

Urban Expansion Analysis and Land Use Changes in Rangpur City Corporation Area, Bangladesh, Using Remote Sensing (RS) and Geographic Information System (GIS) Techniques

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Abstract

Rangpur City Corporation (RCC) is the main administrative functional area for both of Rangpur City and Rangpur division and experiencing a rapid change in the field of urban sprawl, cultural and physical landscape, and city growth. These agents of Land use/Land cover (LULC) varieties are responsible for multi-dimensional problems such as traffic congestion, waterlogging, and solid waste disposal, loss of agricultural land. In this regard, this study fulfills LULC changes by using Geographical Information Systems (GIS) and Remote Sensing (RS) as well as field survey was conducted for the measurement of change detection. The sources of data were Landsat 7 ETM and Landsat 8 OLI/TIRS of both CI levels 1. Then after correcting the data geometrically and radiometrically change detection and combined classification (supervised & unsupervised) were used. The study finds considerable changes for LULC. The findings show that built-up area, water source, agricultural land, bare soil in a change of percentage is 17.23, 2.58, -9.94, -10.19 respectively between 2009 and 2019. Among these changes bare soil is changed to a great extent which indicates the expansion of urban areas is utilizing the land to a proper extent respectively. But these changes also measure the reduction of agricultural land in the context of haphazard urbanization which is risking the term planned urbanization and food security for present and future aspects.

Keywords: Urban expansion; land use; land cover; remote sensing; geographic information system (GIS); Rangpur City Corporation (RCC).

Introduction

Bangladesh is a developing country with the rapid growth of the population. Rangpur is also a fast-growing city in the field of urbanization with having a population of 2.96 million. Because of the fast population growth LULC also changing the emphasizes function of urbanization. The satellite image is carrying many more essentialities for the proper and quick planning of LULC. For this reason, the field surveying method is considered time-consuming and costly which is replacing by RS techniques.

Facial (2000) asserted the nature of land-use changes, location of agricultural land losses and for the reason of urbanization, the supply of higher quality of agricultural activities is reducing. Remote sensing satellites are playing a vital role in mapping land use and land cover changes and infrastructural development for several past recent years (Arimoro et al., 2003). But in RCC no such application is implemented for the detection and assessment of these types of operational work (Dewan and Yamaguchi, 2009). Land-use changes arising from agriculture, pasturing, urbanization, bare soil, and deforestation are some of the responsible factors to land cover changes in RCC. These changes in LULC reflect on the growth of population, consumption of land and the local climate. Expansion of RCC has resulted not only in the depletion of natural resources but deterioration of the environment. Agriculturally productive land, forest land, bare land has been transformed into different commercial, residential and other uses. The LULC is the result of the social, economic, environmental phenomenon and their perspective of utilization. The collection of remotely sensed data contributes the synoptic assessments of the function of earth-system, patterning, and change at local, regional and global scales over time (Rajeshwari, 2006).

However, the objective of this study is to attempt mapping out the LULC status of RPCC between 2009-2019 with a view of detecting the land consumption rate and the changes that have taken place using RS and GIS techniques; serving as a precursor to the further study on urban induced variations or change in weather pattern of the city. The changes in rapid land use are the cause of the growing population, which is reducing another area of interest like natural vegetation (Nicolson, 1987). The urban centers are increasing in population, but a twofold conversion is undergone for the pre-urban areas; arable and non-arable land both are providing an increasing number of establishments such as commercial, industrial and residential (Heimlich and Anderson, 2001). Kalnay and Cai (2003) assessed that the urban area and its surroundings can be altered by the local climate which is the cause of urban expansion. Instead of using traditional approaches satellite remote sensing is essentially monitoring the change of land use with the facilities of high resolution, which is associated with lower cost (Belal and Moghanm, 2011). Socio-economic factors are influencing human activities for built-up and non-built-up changes even having physical barriers (Long et al. 2007). Another study shows LULC and its alluvial with risks for soil erosion in the Khlong Kui in 1991, 2005 and 2014 by using GIS techniques and monitored increasing in evergreen forest, rice field, urban areas with decreasing wetlands and deciduous forest(Chaikaew, 2019). In addition the matter of accomplishing GIS data with other data models could have possible solutions. Sing et. al (2018) has shown the changes of LULC for 30 years in the Dhanbad district, Jharkhand, India, which found the possible reasons to reduce dense forest, open scrub, agricultural fallow, river, body of water and mining in 42.63, 60.45, 21.47, 28.80, 50.37 and 19.85% respectively, which could be the harvest of forests for fuel, shelter and agriculture, construction of residential houses on fallow lands, urbanization and sand removal for construction material.

