Urban Area Change Analysis in the Rangpur Sadar Upazila, Bangladesh Using Landsat Imageries

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Abstract: ***Rangpur sadar Upazila has been becoming an important city in terms of administration, livelihoods, education and population migration from its nearest Upazilas. In this paper, temporal changes of the urban and agriculture areas were estimated using two multi-date Landsat imageries from 1989 and 2014. Two thermal imageries from the both years were also used to investigate Land Surface Temperature (LST). From this study, it is estimated that urban areas have increased by 20% at annual growth rate while agriculture was only 3%. These percentages of agricultural areas were converted from forest and wetlands. An increase trend of temperature was found in the area. The mean LST was 19^{0}C and 40^{0}C in 1989 and 2014 respectively. In order to understand the relationship between population growth and urbanization, we used a regression analysis, which was 92%. The overall accuracy for urban and agriculture was 92% and 95% in 1989 and 2014 respectively.***

Keywords: Urban, Remote sensing, GIS. Agriculture, Landsat, LST, Bangladesh, Rangpur

1. Introduction

Rapid urban expansion becomes a burning issue for human development research and creates rising pressure on global biodiversity all over the world. The urbanization takes place at a rate of twice faster as increase of urban population. Several research works estimates that about 60% world population is expected to move in urban areas by 2030 [1]. However, the rate of urban expansion differs country to country. Most of the developing countries are expanding urban areas more than expectation.

Bangladesh, as a least developing country, is also getting experience of rapid urban expansion. The urbanization process takes places in plain land surface than the hilly area or remote coastal area in the country. The increasing population requires increased human habitation and thereby urbanization. Compare to the annual national population growth rate 1.7 % of the country, the urban expansion percentage rate is much higher and faster. It is expected that by 2025, more than 50% population of the country will reside in urban areas [2].

People move away for job and better living towards urban area from rural area especially from the areas of economically depressed. On the other hand, people from coastal area are migrating due to severe calamities affected by climate change. Rangpur *Sadar Upazila* is also expanding urban areas rapidly in unplanned way. People who suffer riverbank erosion or flood are mainly migrating to this region. Besides, many poor people settle down in the city area in search of job. *Monga,* a regional temporary famine like seasonal food crisis period, create pressure on the affected people streaming to the city in a hope of food and labor work [3].

Now-a-days, it becomes a great challenge for the city to accommodate all the incoming people except urban expansion. The urbanization process also creates threat on the local biodiversity. In consequence, agricultural land area is decreasing due to uncontrolled built up urban areas. There is a significant relationship between urban expansion and biodiversity [1] [4]. Urban expansion possesses threat to ecological imbalance and often alters local species or their habitat fragmentation [5] [6].

Remote sensing technology has great implication on detecting urban land use change [7]. The technology is commonly used worldwide in city planning, urban design and land use change detection. Fichera C R et al (2012) has carried out a research work on land cover changes at the Province of Avellino (Southern Italy) using multi-temporal Landsat images [8]. The results revealed that during five decades analyzed period, a significant land conversion took place in that area. Azaz L K A. (2004) used satellite images and GIS analysis to find out the urban changes in Alexandria city, Egypt [9].

2. Objective of the study

The main objective of this study is to classify urban expansion of Rangpur *sadar Upazila* in Bangladesh using two multi-date Landsat imageries. The specific objectives are as follows:

- To assess urban and agriculture features and their changes in 25 years
- To extract status of land surface temperature (LST) over the extracted urban areas.

