IMPACT ANALYSIS OF URBANIZATION ON LAND USE LAND COVER CHANGE FOR KHULNA CITY, BANGLADESH USING TEMPORAL LANDSAT IMAGERY

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ABSTRACT:

Urbanization has given a massive pace in Land Use Land Cover (LULC) changes in rapidly growing cities like Khulna, i.e. the third largest city of Bangladesh. Such impacting changes have taken place in over-decadal scale. It is important because detailed analysis with regularly monitoring will be fruitful to drag the attention of decision maker and urban planner for sustainable development and to overcome the problem of urban sprawl. In this present study, changes in LULC as an impact of urbanization, have been investigated for years 1997, 2002, 2007, 2012 and 2017; using three generation of Landsat data in geographic information system (GIS) domain which has the height competence in recent time. Initially, LULC have categorised into Built-up, Vegetation, Vacant Land, and Waterbody with the help of supervised classification technique. Field work had been carried out for acquiring training dataset and validation. The accuracy has been achieved more than 85% for the changes assessed. Analysis has an outlet with increase in built-up area by 27.92% in year 1997 to 2017 and continued respectively in each successive interval of half a decade at the given years. On the other side waterbody and vacant land decreased correspondingly. Bound to mention, instead to having largest temporal durability, the moderate spatial resolution of Landsat data has a limitation for such urban studies. These changes are responsible by both of natural or anthropogenic factors. Such study will provide a better way out of optimization of land-use to prepare detail area plan (DAP) of Khulna City Corporation (KCC) and Khulna development authority (KDA).

1. INTRODUCTION

The LULC pattern of a city is resultant of natural, socioeconomic factors and utilization in time and space by the inhabitants. LC refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, etc. Land Use has been defined in terms of human activities such as development activity, agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity (Sajjad & Iqbal, 2012). Over recent decades, developing countries are characterized by a decrease in rural land use and an increase in urban land use through urbanization (Dewan & Yamaguchi 2009a; Jat et al., 2008; Mundia & Aniya 2006; Yin et al., 2011). At very present, urban areas spikes only 3% of the Earth's land surface but accommodate over half of the world's population (Herold et al., 2003; Liu & Lathrop 2002; United Nations 2001). Anthropogenic activities in cities have brought significant changes in LULC pattern at both local and global scales. Satellite remote sensing has been widely applied in detecting LULC change especially urban expansion and cropland loss (Sajjad & Iqbal, 2012). There are a number of methods to detect changes in LULC from remotely sensed data such as selective principal components analysis, vegetation index differencing, image differencing, direct multi-date classification, univariate image differencing, image ratioing, change vector analysis and post-classification and so on (Mas, 1999; Yang & Lo, 2002; Sajjad & Iqbal, 2012). Among all of these the most common used methods for LULC change is post-classification.

Urbanization is one of the most obvious human induced global changes worldwide. In the last 200 years, the world population has increased 6 times and the urban population has multiplied 100 times (Kashem, 2008). Like many other cities in the world Khulna, the third largest metropolitan city of Bangladesh, is also the outcome of spontaneous rapid growth without any prior or systematic planning. As the growth of population in Khulna is taking place at an exceptionally rapid rate 3.8% growth rate (Khan, 2012). The city has undergone radical changes through both vast territorial expansion and internal physical transformations over the last decades. Which have created exclusively new kinds of robustness in urban texture. In the process of urbanization, the physical characteristics of Khulna city are gradually changing as low land and water bodies have been transformed into reclaimed built-up lands, open spaces into building areas, agricultural land into built-up lands, decreasing water body (Moniruzzaman & Azim, 2017) etc. The impact of the urbanization has to be analyzed to understand the changes in LULC that have led to the growth of Khulna city as the city has recorded massive urbanization over last two decades such that sustainable land use and eco-environmental restoration planning can be formulated by policy makers.

2. STUDY AREA

Located in the south-west Bangladesh, Khulna metropolitan city, consisting 31 municipal wards, with a geographical boundary range from 22°46´ to 22°58´ North latitude, 89°28´ to 89°37´ accommodate total population of 663,432 with 11,000/sq. km. in 59.57 sq. km. area (population & Housing Census 2011). The city has Bhairab and Mayur river in the north, Hatia and Pasur river in the south while Rupsa river in the central region of the city (Roy et al., 2005). Khulna has humid summer and pleasant winter type of climate with annual average temperature of 26.3°C (79.3°F) and monthly means varying between 12.4°C (54.3°F) in January and 34.3°C (93.7°F) in May while the annual average rainfall is 1,809.4

