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Impacts of Urbanization on Land Cover Pattern in Bangladesh: A Downscaled Approach for Chuadanga District

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Abstract
Bangladesh has been facing rapid and unplanned urbanization for last several years resulting devastating change to vegetation, fresh water body and bare soil in this area. This integrated study aimed to find out the trend of urbanization and land cover changes in Chuandanga, a western district of Bangladesh. This downscaled approach used GIS and remote sensing techniques for supervised land cover classification of Landsat images for last five years (2014-2018). The study has portrayed an increasing trend in built up area and bare soil whereas a decreasing trend in vegetation and water body. Meanwhile, it has been found that change in built up area and vegetation cover is strongly correlated whilst built area is increased by 1.28% (14.84 sq.km) and vegetation decreased by 16.54% (191.96 sq.km) during this period. Moreover, it is also observed that rapid growth of urban areas has a considerable influence on decreasing water body and bare soil as well as the changing pattern showing the forthcoming urbanization in this city. This study shows the importance of urban expansion for achieving Sustainable Development Goals (SDG) in particular *Goal 11, Sustainable Cities*.

Key words: Bangladesh, Downscaled approach, GIS and Remote Sensing, Land cover change, Urbanization

Introduction

Urbanization is one of the most dramatic global social transformations of the present century. Historically, it has been closely connected with industrialization that initiates industrialization-led economic growth along with the transition from agricultural-based income and employment to non-agriculture based livelihood opportunities (D'Odorico *et al.*, 2018). Today's urban population 3.2 billion will rise to nearly 5 billion by 2030 (Islam *et al.*, 2013), when three out of five people will be living in cities (Islam *et al.*, 2014). It is predicted that by 2050 about 64% of developing countries and 86% of the developed world will be urbanized (Dociu and Dunarintu, 2012). A majority of the population in least-developed countries will be living in urban areas by 2020 that will be dramatic in Asia and Africa (Hubacek *et al.*, 2009; Islam and Azad, 2008; Wagner, 2001).

Urbanization is widely accepted as a process with several consequences, such as social, economic, environmental and it usually occurs in developing countries. Managing urban growth has been very complex phenomena and big challenge of this century (Fragkias *et al.*, 2013). Urban growth changes the physical and functional components of built environment and subsequently the transition of landscape to urban form (Dahal *et al.*, 2018; Ernstson *et al.*, 2010; Kendall *et al.*, 2010).These complex processes influence a significant impact on natural resources mainly on water bodies and overall life quality (Lee *et al.*, 2018; Mahamud *et al.,* 2016; Qin *et al.*, 2014). Generally urbanization needs building up more houses, roads, commercial and industrial buildings etc. that eventually causes to stream channels changes to accommodate buildings, lead to more land erosion resulting more sediment to washed out by surface runoff and ultimately contamination (Chowdhury and Mukhopadhaya, 2016; Dociu and Dunarintu, 2012; Rahman *et al.,* 2018; Rana, 2011).

One of the fastest urbanized countries, Bangladesh has experience a rapid and unplanned urbanization in recent years (Hassan, 2017; Islam and Azad, 2008). While the annual population growth rate is 1·5% at national level, it is more than 5% in most of the big cities, and it is expected that more than 50% of the population of Bangladesh will live in urban areas by the year 2025 (Dewan and Yamaguchi, 2009; Islam *et al.*, 2014). Chuadanga is one of the oldest districts in Bangladesh where population is increasing and unplanned urbanization creates enormous pressure on it. For this unplanned urbanization the effects are fallen onto the total land cover of the districts and changed overall feature of the areas. Vegetation cover, bare soil, water body all are negatively changed because of rapid urbanization. Many environmental, geographical and political factors act as the dynamic drivers of landscape change (Chen *et al.*, 2009; Chowdhury and Mukhopadhaya, 2016; Ramalho and Hobbs, 2012; Rashid, 2009).

This study is conducted to investigate the impacts of urbanization on land cover in relation to infrastructural expansion in Chuadanga district. In addition, it assessed the impacts of urban expansion on vegetation, bare soil and fresh water body.

Methodology

Study area

This study is conducted on Chuadanga, a Western district of Bangladesh (Fig 1) which covers an area of 1,157.42 sq. km (446.88 sq. miles) and located between 23°22″ and 23°50″N latitudes and 88°39″ and 89°00″E longitudes. Total population of this district is about 1007130 with 49.18% female in which 68% of total people are involved in agricultural activity and 12% is involved in commerce (BBS, 2016).