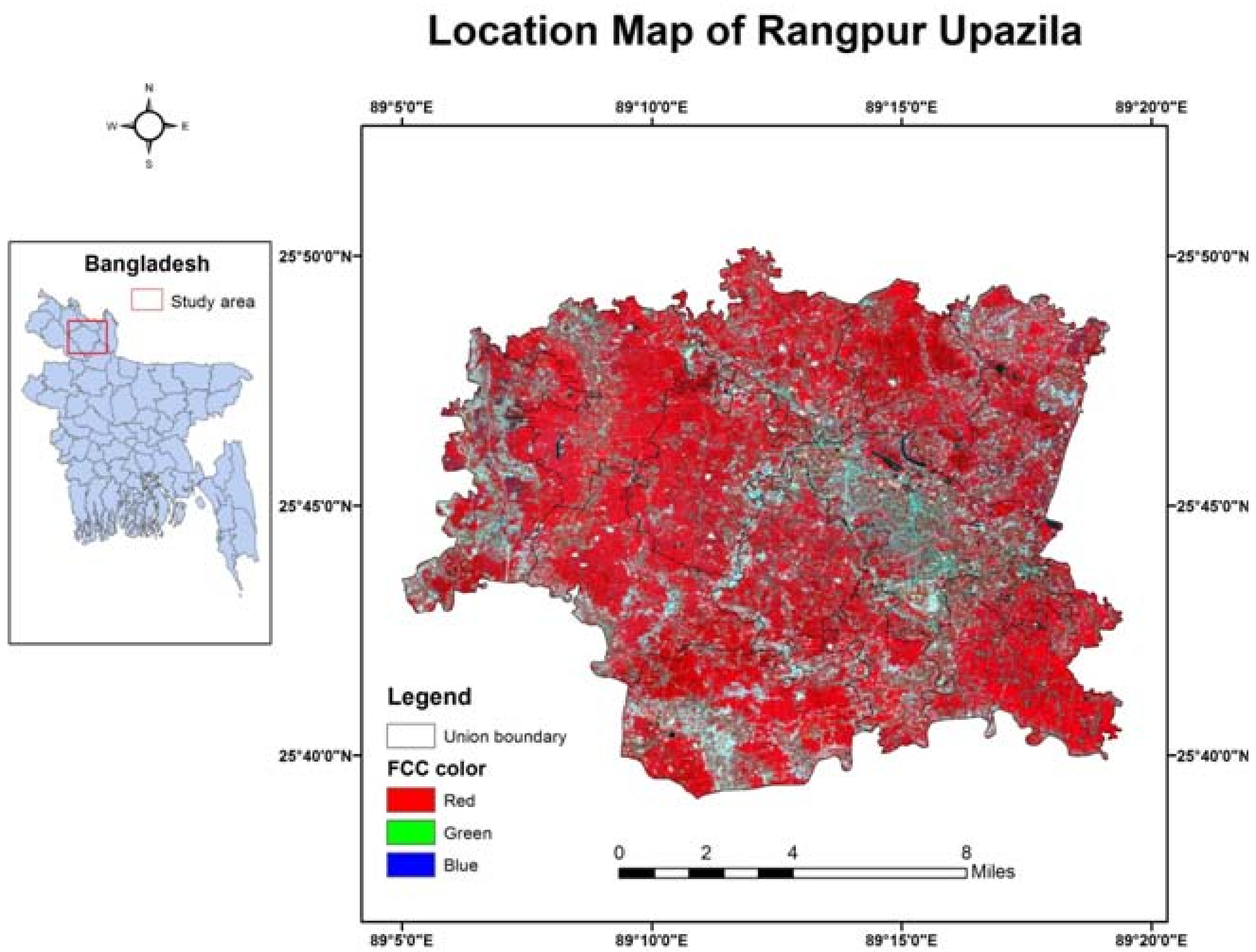

Figure 1: Location map of the study area

3. Study area

Rangpur Sadar is one of the major *upazilas* of Rangpur district, located in the north west of Bangladesh (Figure 1). The *upazila* covers a land area of 330.33 square km. Teesta and Ghaghat are the main rivers. The *upazila* is bordered by Mithapukur *upazila* at south, Gangachara *upazila* at north, Taraganj *upazila* at west and Pirgachha *upazila* at east side. The population of the Rangpur *Sadar upazila* is 251699 [10]. Topgraphically, the area is predominantly alluvial plain land. The average maximum temperature is 32°C during summer and average minimum temperature 11°C during winter. The annual average precipitation is 2931 mm [11].

4. Supporting data and materials

To carry out this study, two multi-date imageries from Landsat of 1989 and 2014 were used. Mainly four channels; Blue, RED, NIR and MIR were used for computing different algorithms and image classification methods to extract urban and agriculture areas. On the other hand, thermal bands of the both images were used to calculate land surface temperature.

The other information of the imageries used in the study is presented in Table 1.

Table 1: Remote sensing metadata

Landsat	Row/ Path	Date of acquisition	Resolution (Meter)	Projection	Channels
TM	044/ 138	1989-01-19	30	UTM/WGS 84	Blue, Green, RED, NIR, MIR and Thermal
OLI_TIRS	042/ 138	2014-04-22	30	UTM/WGS 84	Blue, Green, RED, NIR, MIR and Thermal

A vector polygon shape file of Rangpur *upazila* used to mask out the study area from the whole scenes of Landsat imageries. ENVI v.4.5 and ArcGIS v.10 were used to process all kinds of image processing tasks and final layouts. Some basic resultant information from the both years was added as the main variables to conduct significant primary statistical analysis using Microsoft Office Excel.

