

A GIS-Based Approach to Integrate Urban Open Space for Managing Urban Environment

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Abstract

In recent times, climate change has become a matter of concern resulting from greenhouse gases. Due to climate change and urbanization, the urban environment is gradually losing its ecological balance. Considering this, the study proposes Dhaka city as the study area. The study formulated two objectives: to define the landscape differences of different periods based on the urban environment and to propose open forest and rain garden as urban open space for managing the urban environment. The Landsat images of 1999, 2009, and 2019 were used for supervised image classification. According to the analysis, the overall accuracy of all the images was above 80%. The study found notable changes in the land-use patterns of the mentioned year. The findings and analysis can be helpful to other fervent regions as well as the concerned authority. Implementation of open forest and rain garden works as a recreational center and is a sustainable solution for the urban environment. The study's proper implementation ensures harmony between city dwellers and the urban environment to save nature for secure urban lifestyles.

Keywords: *Open Forest; Rain Garden; Supervised Image Classification; Urbanization; Urban Open Space.*

1. Introduction

A developing country like Bangladesh has a limited amount of natural resources. Industrialization and rapid growth of urbanization are the two most contemporary issues of Bangladesh, where rural-urban migration plays an important role in the urbanization process. About 13 years prior, in 2008, almost half of the world's total population lived in urban areas. This phenomenon has continued, and it is expected to achieve further momentum in future. As indicated by United Nations (UN), it is projected that the world urban population will increase by 72% by 2050, from 3.6 billion in 2011 to 6.3 billion in 2050 (Zhang, 2015). Bangladesh is already facing tremendous pressure on people's migration in urban areas, especially in Dhaka city. The population of Dhaka city is about 19.58 million people that is predicted to rise by 28 million by 2030 (Wang and Sarker, 2020). This rapid growth of population creates extreme

pressure on the urban environment. At the same time, human activities are also affecting the natural greenhouse effect. An increase in global warming is alarming the climate. In recent times, the water logging problem, the pattern of changing temperature in Dhaka city are the result of climate change. For managing the urban environment, open space plays an essential role in the ecological balance by producing conceptual, theoretical, and practical information on the use and meaning of open spaces such as parks, gardens, recreational spaces, playgrounds, streets etc. Lack of open space is a barrier to healthy urban life and activities. According to the survey of RDP 2013, there are 52% of the land is used for non-urban use, but only 0.30% of the land is used for recreational facilities (*Dhaka Structural Plan, 2015*). It is also estimated that the percentage will become more critical in 2035 (*Dhaka Structural Plan, 2015*). So there is a tremendous absence of open spaces in Dhaka city. In the current DAP of Dhaka City, it is mentioned that 25.3% of the land is required to be preserved as open space (*Dhaka Structural Plan, 2015; Khan, 2014*). So, it is high time to re-secure urban open spaces in Dhaka City. Considering the above issues, Dhaka city has been chosen as the study area. This study formulated the following objectives:

- to define the landscape differences of different periods based on urban environment
- to propose open forest and rain garden as urban open space for managing the urban environment

This study proposed open forest and rain garden as urban open space which could also provide recreational facilities. Landsat images of 1999, 2009, and 2019 were used for conducting supervised image classification, where overall accuracy was above 80%. The outcome of the study has a satisfactory result and helps to manage the urban environment.

2. Study Area Profile

Dhaka is the only megacity and also the capital of Bangladesh, situated near the Buriganga Riverbank. The geographical location of Dhaka Metropolitan Area (DMA) is between 23.40° North to 23.54° North latitude and 90.20° East to 90.30° East longitude, covering 300 sq. km area boundary (Khatun et al., 2015). According to the BBS Report (Bangladesh Bureau of Statistics) of 2011, the study area's total population was 64,82,875 in 2001 and 89,06,039 in 2011, with an annual growth rate of 3.74% (*Bangladesh Bureau of Statistics, 2013; Khatun et al., 2015*).

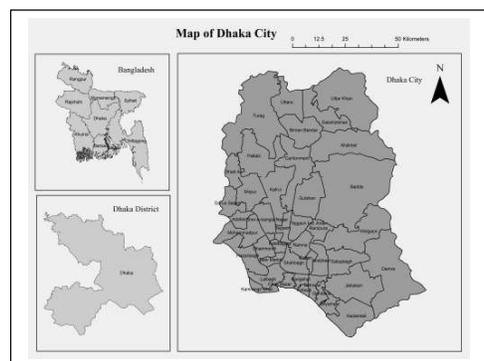


Figure 1. Map of Dhaka City.

Because of being the most important commercial hub of the county, many people migrate from rural areas to Dhaka City daily. This is the only reason for this higher density. The rate of density

is increasing unconditionally. As a result, the open spaces and recreational places are being replaced by the buildup area to accommodate the people. Quantity of recreational facilities isn't available in this area. As a consequence, children and other peoples are using school, college playground as recreational place and open space, which has become an obstacle to the development of their healthy mindset.

