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INFLUENCE OF LAND COVER CHANGE ON LAND SURFACE TEMPERATURE USING RS AND GIS TECHNIQUES: A CASE STUDY OF GAZIPUR DISTRICT

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Abstract
Climate change has obtained more and more attention as the land surface temperature is getting high day by day. It's being done as people are being attracted to live in urban area and this rate is increasing at an alarming rate. Gazipur which is situated beside Dhaka is one of the area which is experiencing rapid urbanization which is the main cause of urban heat island, decreasing of waterbody which will surely make a serious influence on regional climate, environment. This study represents integrated study of land cover changes between the periods and investigated their impacts on LST of Gazipur district by using Geographic Information System (GIS) and Remote Sensing (RS). In this study, remote sensing techniques were used to retrieve the land surface temperature (LST) and land cover change by using the Landsat Satellite imagery product. Landsat TM and ETM+ images from 1995 to 2015 are used as data source. The integration of remote sensing and GIS was further applied to examine the impact of land cover change on surface temperatures. Strong relationship is found between land surface temperatures over land cover classes. The result shows that waterbody is being decreased from 1206 Sq.km to 74 Sq.km. Result is same for vegetation land cover which also have decreased at an alarming rate. These areas are being converted into built-up an area which is increasing temperature. Over 10 years' temperature is changed from 26°C to 30°C. The results indicate that land surface temperature can be related to land cover classes in most cases. Vegetated and other natural areas enjoy lower surface temperature, than build up areas with little vegetation.

Keywords: Land surface temperature; land cover; change detection; urban heat island; climate change.

INTRODUCTION

Land is one of the most important resource from the first day human stepped on earth. With the passage of time land is being transformed from one type to another which is an extremely complex process, it is subject to the combined effect of a wide range of human activities, natural environment and economic environment and so on, all of that react on humans (Jianzhong et al., 2002; Station & Province, 2004). Urbanization is highly responsible to transform natural land surfaces into modern land which is consist of buildings, roads, and other impervious surfaces that affect the inhabitability of urban areas. This land use land cover changes leads to Urban Heat Island (UHI)(He et al. 2007) which causes temperature rise even 5-6°C surrounding the urban areas. UHI is defined as an environmental phenomenon where air and Land Surface Temperatures (LST) of urban areas are higher than those of its surrounding areas (Trenberth 2004). There are multiple factors which are responsible for the generation of UHI. Land cover change due to urbanization is the main driver for causing change in the LST because the quality, characteristics of each land type is different (Ahmed et al. , 2013). However, this absorbed solar energy is re-radiated at night in the form of thermal

infrared (Patz et al. 2005). Because of this, in a day, LST of a land cover type varies. In addition, this cross-sectional relationship between land cover types and LST also enabled researchers to investigate the impact of land cover changes on LST over time (Lo and Quattrochi 2003). This study has been intensified because of the availability of remotely sensed database and it focused on the past land cover change (Patz et al. 2005).

The aim of this study is to monitor and analyze the influence of land cover change on land surface temperature in Gazipur district using RS and GIS techniques for the years of 1995 to 2015.

METHODOLOGY

The study area, Gazipur district of Bangladesh [Fig. 1] has been selected because migration of huge population is seen as because; it is very near to Dhaka capital city. It carries a good number of site for urban development center. As a result of population pressure and unplanned development, the local people are destroying forest, trees and valuable cultivable land for making various industries and brick fields etc. As a result, the forest area is gradually decreasing and the environment is changing significantly.