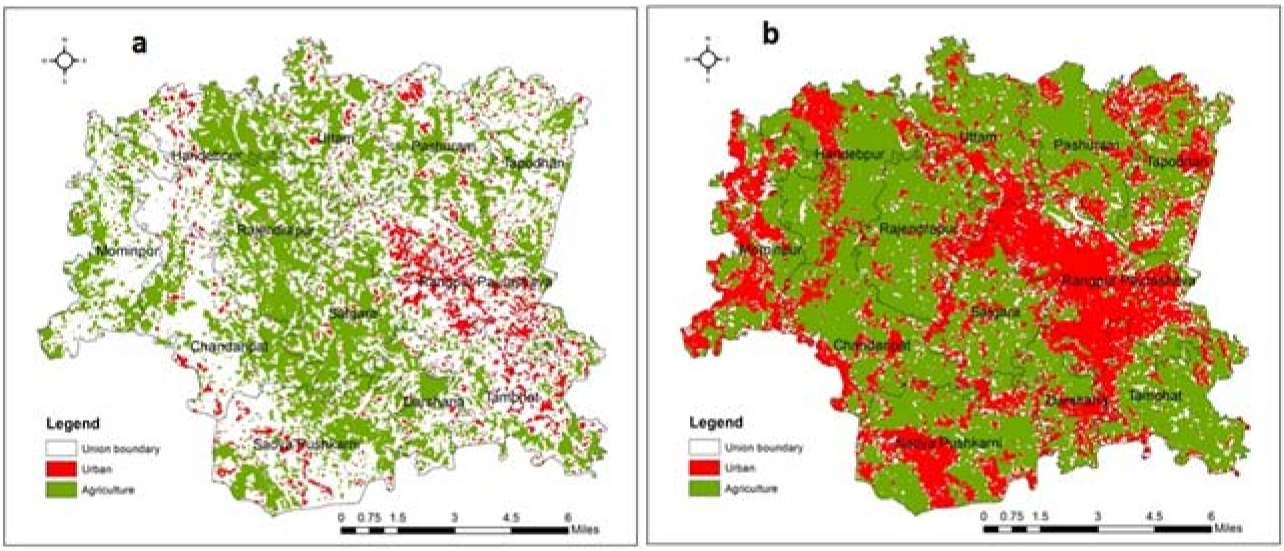

Figure 2: Spatial distribution of urban (red color) and agriculture (green color) in 1989 (a) and 2014 (b).

5. Methodology

5.1 Satellite Data Analysis

ENVI (Environment for Visualizing Images) and ArcGIS were used to carry out all image processing tasks in the study. Pre-processing of satellite data includes many intermediate steps such as image importing, sub-setting, conversion to radiance, conversion to reflectance etc [12]. To estimate urban and agriculture areas, NDVI (Normalized Difference Vegetation Index) has been used in the study using RED and NIR images (Figure 2). On the other hand, land surface temperatures from the both years were calculated using some empirical calculations in the study.

5.2 NDVI for Urban and Agriculture

NDVI is a useful algorithm for classifying vegetative and non-vegetative areas. It is one of the most widely used vegetation indexes [13]. Both NDVI images were used to delineate urban and agriculture. NDVI is a non-linear function which ranges