3. Methodology

3.1 Data Collection

This study mainly focused on secondary data sources. Landsat images (1999, 2009, and 2019) were used to define the land use land cover changes of the study area by supervised image classification. All the satellite images were downloaded from US Geological Survey (USGS). For 1999 and 2009, Landsat 5 images were downloaded, where Landsat 8 was used for 2019.

Table 1. Details of Landsat satellite images.

Year	Attained date	Data set	Cell Size (X, Y)	XY Co-ordination system
1999	01/01/1999	Landsat 5	(30,30)	WGS_1984_UTM_Zone_46N
2009	01/01/2009	Landsat 5		
2019	01/01/2019	Landsat 8		

Source: US Geological Survey, 2021.

The above table explains the details of Landsat images. XY coordination system of all the satellite data was WGS_1984_UTM_Zone_46N. Besides, the Google Earth image of Dhaka City was also included for a precise supervised classification.

3.2 Data Analysis

Landsat images were used in supervised classification with the help of the software ArcGIS 10.7. The image had been classified into four different types of classes: buildup area, vegetation, water body, and bare land. The class-wise area was calculated from the classified images to identify the increase and decrease of the land use patterns. Necessary data were represented as map and graph with GIS (Geographic Information System) and MS Excel. Finally, rain garden and open forest were proposed for implementing open spaces in Dhaka city.

4. Application of Supervised Image Classification

An application of supervised image classification was used for Land Use Land Cover classification, where the maximum likelihood classification algorithm was used. Landsat images of 1999, 2009, and 2019 were used for supervised image classification. In this study, Land Use Land Cover (LULC) has been classified into four classes: bare land, built-up area, vegetation land, water body. Bare land included bare soil, open space, fallow land. The Built-up area included settlements, residential area, commercial area, industrial area, road, rural area,

urban area, and infrastructure. Vegetation included agricultural land, greeneries. Water-body included rivers, lakes, ponds, permanent open water bodies, canals.

Image classification and accuracy test both were performed in ArcGIS 10.7 software. Total 1000 points were taken to generate the classification process, where per class represented 250 points.

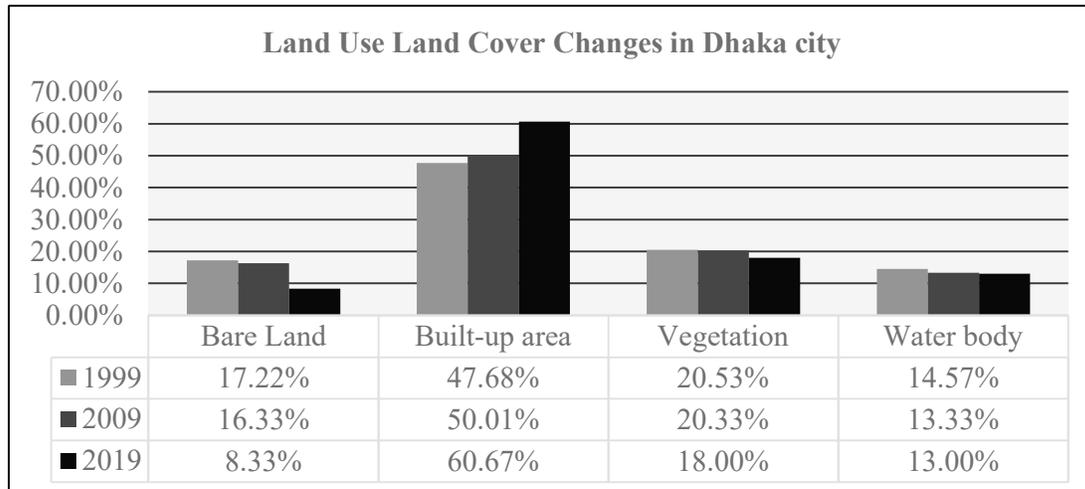


Figure 2. Land Use Land Cover Changes in Dhaka city.

Table 2. Accuracy Test of Classified Images

Year	Bare Land	Built-up Area	Vegetation	Water Body
1999	80.05%	81.04%	81.00%	95.00%
2009	84.06%	89.07%	85.07%	95.07%
2019	90.00%	97.06%	94.44%	96.97%
Kappa Co-efficient= 97.90%				

According to the classification, the land cover percentage of built-up area has been increased, while other land cover percentages have been decreased. In 1999, 47.68% of the total land cover covered built-up area, which increased by 60.67% within 2019 (Figure 2). The amount of bare land in 1999, 2009, 2019 are respectively 17.22%, 16.33%, and 8.33% (Figure 2). The result from the classified images shows a reverse relationship between bare land and built-up area. From the accuracy assessment, the overall accuracy of all classes is above 80%, where the kappa co-efficient is 97.90% (Table 2).

As shown with observations, the outcome from the supervised image classification among the 20 years shows an inadequate result of the classes. The increased rate of built-up area and the decreased rate of bare land have terrible percentages. This is affecting the urban environment of the study area and gradually making the city uninhabitable. Besides, this is also influencing the ecological balance of the city and destroying nature. So, it is high time to manage the urban environment of the study area to secure the lifestyles of the city dwellers.