Data sources

This study is based on the secondary data especially Landsat 8 image analysis, different peer reviewed journal articles, books and news articles retrieved from respective data sources. A systematic analysis and classification of these data were done which are connected to urbanization in Bangladesh perspectives.

Table 1. Acquisition date of the images

Image Year	Acquisition Date
2014	3 March, 2014
2015	4 February, 2015
2017	25 February, 2017
2018	12 February, 2018

Data acquisition

There are two Landsat 8 Surface Reflectance (SR) images acquired for Chuadanga district from 2014 to 2018 (2016 excluding) from Earth Explorer of United States Geological Survey (USGS) online database (Table 1).

These images were acquired by Operational Land Imager (OLI) sensor which contain 30 m multispectral spatial resolution (red, green, blue and near-infrared bands) along with 185 km wide swath (Path 138 and Row 44). For avoiding interference of cloud cover and ensuring more accuracy in analysis, the study area from the true color scenes was merged and clipped with shape file.

Classification

Maximum Likelihood Supervised classification method in ArcGIS 10.1 carried out for processing and analyzing the land cover changes in Chuadanga district. Firstly, bands 2,3,4 of images were been composited and set RGB composite in the band 4 for red, 3 for green and 2 for blue channel. Afterward, steps of maximum likelihood classification method such as creation of training areas and signature files and classifying the images. Simultaneously, Training Areas (TA) have been created from the composite images into four macro-classes i.e., water body, vegetation, bare soil and built up area. There are more than 120 training sample polygons for each class were been drawn for image classification. By using this method, land cover of Chuadanga were been classified for five (04) consecutive years. Finally, the attribute data of these classified images were been extracted to further analysis in MS Excel.

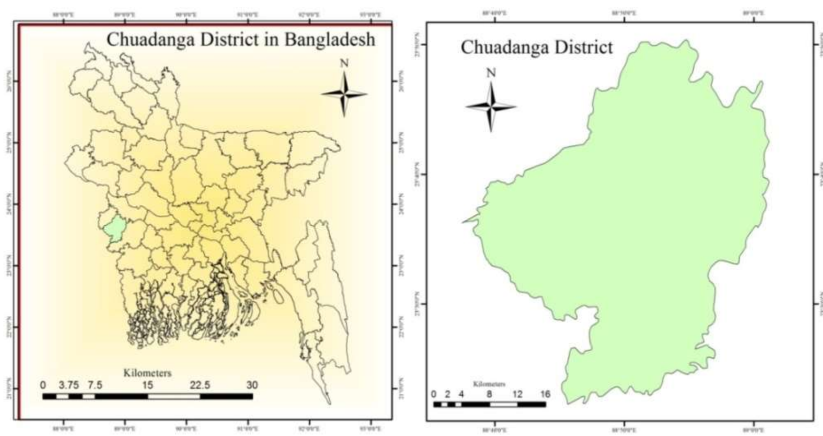

Fig 1.Chuadanga district in Bangladesh

Results and Discussion

The study found the total land cover 1160.69 sq. km which is categorized into four classes i.e., Water body, Vegetation, Bare soil and Built up area. The study revealed that water bodies covered 87.08 sq.km (7.50%) in 2014 in this district in comparison to 639.81 sq.km (55.12%) of vegetation, 414.34 sq.km (35.70%) bare soil and 19.46 sq.km (1.68%) built up area respectively. Meanwhile, in 2015 water bodies increased to 143.04 sq.km (12.32%) whereas vegetation and bare soil slightly decreased into 596.91 sq.km (51.43%) and 397.97 sq.km (34.29%) while built up area increased to 22.78 sq.km (1.96%) respectively. As well, water bodies and vegetation were decreased to i.e., 83.20 sq.km (7.18%) and 558.39 sq.km (48.10%) in 2017 while bare soil and built up area increased to 488.46 sq.km (42.08%) and 30.65 sq.km (2.64%) respectively. In recent, this study observed that water bodies, bare soil and built up area were increased to 94.64 sq.km (8.15%), 583.90 sq.km (50.31%) and 34.30 sq.km (2.96%) in 2018 comparatively decreased in vegetation cover i.e., 447.85 sq.km (38.58%) respectively (Table 2 & Fig.2).

