SPATIO-TEMPORAL ANALYSIS OF LAND COVER CHANGES OF DHAKA CITY IN BANGLADESH

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ABSTRACT: The objective of this study was to identify the Spatio-temporal variation in land-cover of Dhaka city, the capital of Bangladesh. The study was conducted to highlight the issues of changing land-cover of mega cities of Bangladesh and its future environmental consequences. Land cover changes and temporal maps for the selected study areas were developed by using multi-temporal information data sets by Multispectral Scanner (MSS), Thematic Map (TM), Enhanced Thematic Mapper (ETM), Enhanced Thematic Mapper Plus (ETM+),or Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) for the years 1993, 2000, 2010 and 2015. The results of this study highlighted the rapid urbanization in Dhaka which caused significant decline in vegetation cover and increase of built-up or paved surfaces. The land-cover classified images highlighted, that in 1993 only 22% per cent area of the study area was covered with built-up surface. However, in 2015, it increased up to 48%. This substantial decline in vegetation cover and upsurge in built-up area of Dhaka city may put petrifying effect on local environments.

Key words: Dhaka, Landsat Images, Land Cover Change, United States Geological Survey (USGS).

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INTRODUCTION

Today almost the whole earth surface is being exploited by human activities but to a variable extent. Land modifications are sometimes restricted to a small area but having wide-range of consequences, which may be noticed as systemic development at the global level. Urban land cover is a significant landscape on the surface of the earth manipulated by man-made activities. The large scale modifications in land cover and its spatial pattern caused by urbanization are traced impartially; to whatever extent its position as well as time i.e. spatial and temporal (Liu *et al*., 2008).

Land cover is a considerable condition of earth that encompasses inherent facilities i.e. crop lands, mountains, foliage, top soil horizon, biodiversity, and water resources as well as artificial developments i.e. edifice and asphalt roads. Land cover alteration typically takes place in two ways i.e. land cover adaptation and modification (Lambin *et al.,* 2006). Generally the land cover adaptation is modification in the organization of land cover through an entire change, to a different form, owing to a modification in urban area, farming extension and vegetation removal. The land-cover modification is merely an environmental modification, without going through its whole classification (Lambin *et al.,* 2003).

It is one of the important outcomes of many reported studies that anthropogenic activities have tremendously affected the urban ecosystem however, more concentration is being intended towards examining the modifications in urban land use and land cover (Stow and Chen, 2002). The man-made activities causing land-use/land-cover (LULC) modifications are taking place more rapidly in less developed countries than the developed world. By 2020, it is expected that the less developed countries will be having most of the mega cities (World Bank, 2007). In the developing countries, like Bangladesh where the magnitude of urbanization is high, urban spread out is a major land cover modification source (Oguz, 2000). In a study Joshi and Suthar (2002) reported the temporal change of urban land use and its impact on ecology and environment of Jaipur city by using remote sensing technique as well as through conventional methods. The urbanization process in Jaipur city resulted in the change of agrarian lands into non-agricultural uses. At present mostly green spaces, vegetation and barren lands have been changed into built up areas like buildings and infrastructures. In Malaysia, the most considerable land use changes occurred in the Klang Valley Region (Takeuchi *et al., 2010*).

From a small local head quarter, the Dhaka has emerged as an integrated economical, physical and ecological entity of Bangladesh. In Dhaka, land cover modifications are prodigious and complex enough to grasp without temporal mapping that has been taken place on annual basis. The pace, at which these

modifications in LULC are taking place, could better be observed efficiently with the knowledge of Remote Sensing and Geographic Information Science (Khan, 2000).

MATERIALS AND METHODS

Study Area: Dhaka is the capital of Bangladesh. The Geographical coordinates of the city are between 23°42′N and 90°22′E. The vicinity of study covers up is 416 km^2 as well as it is enclosed by four chief stream arrangements, i.e. the tributaries of Buriganga, Turag, Tongi and Balu; those are sinuous towards all the four directions (Mamun *et al*., 2010). The city is located in the middle of the country and is situated in the sub-tropical monsoon zone. It has flat surface and is located mostly on productive agricultural land, usually known as to Madhupur patio of Pleistocene era. Dhaka experiences 2,000 millimeters of yearly precipitation. Figure 1 highlights the map of study area. The city is marked within red line based on the land covered area having properties of built-up surfaces.