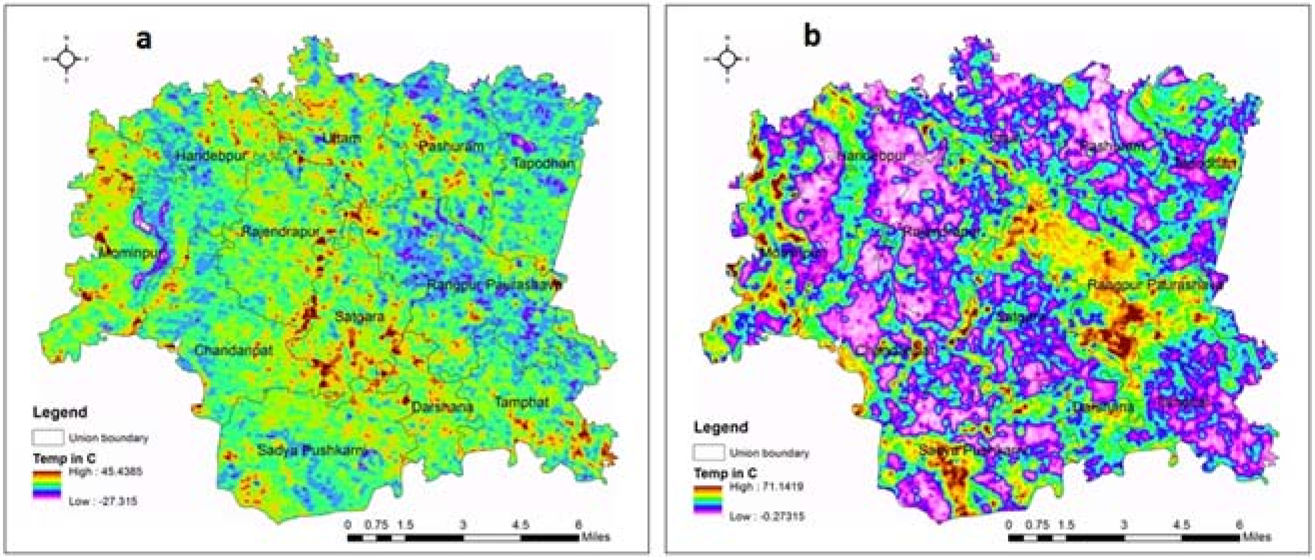

Figure 3: Urban land surface temperature in the study area in 1989 (a) and 2014 (b).

between -1 to +1 where water, rocks, and bare soils are indicated by values in -1 range and the vigor of vegetation is indicated by values near to +1 [14]. The following equation (1) is used to calculate open water and winter crops in the study:

[NDVI = (NIR – RED) / (NIR + RED)]………………… (1)

In this study, NDVI ranges between -0.8 to -0.1 and -0.7 and -0.2 were extracted as urban areas in 1989 and 2014 respectively. As NDVI image characteristics, vegetation features observed in very high digital number, mainly close to +1. After physical and secondary data validation, we decided NDVI value ranges from 0.5 to 0.8 and 0.5 to 0.9 are vegetation in 1989 and 2014 respectively (figure 2). Finally, we used decision tree classifier to urban and agriculture from the both NDVI images by generating some spectral rules.

5.3 Land Surface Temperature (LST)

Several steps were followed to calculate urban land temperature using the both thermal imageries of Landsat. The following steps (a,b,c) were:

a. Convert the thermal digital number to spectral radiance. The universal equation (2) of this conversion is:

$L_\lambda = L_{MIN} + (L_{MAX} - L_{MIN}) * DN / 255$.................(2)

Where,

L = Spectral radiance

L_{MIN} = 1.238 (Spectral radiance of DN value 1)

L_{MAX} = 15.600 (Spectral radiance of DN value 255)

DN = Digital Number

b. Convert the spectral radiance of the thermal imageries to temperature in kelvin using the equation (3) below:

$T_b = K_2 / \ln \{(K_1 / L_\lambda) + 1\}$ ……………………(3)

Where,

K_1 = Calibration Constant 1 (607.76)

K_2 = Calibration Constant 2 (1260.56)

T_b = Surface Temperature

c. Finally conversion from kelvin to Celsius using the equation (4) below:

$T_b = T_b - 273$ ……………………………… (4)

After completing these steps, two land surface temperatures (LST) in Celsius were created and subtracted 1989 image by 2014 in order to delve the spatial distribution of urban temperature in different places in the study area.

