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.

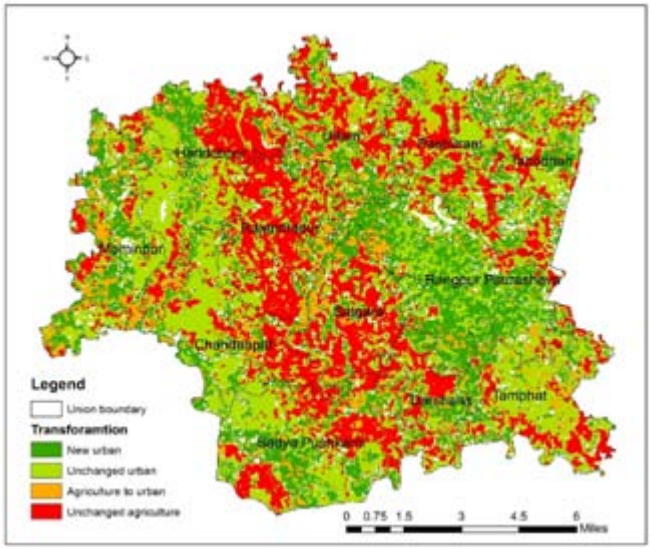

Figure 4: Change detection map of urban and agriculture from 1989 to 2014

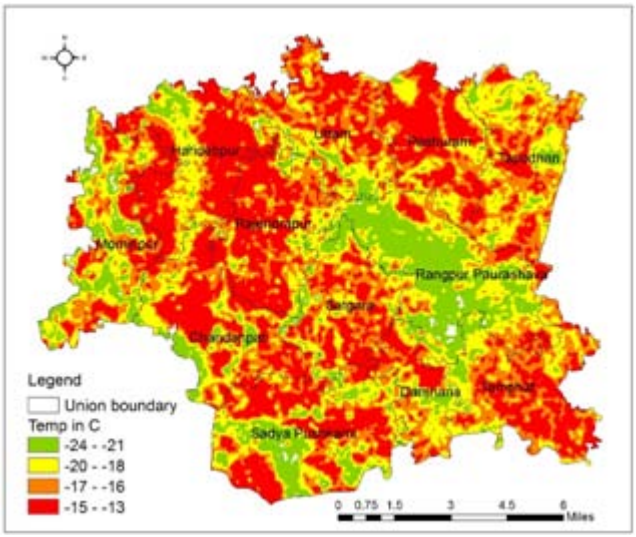

Figure 5: Difference of land surface temperature from 1989 to 2014.

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.

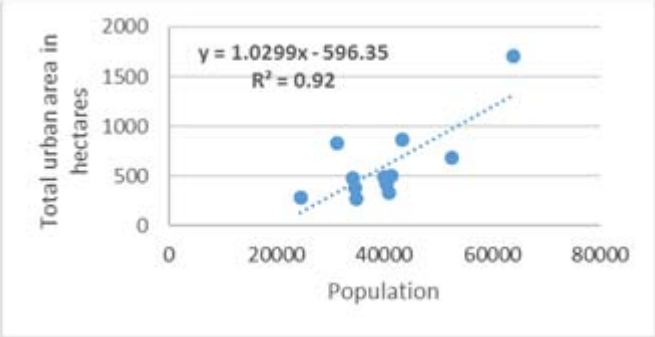

Figure 6: Regression between population and increased urban areas.

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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