Study Area

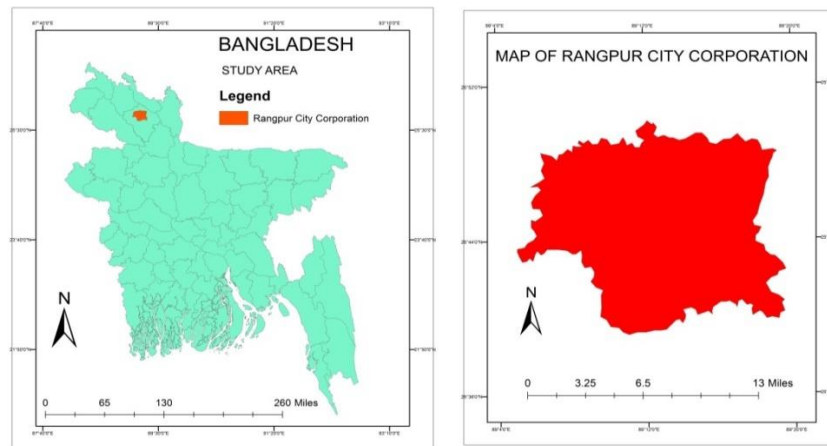


Figure 1: Study Area

RPCC established in 2012 which was previously known as Rangpur Poursava(established 1986) with having 442 villages and 112 mouza (<https://rpcc.portal.gov.bd/site/page/0046cdb2-b2a0-499e-b4cf-1c1c0e89a49d>). RPCC geographically located in between 25°38' and 25°52' North latitudes and 89°05' and 89°20' East longitudes. It is bounded by Nilphamari and Lalmonirhat district on the north, on the south Gaibandha, on the east Kurigram and Dinajpur on the east with having the total area of 205.70 square kilometers (Figure1). And Population growth change of Rangpur is +1.98 per year from 2001 to 2011(<https://www.citypopulation.de/Bangladesh-Mun.html>); (See figure 2) which was increased 865,927 in the year of 2014 (BBS 2015).

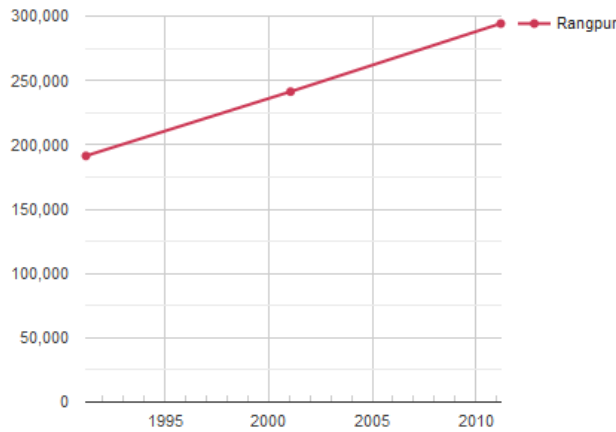


Figure 2: Population growth change

Data and Methods

This study utilizes data for the measurement of LULC changes. Remotely sensed data Landsat 8 and Landsat 7 of both C1 Level 1 were used for the LULC change detection in between the year of 2019 and 2009 (a ten-year time span). Spatial Characteristics of these data having the below approaches (See Table 1). In addition, these data were collected from earthexplorer.usgs.gov whist path and row were 138 and 042.

Table 1: Spatial Characteristics of Data (Used)

Instrument	Month/ year of Image	Sensors	Spatial Resolution	Radiometric resolution (bit)
Landsat 7	February 2009	ETM+	30	16
Landsat 8	May 2019	OLI/TIRS	30	12

Universal Transverse Mercator (UTM) was used for the collected satellite images for the map projection within Zone 46 N-Datum and of the co-ordinate system World Geodetic System (WGS) 1984 and the pixel size is 30 meters. The extraction of the study area of RCC shapefile of GIS was used with having the same projection of UTM and WGS 1984 which was georeferenced. Then images were taken by Raster Processing tool under Data Management tool of ArcToolbox in ArcGIS 10.5. And finally the image classification was conducted by the combination of supervised and unsupervised classification. An extensive field survey was performed of the RCC by using GPS(Global Positioning System), earlier the preprocessing and classification of satellite imagery. GPS was used for scaling the satellite image data by comparing the field data. And this fieldwork was done in the mid of February 2019.