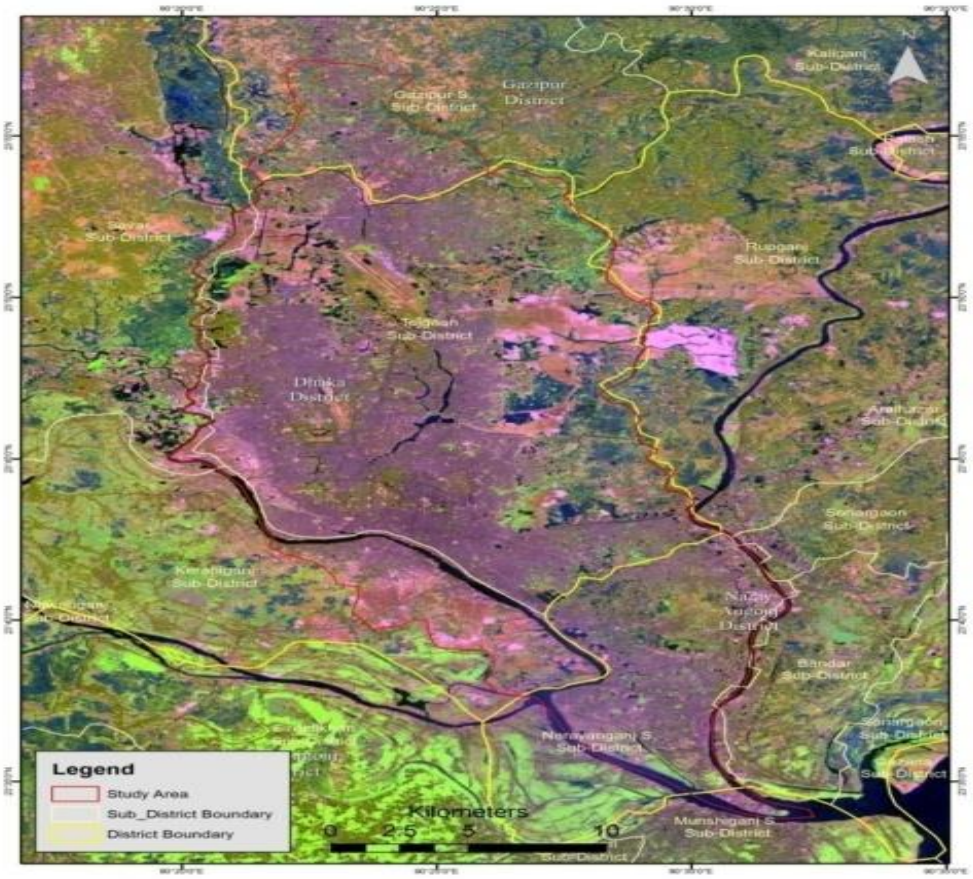

Figure 1. A satellite view of case study area of Dhaka city derived from Diva-gis.org.

Data source: The data was derived from Landsat images, for this study which were acquired from the United States Geological Survey (USGS) global archive. These images were carefully chosen to get maximum information by considering the solar azimuth angle at the time of image acquisition, percentage of cloud cover in an image, phonological stages of vegetation and other geographic features. Landsat Thematic Mapper (TM, ETM, TM and OLI) images were acquired pertaining to January 31st of 1993, February 28th of 2000, January 30th of 2010 and March 17th of 2015 through the Geo-referencing process. In this study an advanced classification technique i.e. Object Based Image Analysis (OBIA) was applied on the satellite images. Object based image analysis showed better accuracy ratio as compared to pixel based analysis (Chaudhary and Sivertun, 2014).