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mm. (71.24 inches) (Bangladesh Meteorological Department, 2016).
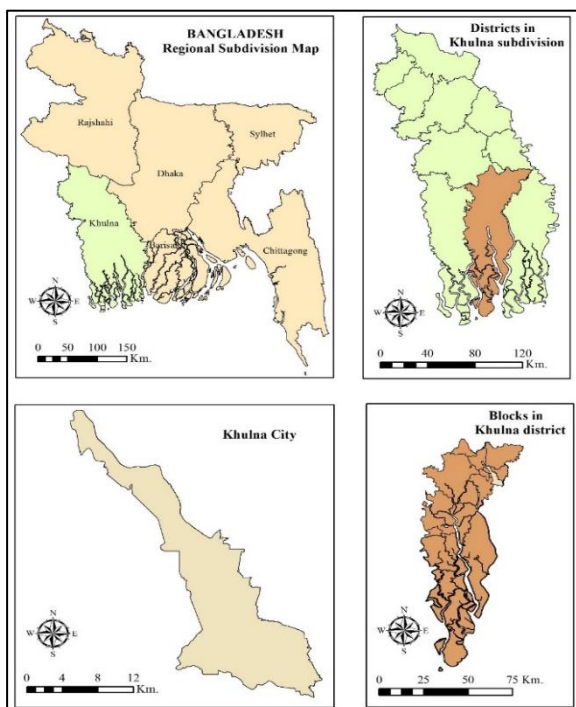

Figure 1. Study Area

3. METHODOLOGY

The first phase of the study involved the collection of data that covered the study area and the preparation of the LU/LC layers for two decades. Landsat images were selected from among the various levels of spatial, spectral, radiometric and temporal resolution satellite images because of their long-term availability and cost-effectiveness. The LU/LC layers were generated by using satellite images of Landsat-8 (OLI), Landsat-7 (ETM+) and Landsat-5 (Table 1) to identify the LULC changes over the period of 1997 to 2017. All images were obtained from the website of USGS (http://earthexplorer.usgs.gov/) and were dry season images. In the second phase, the LU/LC changes were analyzed and the impact of urbanization due to subsequent LULC changes also analyzed. The imagery was classified into four separate LULC classes were built-up, vegetation, vacant land and water body. Table 2 highlights the LULC features included for each class.

Table 1. Characteristics of Landsat data sets for the study.

Date of Acquisition	Landsat Sensor	Spatial Resolution
01 January, 2017	OLI	30 meter
24 February, 2002	ETM+	30 meter
12 January, 2012	ETM+	30 meter
06 January, 2007	ETM+	30 meter
01 January, 1997	TM	30 meter

Table 2. LULC Classes Considered in the study.

Class	Features
Built-Up	Residential, industrial, transportation networks, and commercial infrastructures.
Vegetation	Trees, parks, grasslands, plantations.
Vacant Land	Vacant lands, bare soils, sand, playgrounds.

Water Body	Lakes and coastal water.

To classify the LULC from the three pre-processed Landsat images, the supervised classification technique was used.

To examine the classification accuracies, 365 ground truth reference points were sampled (through stratified random sampling method) across the study area. The classified results had overall accuracies of 85% (1997), 86% (2002), 91% (2007), 86% (2012), and 94% (2017) with Kappa coefficients of 0.84, 0.85, 0.90, 0.85, and 0.94. Besides that, Google Earth Engine and some others source data (Khulna Development Authority, Khulna City Corporation, Detail Area Plan & open source website) are used to validate major land use features.

4. RESULTS AND DISCUSSIONS

By analysing the progressive change (%) in LULC during 2002, 2007, 2012, 2017 with respect to 1997 (Figure 2) and progressive trend of change (%) LULC (Figure 3) it is found that from 1997 to 2017, the amount of vacant land declined consistently by 13.55%. During the same period, the built-up area increased by 6522 ha (27.92%) of the study area. The amount of vegetation increased from the years 2002 to 2007 by 1343 ha i.e. 5.85% in the study area.
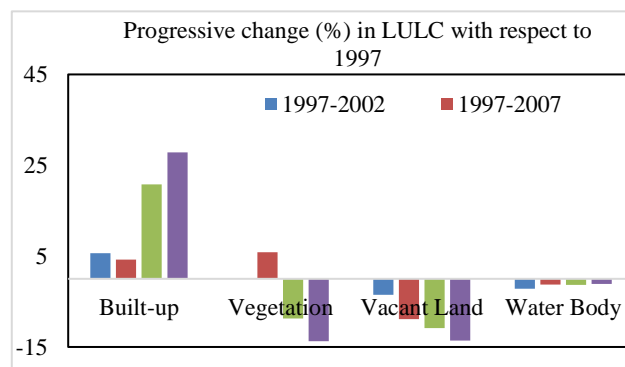