Results and Discussion

4.1 Results

In this section, results are shown on the basis of LULC distribution, area measurement, percentage of covered area, change detection and changing pattern. The city of Rangpur gets a haphazard expansion of urban area which is the result of conversion of agricultural and bare land. During the period of 2009 and 2019 due to the urbanization and the cause of Rangpur Pourosova turning into RCC in 2012 has made the city expanded largely into urban area which is 5670 hectares of 17.53 percent of total area(Table 3).

The distribution of LULC changes rapidly in the sector of the built-up area which is nearly two times higher than in 2019 also the noticeable decreases land is agricultural which is the indication of 10% loss. But it decreased to a great extent of bare soil from 3439 to 145 hectares(Table 2). These changes are defining the urban expansion where agricultural and bare soil is used to urbanized the areas. As city population is increasing the city has been expanded extensively to accommodate the increasing population compared to its early stage the cities spatial expansion is the modification of several constrained physical factors. However the loss of natural resources is the cause of the development.

The LULC pattern changes spatially from 2009 to 2019(Figures 3 & 4). Earlier in 2009 built-up area was congested at the center where other parts also carried it haphazardly in the northwest, north-south direction. In 2019 the urban area expanded largely northward, westward and southward where the direction of eastward expansion was very low compared with them respectively. The

LULC map interpretation in between 2009 and 2019 shows that RCC is expanding in all of the following directions northwest, south-west and southern parts by filling up low lying areas. The major perspective of expanding these areas is the increasing of residential, public and private structural development.

The maximum loss of agricultural land and bare soil provides information about the pressure of urban expansion of it. The study area urbanization is rapidly growing and if it continues it will decrease land cover areas 35.06 percent within the next 20 years which will lead diversified and uneven expansion like present times in 2019. The contributing factors of urban sprawl are increased amount of population, poor land-use policy, low land, unplanned housing and expansion of industrial areas, poverty, absence of multiuse of urban areas which are creating the slums and squatters with decreasing food safety due to the loss of agricultural land. This diversification is negatively affecting both the natural environment and human health as well as for the development of near future perspectives.

Table 2: Land Use Land Cover Distribution (areas in hectares)

Classification category	2009		2019	
	Area(ha)	Area Covered(%)	Area(ha)	Area Covered(%)
Built Up Area	3468	10.73	9138	28.26
Water Source	1973	6.10	2805	8.68
Agricultural Land	23453	72.55	20245	62.61
Bare Soil	3439	10.64	145	0.45
Total	32333	100	32333	100