Table 2. Total land cover areas of Chuadanga district in 2014, 2015 2017 & 2018

Year	Water (Area sq.km)	Vegetation (Area sq.km)	Bare Soil (Area sq.km)	Built Up (Area sq.km)
2014	87.08 (7.50%)	639.80 (12.32%)	414.34 (7.18%)	19.47 (8.15%)
2015	143.03 (55.12%)	596.90 (51.43%)	397.97 (48.10%)	22.78 (38.58%)
2017	83.20 (35.70%)	558.39 (34.29%)	488.47 (42.08%)	30.65 (50.31%)
2018	94.65 (1.68%)	447.85 (1.96%)	583.90 (2.64%)	34.30 (2.96%)

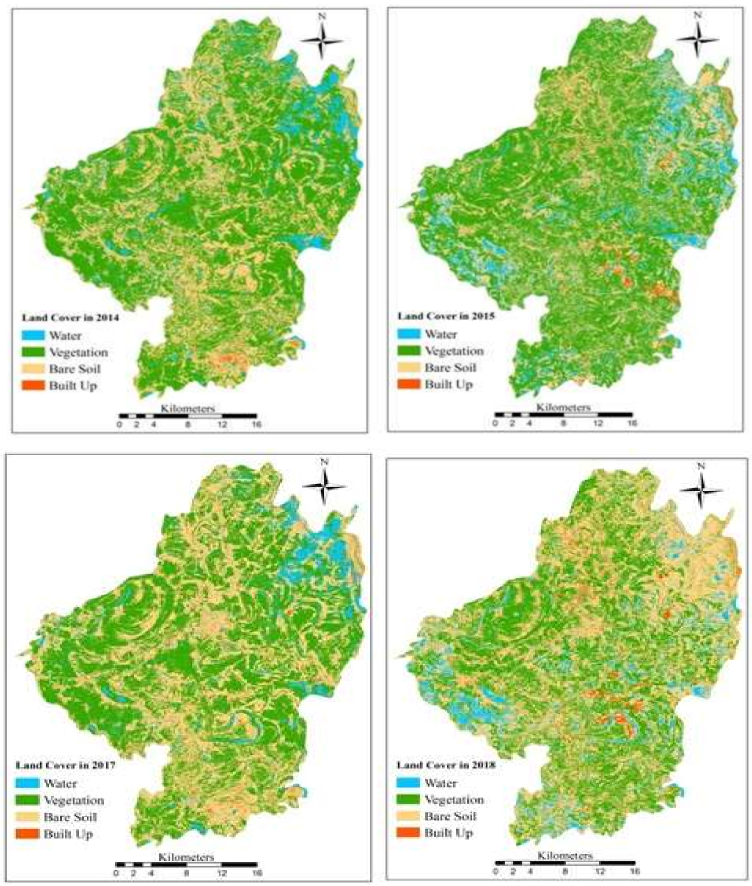

Fig 2. Shows the land cover change of Chuadanga district in 2014, 2015, 2017 & 2018

The result of land cover change showed that there is a variation in water and bare soil where they are temporally decreased and increased but the vegetation cover is constantly decreased and the built-up area is sequentially increased. These features represent the socio-economic development of the area is up warding. But the impact of the urbanization has fallen into the natural elements mostly on vegetation.

Total land cover change of the study areas show that water body and bare soil are respectively decreased and increased in last five years, the vegetation cover are respectively decreased and the built up area are constantly increased. There show urbanization impacts are fall into the vegetation cover partially.

In 2014 the water body was 7.50%, in 2015 this water body was increased 4.82% and reached 12.32%, in 2017 water body is decreased 5.15% and reached 7.17%, in 2018 water body is slightly increased 0.98% and reached 8.15%. In 2014, 2015, 2017 and 2018 the vegetation cover is constantly decreased and the values are 55.12%, 51.43%, 48.11% & 38.58%. In 2014 the bare soil is 35.70%, in 2015 this is decreased 1.41% and reached 34.29%, in 2016 & 2018 bare soil is constantly increased and the value are 42.08% & 50.31%. In 2018 the built up area is constantly increased and the value are 1.68%, 1.96%, 2.64% & 2.96% (Table 2).

This study revealed a changing scenario in the coverage of water body in the Chuadanga district. It shows (Fig 3) that proportion of water area has been increased in 2015 in comparison to its last year (87.08 sq.km to 143.04 sq.km) while again decreased in forwarding year (i.e., 83.19 sq.km) and again slightly increased in 2018 (i.e., 94.64 sq.km) respectively. It is scrutinized that water was stagnant in 2015 in the low land areas comparatively other analyzed years.