Figure 2. LULC Change (%) with Respect to 1997

However, significant decrease in vegetation observed in the years 2007 to 2012 and 2017 by 14.56% and 19.56% of the study area accordingly. And changes among classes between the year 1997 and 2017 is provided in Table 3. Finally, the areas of water body slightly increased by 209 ha (0.90%) and 370 ha (1.06%) of the study area in the year 2002 to 2007 and
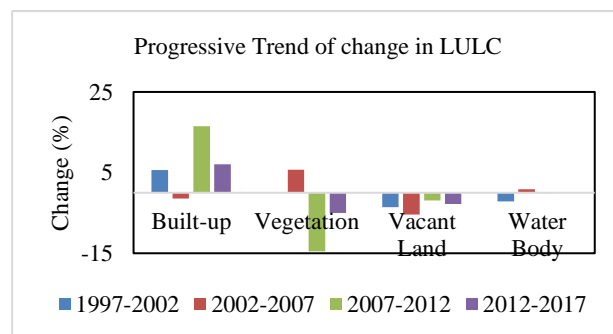

Figure 3. Trend of Change (%) in LULC

2017; and decreased by 137 ha (1.12%) of the study area from 1997 to 2017 (Figure 4).

Table 3. Change matrix of LULC (1997-2017)

2017						
		W. B	Veg.	B-U	V. L	G. T
	W. B	2606	156	419	130	3311
	Veg.	249	3554	3552	867	8222
	B-U	94	768	4129	400	5391
	V. L	225	538	3813	1857	6433
1997	G. T	3174	5016	11913	3254	23357

W. B – Water Body, Veg. – Vegetation, B-U – Built-up,
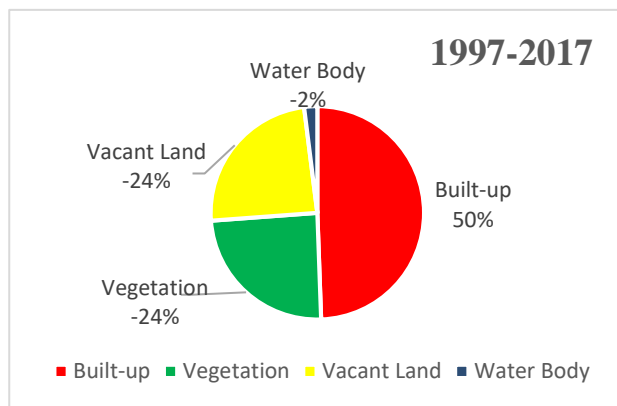V. L – Vacant Land, G. T – Grand Total

Figure 4. Areal Distribution (%) of LULC 1997-2017
LULC spatial distribution and change map for the years 1997, 2002, 2007 and 2017 is shown in figure 5.
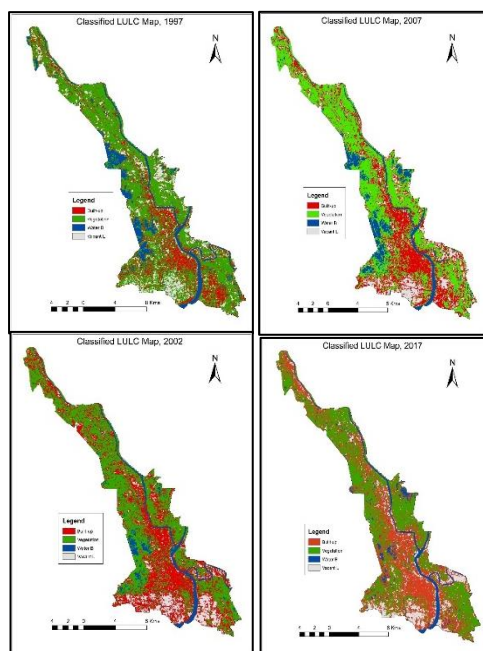

Figure 5. LULC Change Map

5. CONCLUSION

This study compared six separate Landsat images acquired by three different sensors to evaluate LULC changes during last two decades in Khunla city, Bangladesh where urbanization is beginning to explode. It also examined the trends in the LULC changes during these periods and their intra class relationships among LULC classes. Since 1997 to 2017, the built-up area in Khulna has increased, resulting in contentious decreasing vegetation and vacant land. If such a trend continues, built-up areas will paved the most of the ground surface within this city area. Such increases in built up areas along with their temperatures will have numerous heterogeneous medical, environmental, and social impacts and consequences. The results of this study will be considered by city planners, managers and all organizations involved in the decision-making process regarding land use and the creation of prospective land use policies for environmental sustainability, protection of natural resources and preparation of future city master plan.

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