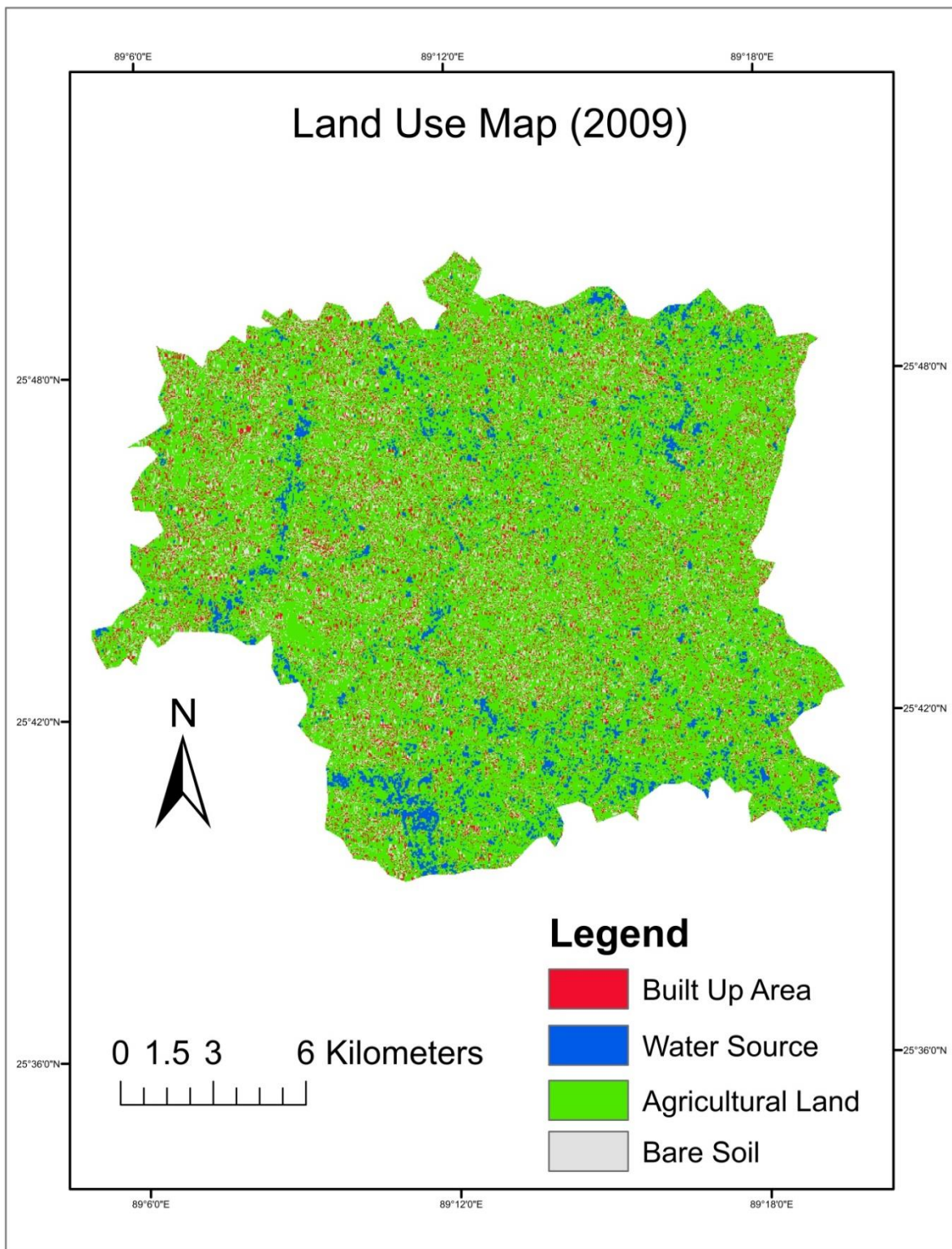


Figure 3: Land Use Map 2009

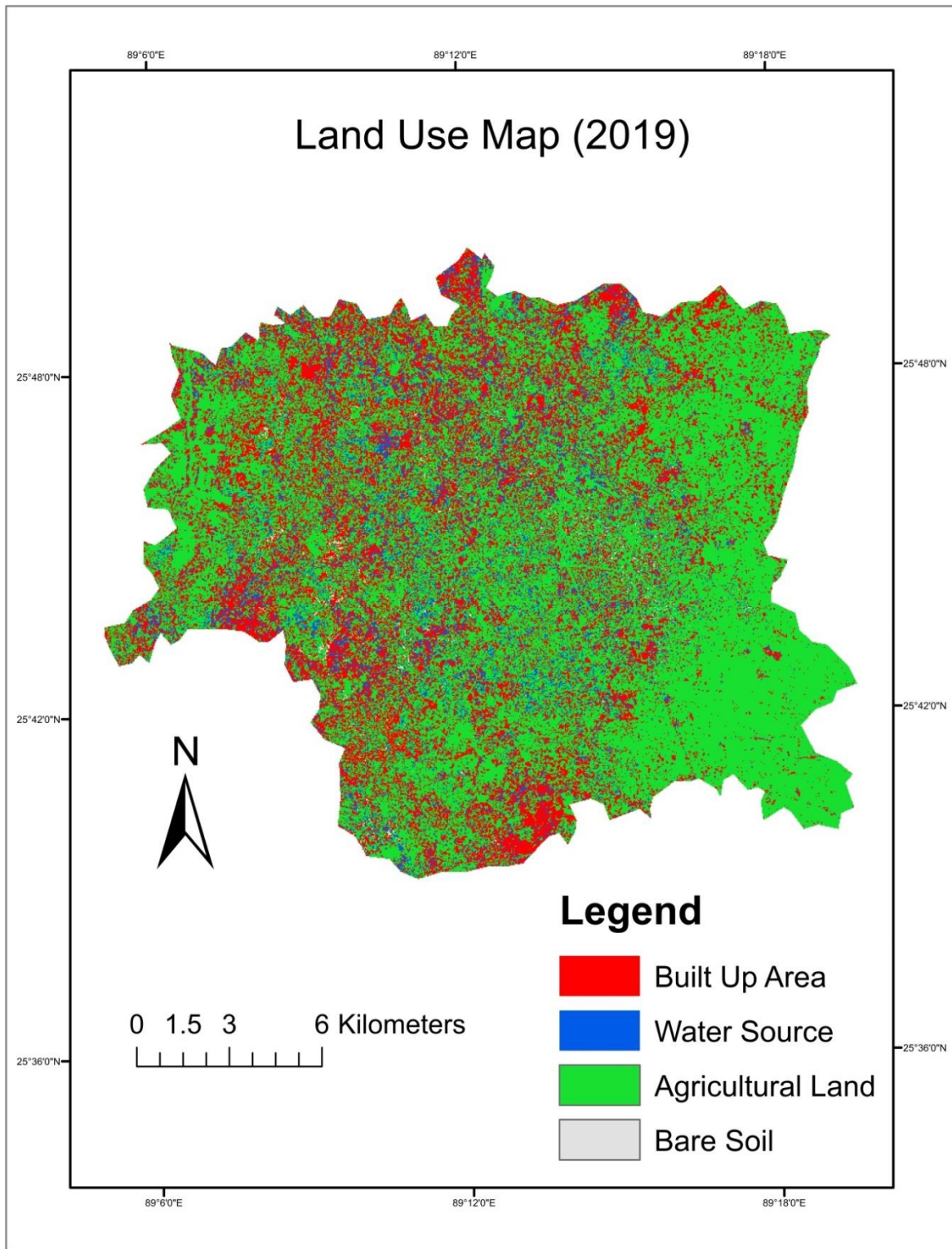


Figure 4: Land Use Map 2019

Table 3: LULC Change of RCC and its environs

Classification category	2009 Area(ha)	2019 Area (ha)	Difference in Area(ha)	Difference in Area(%)
Built Up Area	3468	9138	5670	17.53
Water Source	1973	2805	832	2.58
Agricultural Land	23453	20245	-3208	-9.94
Bare Soil	3439	145	-3294	-10.19

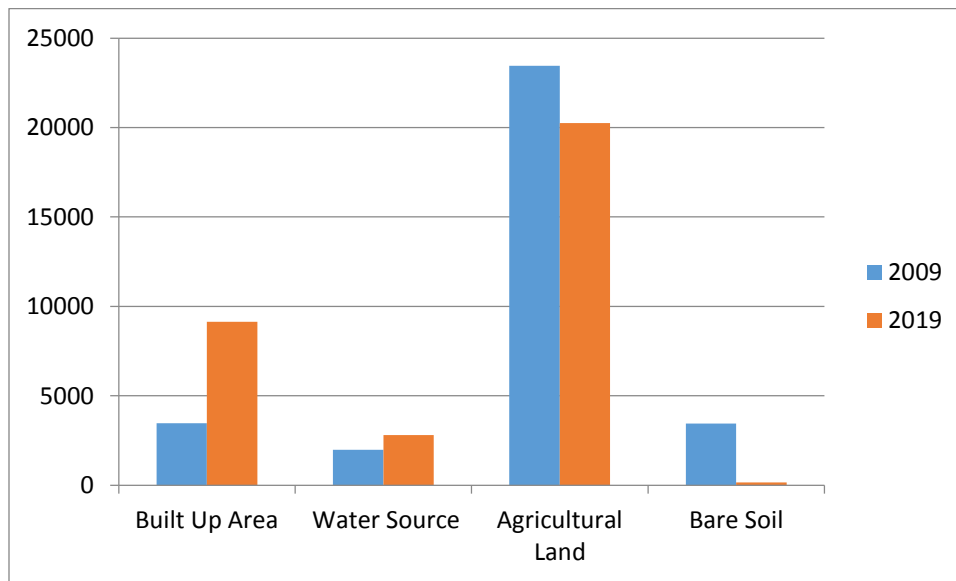


Figure 5: LULC Change Detection between 2009 & 2019

4.2 Discussion

4.2.1 Land use–land cover change: Trend, rate and magnitude:

Results of Table 2 and Figure 3, 4 makes an evidence of congestion of the city and haphazardly increasing number of built-up area which includes residential, commercial and services, industrial, transportation, roads, mixed urban, and other urban areas within the percentage of 17.53(5670 ha) wherewith the same increasing trend water source also got improvement. The responsible factors for this urban expansion are mainly population growth and haphazard development of residential, industrial as well as public infrastructure. For this reason, the temperature is increasing 20 percent annually where agricultural activities are responsible only for 3 percent(Hasan and Islam, 2015). And the improvement and increased amount of water bodies prove that permanent water sources like river, permanent open water, lakes, ponds, and reservoirs are extended whereas temporal or seasonal water sources like permanent and seasonal wetlands, marshy land, swamps have been decreased. 3208 hectares of agricultural land are negatively increased due to the positive extent of built-up area of 5670 hectares where agricultural land indicates the agents of both cultivated and planted trees like crop fields, fallow lands, vegetable lands, roadside planted trees, mixed forest lands, homestead forest. The bare soil is providing space both for the built-up area and permanent water source and for this reason it is increased negatively of 10.19 percent of 145 hectares of the 10 years span of time. In very recent period bare soil indicates exposed soils, sand fill, landfill sites, and areas of active excavation. This reduction of agricultural land and bare soil is leading the fact of urbanization rapidly.