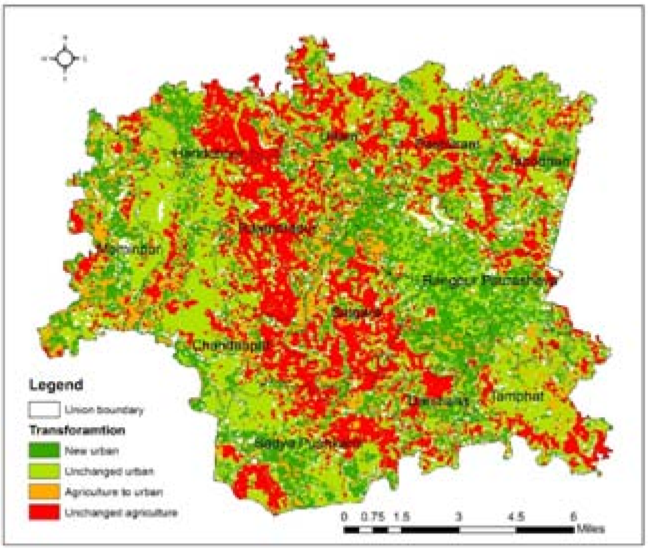

Figure 4: Change detection map of urban and agriculture from 1989 to 2014

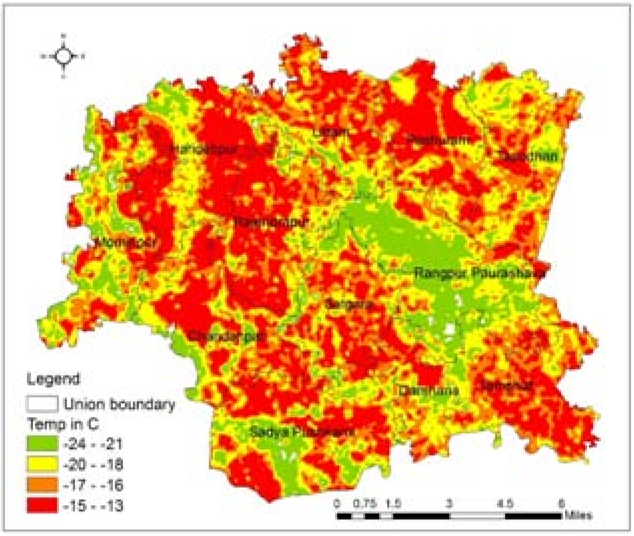

Figure 5: Difference of land surface temperature from 1989 to 2014.

Table 2: Change detection results of urban and agriculture classes

Feature	1989 (Ha)	% of total area	2014 (Ha)	% of total area	Overall Change	Growth Rate %
Agriculture	18168	54	11414	34	6754	3
Urban	2073	6	10540	31	-8467	20

Table 3 : The original LST of 1989 and 2014

Statistics	1989	2014
Min	-27.31	-0.27
Max	45.43	71.14
Mean	19	40.10
St.dev	33.38	29.56

5.4 Change Detection Analysis

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times [14] [15]. In this study paper, change detection statistics is used to calculate changes of these two classified images and their areas (Figure 3). Change detection analyses describes and quantify differences between images of the same scene at different times [16]. Figure 4 shows a status of four entities of new urban, unchanged urban, agriculture to urban and unchanged agriculture areas. Moreover, land temperature image of 1989 was subtracted by the 2014 image in order to find out spatial distribution of increased temperature zones. The minus figure means increased temperature between 25 years (Figure 5).

6. Results and Discussion

From the both NDVI images, about 20% annual growth rate was found in urban class while agriculture was 3% in the study area (Table 2). There is a huge urbanization process from 1989 to 2014. The main driving forces of this urbanization expansion are mainly due to migration from the nearest districts and becoming an important administrative city in the northern Bangladesh.

Land surface temperature shows an evidence for expansion of urban or city. From our LST analysis, it is indicated that about 15^0 to 25^0C has been increased from 1989 to 2014. Most of the increased temperature zones were found in Rangpur *sadar* (Cantonment area), Dharshana, Satgara, Mominpur, Uttam Sadya Pushkarni area. We assumed that if there is any LST difference, urbanization process is exist. Table 3 shows increase trend of mean temperature in the study area as well.

Increase trend of population is one of the main reasons for expanding urban areas. In this study paper, we calculate a regression analysis between population data and extracted urban areas (Figure 6). This analysis shows a strong positive correlation between population and urbanization. It means along with other process, population has been playing a triggering factor for expanding the urban area in the study area.

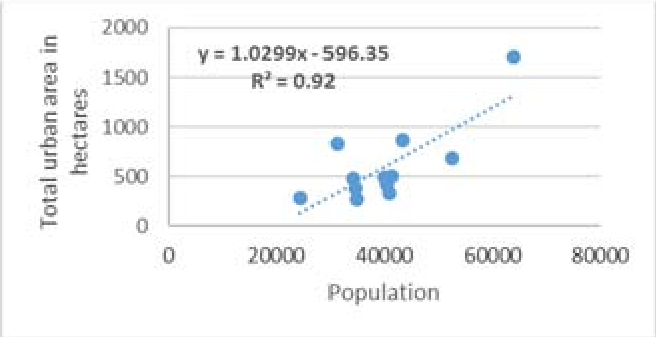

Figure 6: Regression between population and increased urban areas.

An accuracy assessment was done using the classified images and training sets. In this analysis, we found the overall accuracy for urban and agriculture was 92% and 95% in 1989 and 2014 respectively.

7. Conclusion

Landsat visible, near infrared, middle infrared and thermal imageries have been shown a useful data for extracting urban, agriculture and land surface temperature information. In this analysis, urban area has a 20% annual growth rate over the 25 years, which is a matter of proper urban planning issue. The further study should be integrated multi-sources data that can enhance the outputs of the study.

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