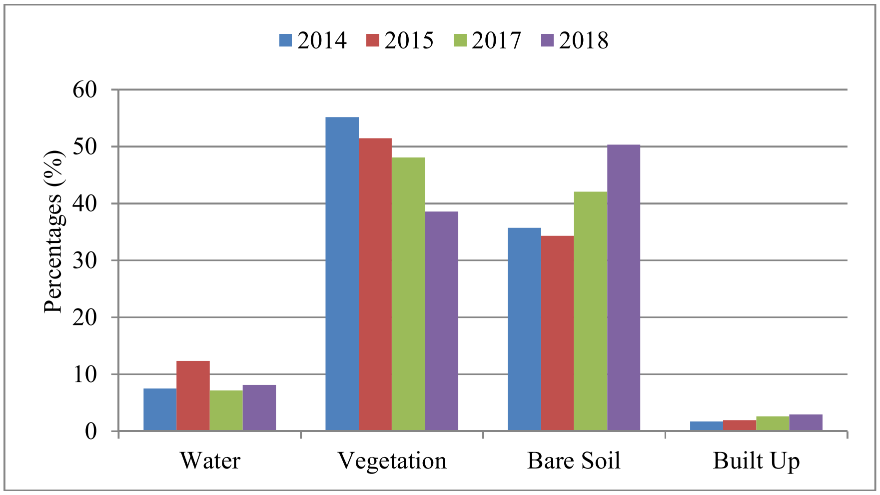

Fig 3.Temporal variations of land cover areas (%) in Chuadanga district

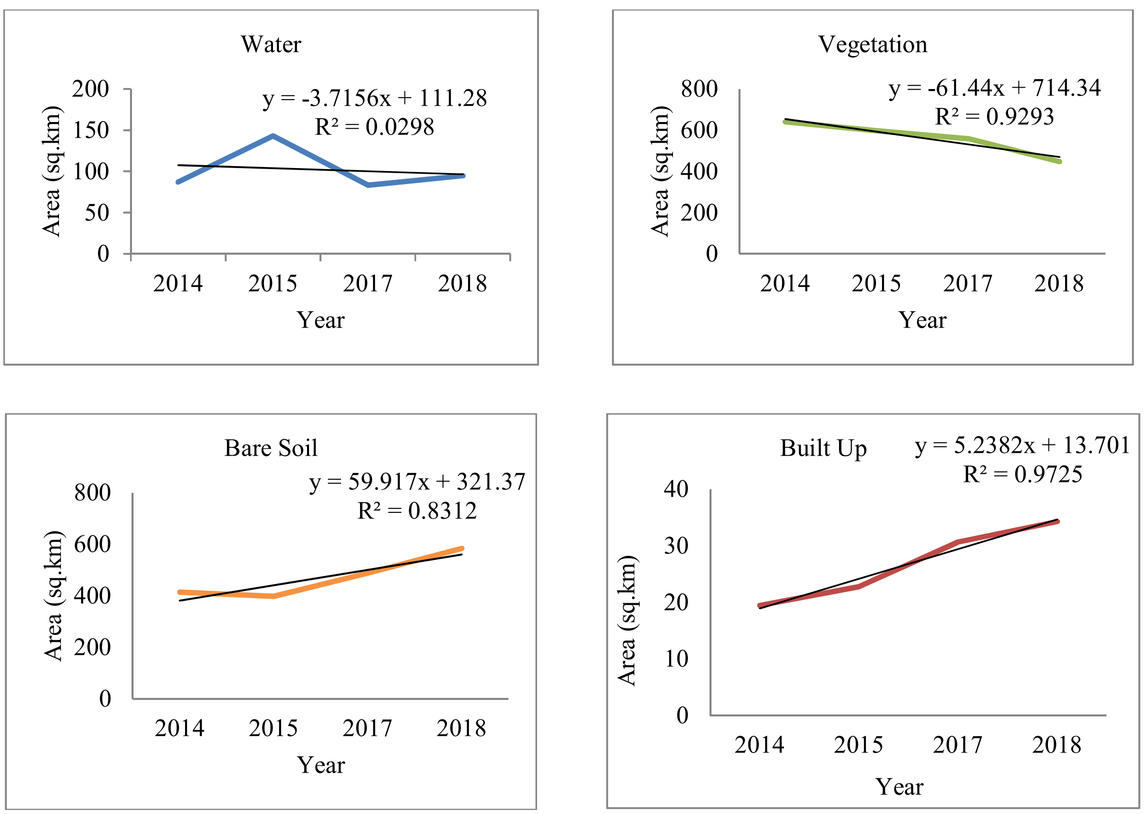

Fig 4.Yearly variation of water body, vegetation, bare soil and built up in Chuadanga district