4.2.2 LULC Change Detection and Analysis

LULC change detection represents the result of Table 3 and figure 5 where rapid change is noticed in the factors of built-up area and bare soil which is about 27.72. Their individual approximate change indicates the built-up area is most commonly responsible for this rapid change. Beyond the changing pattern of built-up area rapid growth of the population of the city(see figure 2) is playing an

essential role. Bare land is negatively changed of 10.19 which is the indication of land use efficiency. For food safety and economic growth (see figure 6) agricultural land carries several responsibilities in Bangladesh agricultural production and 84% of rural people directly or indirectly engaged with agriculture(Mirza 2015). But it is decreased in RPCC of about 10 percent which is an alarming rate for food safety.

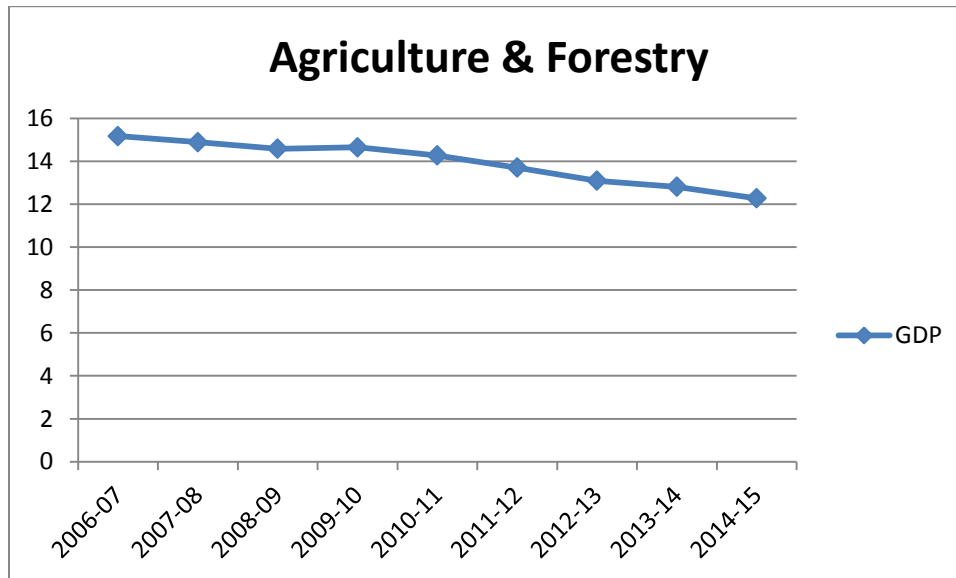


Figure 6: GDP from the sector of Agriculture and Forestry
Source: Bangladesh Bureau of Statistics (BBS)

Loss of agricultural land is the reason for the gradual loss of GDP as it is the field of second-largest source of GDP after manufacturing (20.17% GDP). As water source is increased by 2.58 percent so that agricultural activity could be benefited from it and also fisheries sector is improving for the reason of available water source (field survey).

Conclusion

This study is an indication of the potential use of GIS and RS techniques for obtaining the objective specific measurement of RCC. The study finds uneven and haphazard increasing of 5670 hectares of land in all directions especially the northern, northwestern, southern and southwestern parts which include settlement, industrial and commercial infrastructure are rapid which is the indication of loss of agricultural land, bare soil with increasing of temperature. In addition the responsible factors for increased urbanization space of bare soil which ensuring temperature rise which is more than 17 percent of agricultural land. But this study also finds that the source of water is increased by 832 hectares of land so this could be the indication of future development of agricultural land as well as urbanization. In addition, other primary economic activities like fishing could be improved. And proper management of urban expansion must be implemented for reduction of agricultural land loss; the separate zonation for the expansion of urban infrastructure could also be conducted with multi structural buildings. Furthermore loss of agricultural land also could be covered through multi structural use of existing agricultural and bare land using the available water source.

The extended recommendation proposes a future course of action for the field study to identify the category of several spheres of LULC changes.

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