Land –use/Land-cover (LULC) classes: The Land cover categorization was imperative in order to analyze the LULC changes due to momentous and rapid urbanization since 1993. The land use classification was made into the built-up area i.e. residential, commercial, industrial, transportation and mixed urban, the vegetation cover area including forests, palm trees, agricultural land, grasses, bushes and plantation, the water bodies i.e.

Primarily rivers, permanent open water, ponds, reservoirs and lakes, the bare soil i.e. exposed soils and landfill sites and submerged vegetation low lands including aquatic, temporary, permanent water logged areas.

RESULT AND DISCUSSION

The results of this study showed that the major portion of cultivated land had been transformed into settlements as a consequence of urbanization. The land cover modifications demonstrated that the built-up area had been increased extensively. The Table 1 illustrates the land-use statistics of water bodies, built-up area, vegetation cover, bare soil and submerged land of Dhaka city in 1993, 2000, 2010 and 2015. As a result of land use classes, it was observed that the built-up area of the city in 1993 was 10,203.6 hectares (102 km²) that increased progressively to 22,304.7 hectares (223 km²) in 2015 with an increase of 118 percent expansion within a 22 years time span. Similarly the vegetation cover in 2000 was 15,562 hectares which reduced to 9,155 hectares with a decline of 41 per cent within 22 years. The massive decline in vegetation cover of Dhaka city was the result of rapid urbanization. It was also observed that the bare soil and submerged areas were also converted into built-up land. The Bare soil of study area in 1993 and 2015 was calculated to be 11,968 hectares and 9,097 hectares, respectively with a decline of 24 percent. The submerged soil had the same pattern of decline, as bare soil and vegetation cover. In 1993, the submerged soil of the study area was 5,417 hectares which reduced to 1,628 hectares with a deterioration of 70 per cent within a period of 22 years (Table 2). The illustration of classified Landsat images of 1993, 2000, 2010 and 2015 are given in the Figure 2. The figure 3 elaborated the land use change of each class for different years. It reflected that how the built-up areas of the city were increasing faster than other land use classes.

Table 1: Land-use statistics of Dhaka city for 1993, 2000, 2010 and 2015.

Classes	1993		2000		2010		2015	
	Area (hectares)	area in %	Area (hectares)	area in %	Area (hectares)	area in %	Area (hectares)	area in %
Water bodies	2719.44	5.96	3431.34	7.48	4004.19	8.73	3703.5	8.07
Built-up area	10203.6	22.24	12407.7	27.04	18021.3	39.27	22304.7	48.61
Vegetation cover	15562.6	33.93	18895.9	41.17	11111.4	24.21	9155.16	19.95
Bare soil	11968.3	26.09	9744.66	21.23	11149.6	24.3	9097.47	19.82
Sub-merged soil	5417.91	11.81	1412.46	3.08	1605.51	3.5	1628.73	3.55
Total	**45871.85**	**100**	**45892.06**	**100**	**45892**	**100**	**45889.56**	**100**

Table 2. Percentage of each land-use class and change in land-cover in Dhaka for 1993, 2000, 2010 and 2015.

Classes	Temporal percentage of land cover of each class				% of land-cover change			
	1993	2000	2010	2015	1993-2000	2000-2010	2010-2015	1993-2015
Water bodies	2719.44	3431.34	4004.19	3703.50	26.2	16.7	-7.5	36.2
Built-up area	10203.60	12407.70	18021.30	22304.70	21.6	45.2	23.8	***118.6***
Vegetation cover	15562.60	18895.90	11111.40	9155.16	21.4	-41.2	-17.6	-41.2
Bare soil	11968.30	9744.66	11149.60	9097.47	-18.6	14.4	-18.4	-24.0
Sub-merged soil	5417.91	1412.46	1605.51	1628.73	-73.9	13.7	1.4	-69.9

The results of this study were in agreement with the findings of past studies. The findings of Debasish (2012) who highlighted that during the period of 1989 and 2000, 33.17 km^2 of vegetation land was reduced and was transformed to built-up area. However in this study it was calculated to be 33.3 km^2. He further reported that Debasish (2012) found that Dhaka city expanded at a faster rate during the period of 2000 to 2010 whereas in the present study the results showed that it grew much faster rate during this study period where it expanded 56.14 km^2 within a period of 10 years.