The vegetation cover in 2014, 2015, 2017 & 2018 is constantly decreased. Yearly variation trend of vegetation cover was found to be downward. Besides, the proportion of bare soil area in 2014 to 2015 is decreased (414.34 sq.km to 397.97 sq.km) and in 2015 to 2017 bare soil is increased (397.97 sq.km to 488.46 sq.km) and 2017 to 2018 bare soil is again increased (488.46 sq.km to 583.90 sq.km), respectively. The bare soil changing is mainly shows for the precipitation rate variation and also agricultural activities in the study areas. Aside of, the built up area in 2014, 2015, 2017 and 2018 is constantly increased because of the built up trend of this areas are upward and the developing process of the study area is ongoing (Fig 4).

Table 3. Correlation among four variables in Chuadanga district's land cover

	Water	Vegetation	Bare Soil	Built Up
Water	1			
Vegetation	0.99	1		
Bare Soil	0.98	0.97	1	
Built Up	0.86	0.86	0.95	1

There is a good relation between built up and bare soil (i.e., 0.95), comparatively weak relationship between built up and water (i.e., 0.86) and also between built up and vegetation (i.e., 0.86). In bare soil and water there are a strong relation (i.e., 0.98) compare with bare soil between vegetation (0.97) relationship. Besides, a stronger relation found between vegetation and water (0.99) (Table 3).

Temporal changes of urban areas in Chuadanga district are constantly increases. The trend line of built up and bare soil is upward. In five years built up area is increasing 14.84 sq.km (1.28%). This trend is very fast. If this trend is running, the area will be turn into dense urbanized district in a few years. The impact of urbanization on vegetation cover, bare soil and water body; vegetation is mostly affected by the urbanization. Vegetation in Chuadanga district is constantly decreased. 191.96 sq.km (16.54%) areas of vegetation are decreases in five years. The people of this area may be conduce deforestation more and it fall negative impact on overall environment in this area. In temporal variation water body and bare soil also varied. Water body is changed in upward and downward trend. Trend of bare soil is upward. There also show the vegetation and water body is strongly correlated.

Conclusion

This study has demonstrated rapid urbanization in the cities of developing countries has been a dilemma on economic development and environmental suffering. For economic and others development, urbanization is need but it must be well planned in the beginning. The study not only shows the urbanization trend but also show the vegetation cover, bare soil and water bodies temporal variation. The study determined the concentration on green development that cannot changed the environmental feature negatively.

This study quantitatively characterizes the land use/land cover pattern and dynamics of urban expansion in Chuadanga district in Bangladesh using Landsat imagery enabling with GIS and Remote Sensing techniques over the period of 2014-2018 (excluding 2016). The results suggest that the selected study area has undergone rapid urban development over these 5 years. 1.28% areas are urbanized in this period, resulting a significant decline of vegetation cover (16.54%) is shown. There also show a significant change into water body and bare soil. Unplanned increase in built-up areas and urbanization induced landfills, snatches the vegetative and cultivated lands, water bodies and wetlands, which is environmentally not sustainable. The causes of this kind of resource diminishing urbanization are un-planned development, political crisis, poor legislative actions and inadequate policies.

The land use and land cover changes are gradually fall impact on environmental significant. In this area the vegetation cover decreases gradually, for this reason there show many natural disaster on the area and compare to the past the precipitation rate is less in present. Globally all the situations we face in terms of urban and spatial content of the phenomenon of urbanization, need an urgent adoption of measures and methods to minimize the adverse effects and to strengthen their benefits. Also should be taken into consideration the development of new opportunities in rural areas in systematically (Dociu and Dunarintu, 2012). The promotion of small towns can help by providing income-earning opportunities and basic services, and by establishing a planning framework for small-scale development projects.

In Bangladesh mainly the developing districts of it, the aim has been less one of planning urban and industrial complexes than of inserting a new urban layer which will support rural development and enhance the lives of village people. As such expansion puts a strain on urban efficiencies and creates a wide range of management and environmental problems, GIS and RS technologies might be considered as important tools and techniques for analyzing the processes and effects of many rapidly growing urban areas in less developed countries, where alternative sources of information are limited due to lack of resources. Hence, the time series thematic map and spatial information generated from this study using remote sensing and GIS may assist local planners and stakeholders in the country as well as concerned academia to better understand urban dynamics at a local level. In addition, it will serve as a guide for determining the best use of limited land and other resources that are available at the local level, and in planning for an urban future based on a vision of sustainable urban development and its implications (Hassan, 2017).

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