes in Vegetation (Tree) covered area from 1993-2007

## Spatial and Temporal Trend of Vegetation

In contrast with urbanization, there is a decreasing trend in the vegetation area change (Figure 3 and 4). Total area comprising of vegetation class (grass, trees and crops) has reduced from 58% to 40% from 1993 to 2007. The changes in grass and crop covered area is variable but still is decreasing. However, there is a a marked difference in the area covered with tree type vegetation. Therefore, this section closely examines the changes in tree type vegetation. The tree type vegetation area decreased 2.7% from 1993 to 1996, 3.1% from 1996 to 1999, 0.4% from 1999 to 2003 and 2003 to 2007.

Similar to the urbanization pattern there is no regular pattern in the changes of vegetation class specially comprising of trees. In the image of 1993 vegetation area is seen to be distributed throughout the city, concentrated mainly in some parks like Ramna park, Chandrima Uddan, Botanical Garden Gulshan park etc. Some speckled distribution of vegetation interspersed in and around the builtup areas, water bodies is also observed. However, with time the vegetated areas has reduced (Figure 4) with its growth confined in some major parks only. Intricate image analysis and field investigation corroborate the fact that the decrease in vegetation class has occurred due to the encroachment of open spaces, parks, clearing of trees for development of roads, housing areas.

## Conclusion and Recommendations

The multidate image analysis showed that the urbanization process is affecting other factors like vegetation, waterbodies etc. The social, economic and environmental factors are all interwoven together and there needs to be a balance in their growth within the city boundary to ensure healthy living environment.

The following recommendations are drawn out for further research works:

- Ground truthing needs to be carried out at the proper time in order to correctly verify the information obtained from the classification results.
- High resolution images such as IKONOS or QUICKBIRD can be used to delineate landuse classes with better results.
- The effect of cloud cover is less visible in the NDVI classified images compared to images classified through the Maximum Likelihood method.
- Seasonal difference even for few days can result in huge variation in the results.
- Maximum likelihood technique has been able to produce better results compared to NDVI in delineating the wetland area.

## References


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