The results of this study were in coherence with the findings of Mamun *et al.* (2010) as well as in the present study the pressure of change In LULC was found on built-up area which increased to 118.6% during 1993 to 2015 and 24% of bare soil and 41% of vegetation

cover was transformed into built-up area. He further reported the similar kind of findings during 1990- 2003, the alteration pressure was primarily on the cultivated land and vegetation areas. However, during 2003-2010, the pressure was converted on wetland as near all cultivated land had already been transformed to built-up areas.

In a study Dewan and Yamaguchi (2009) found that the Greater Dhaka had experienced rapid changes in LULC, particularly in built-up/urban areas. The expansion of urban areas (built-up) area increased and resulted in a substantial reduction in the area of water bodies, vegetation, cultivated areas and wetlands/lowland. The dramatic expansion of the urban areas of Dhaka exhibited clear spatio-temporal differences. The conversion of water bodies, vegetation and low-lying areas to urban land has caused extensive and varied environmental degradation in the study area. Urban land expansion has been largely driven by elevation, population growth and economic development.

The findings of this study also corroborated with the prior research findings made by other researchers as well who used ground observation as was reported Chowdhury and Faruqui, (1989) and Islam (1996).

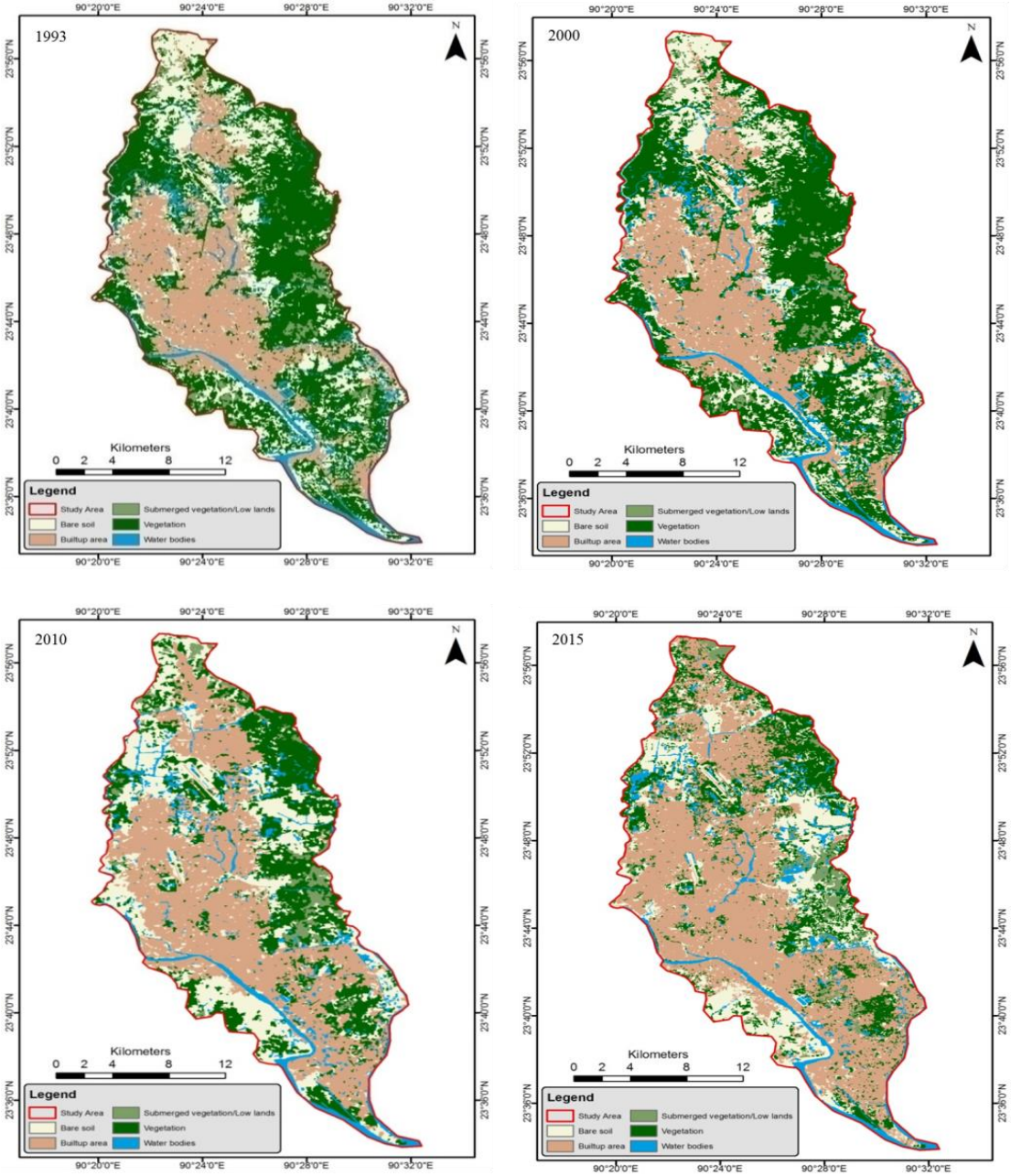

Figure 2. Classified Landsat images of Dhaka city for 1993, 2000, 2010 and 2015.

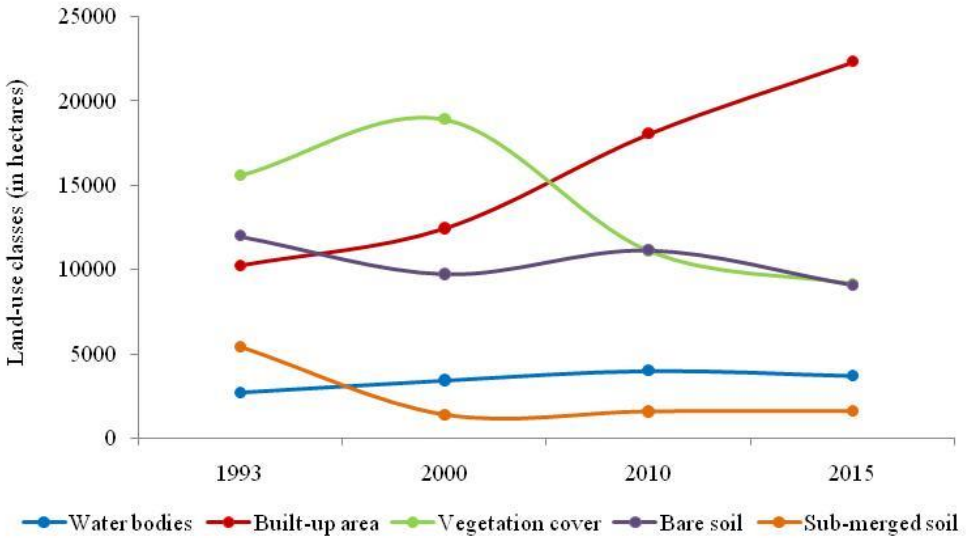

Figure 3. Land-use change in Dhaka city from 1993, 2000, 2010 and 2015.

Conclusion: The rapid urbanization in South Asian region has resulted into environmental consequences such as urban heat island, urban heat stress, heat waves and modification in urban energy balance. While working in several cities of South Asia to note the modification in land cover change with time, the Landsat images of Dhaka city from 1993 to 2015 are classified by using Object Based Image Analysis (OBIA) during this piece of work: The result highlighted that due to rapid urbanization in Dhaka, the natural land surface is converting into paved surfaces. The city built-up area increased extensively from 22 per cent in 1993 to 49 per cent in 2015 that is primarily recognized due to the quick boost in populace owing to large rural–urban movement. As a result bare soil, vegetation, as well as wetland and lowlands are reducing rapidly. The outcome undoubtedly demonstrate that LC alterations were significantly affected during the period under study

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