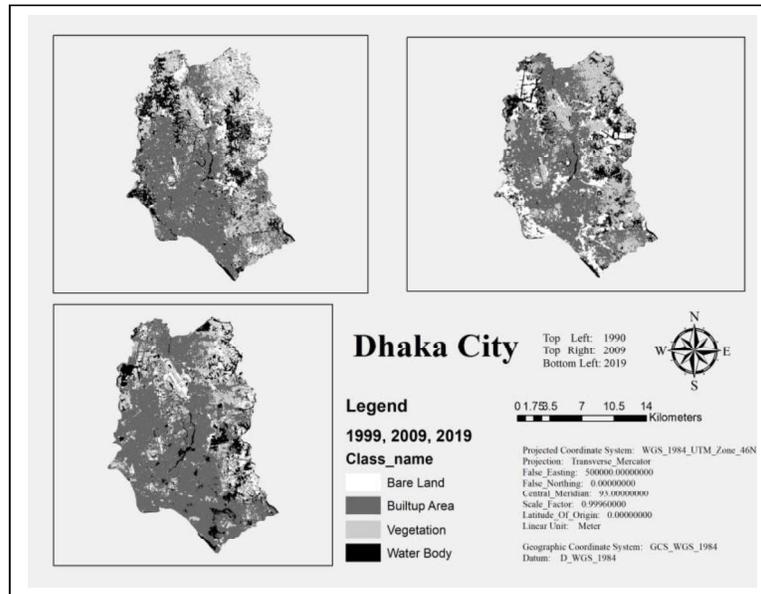


Figure 3. Supervised Image Classification.

5. Proposal for Implementing Open Forest and Rain Garden as Urban Open Space

5.1 Open Forest

Open forest works as a recreational place, which also works as an urban open space. In a broad sense, it includes any woody plant vegetation growing in and around human settlements. Open forest helps to stock trees for over 100 years and also helps to reduce the high temperature. Besides, an open space reduces air pollution, helps in rainwater runoff reduction, saves urban lives. An Open Forest can be located at the periphery of a town. This is an eco-friendly solution.

5.2 Rain Garden

A rain garden is not a water garden; instead, it collects rainwater during rainfall and prevents water logging problem. Generally, a rain garden is built on natural slop. The integration of rain gardens intercepts stormwater. By storing rainwater, rain gardens help to improve water quality, manage floods, and create sustainable management of the environment. This is full of bio-recreational facilities.

In the study area, most of the regions are fervent with their high land surface temperature. So, the open forest is suggested, which can provide both shades and recreational facilities during that period in the study area. Besides, a rain garden can help to stop the water logging problem in the study area. Both of these works as urban open spaces. Implementation of such a sustainable solution in the study area can help reduce unusual climate change, improve air quality, and manage the urban environment of Dhaka City towards sustainability. To make a city livable, integration of such kind of urban open space in a city can be the best eco-friendly solution, especially for Dhaka City.

6. Conclusion

Sustainable solutions help to create a balance between the city dwellers and the urban environment. Implementation of open forest and rain gardens are a sustainable solution for managing the urban environment. There is a clear manifestation in the research paper that because of a small amount of open space in Dhaka City, the city is unable to accommodate further infrastructural development. This study also defined that the rapid growth of urbanization is gradually making the city geographically vulnerable. Considering this, Dhaka City has been chosen as the study area, where this study proposes urban open forest and rain garden as urban open spaces in Dhaka City as a solution to the situation.

Nature is a blessing as long as people use it properly. Living in a green environment is good for health. Proper implementation of the study ensures an eco-friendly solution towards the urban environment to mitigate climate change. So, the concerned authority should take all necessary steps to secure the urban environment. Besides, this study can also be an example for other fervent regions of the country, as well as the world. To sum up, for managing the urban environment, the implementation of urban open forest and rain garden as urban open spaces play a vital role and ensures a healthy community for better, safe, and secure urban lifestyles.

References

- Dhaka Structure Plan, 2015*, DMDP: Dhaka Metropolitan Development Plan (2016-2035), Dhaka, Government of Bangladesh, 2015, Dhaka.
- District Statistics 2011: Dhaka District, 2013, *Bangladesh Bureau of Statistics (BBS)*.
- Khan, M. (2014). Study of Open Spaces in the Context of Dhaka City for Sustainable Use: A Syntactic Approach. *International Journal of Engineering and Technology*, 6(3):238-243.
- Khatun, H., Falgunee, N., & Kutub, J. R. (2015). Analyzing urban population density gradient of dhaka metropolitan area using geographic information systems (gis) and census data. *Geografia : Malaysian Journal of Society and Space*, 11(13), 1–13.
- Wang, L., Sarker, P. (2020). Analyzing Urban Sprawl and Sustainable Development in Dhaka, Bangladesh. *Journal of Economics and Sustainable Development*. Vol.11, No.6, 2020.
- Zhang, X. (2015). The Trends, Promises and Challenges of Urbanization in the World. *Habitat International*.