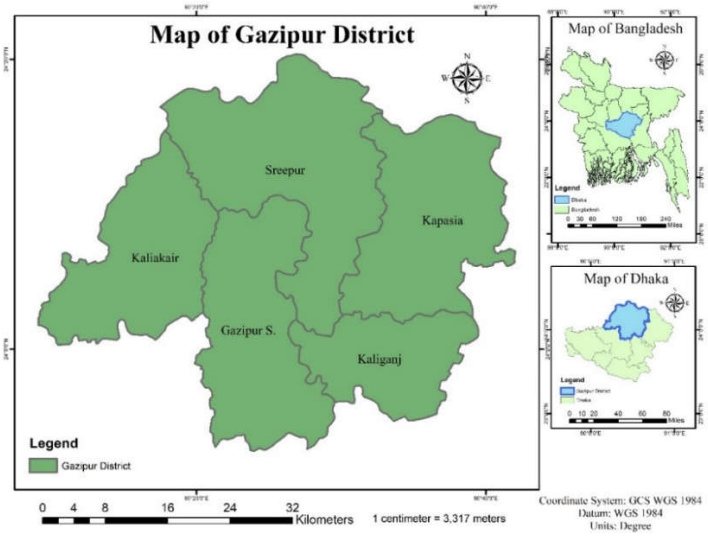

Fig. 1. Map of Study Area Location

For the study a consecutive methodology has been adopted. The estimation of impact of temperature on the land use has been done in several stages. For carrying the study TM and OLI TRS data of Landsat satellite imagery data is collected of three different years which is 1995, 2006 and 2015 and these data are taken of March-April month so that temperature of summer can be easily estimated. The cloud cover of all these data is less than 2%. After this the data is prepared for the analysis. The supervised classification used to determine the land use pattern of the study area. After supervised classification a conduction of accuracy assessment is done to assess the accuracy of the classification. Change detection is a process which has been done to estimate the change of land use in a time period such as a period of 5 years or 10 years. It actually determines what changes in land use the area undergo in a specific time period. After supervised classification this compared the resulting maps on a pixel-by-pixel basis using a change detection matrix to estimate the land use change of the study area in ten years 2000-2015.The one of the most important stage of the study to estimate the temperature from the prepared satellite image. This process is done into two steps. The first step is to convert the thermal band into radiance. Then the radiance is converted into temperature in Kelvin unit. Then temperature is again converted Kelvin to Degree Celsius. For Landsat TM image digital numbers DNs of thermal band (band 6) of were converted into radiance using the following Eq. (1)

$$T_{TM6} = \frac{V}{255}(R_{MAX} - R_{MIN}) + R_{MIN} \quad (1)$$

Where V represents the DN of band 6 and

$$R_{Max} = 1.898(\text{mW} * cm^{-2} * \text{sr}^{-1}), \text{R}_{\text{MIN}} = 0.1534(\text{mW} * cm^{-2} * \text{sr}^{-1})$$

And the second step, conversion of radiance into temperature in Kelvin T(K) was done by the following Eq. (2)

$$T = \frac{K_1}{\ln(\frac{K_2}{\frac{R_{TM6}}{b}}+1)} \quad (2)$$

Where, K_1=1260.56K and K_2= $607.66(\text{mW} * \text{cm}^{-2} * \text{sr}^{-1} * \mu\text{m}^{-1})$, b represents the effective spectral range and b=1.239(μm)

For Landsat OLI_TRS, at first, OLI and TRS band data can be converted to TOA using the following Eq. (3)

$$L_\lambda = M_L W Q_{cal} + A_L \quad (3)$$

Where,

L= TOA spectral radiance $(\text{Watts}/\text{m}^2 * \text{srad} * \mu\text{m})$, M_L= Band specific multiplicative rescaling factor from the metadata, A_L= Band specific z rescaling factor from the metadata. Q_{cal}= Quantized and calibrated standard product pixel values (DN)

For converting spectral radiance to temperature following Eq. (3) is used

$$T = \frac{K_2}{\ln(\frac{K_1}{L_\lambda}+1)} \quad (4)$$

Where

T= At satellite brightness temperature (K), L_λ= TOA spectral radiance $(\text{Watts}/\text{m}^2 * \text{srad} * \mu\text{m})$, K_1= Band-specific thermal conversion constant from the metadata (K_1_CONSTANT_BAND_x, where x is the band number, 10 or 11) , K_2= Band-specific thermal conversion constant from the metadata (K_1_CONSTANT_BAND_x, where x is the band number, 10 or 11)

Temperature are derived in 'Kelvin (A)' which were converted into 'Degree Celsius (B)' using the following equation

$$B = A - 273.15 \quad (5)$$

The final stage of the study is the estimation of relationship between the land temperature impacts on the land use change.

RESULT AND DISCUSSION

From reclassified map of Gazipur for the year 1995 it can be said that the dominant land use of that time was vegetation. Almost more than half of the total area is covered by vegetation and water body. The other land use was open space and a very few portion of the area was build up area. From the land surface map of Gazipur for the same year, also this can be said that in the portion of the area which contains waterbody and vegetation has the lowest land surface temperature than other areas and the lowest land surface temperature at that time for Gazipur was between 22.08°C -23.82°C. The highest land temperature at that time was between 25.54°C -30.56°C which was the land used for buildup area and open space.

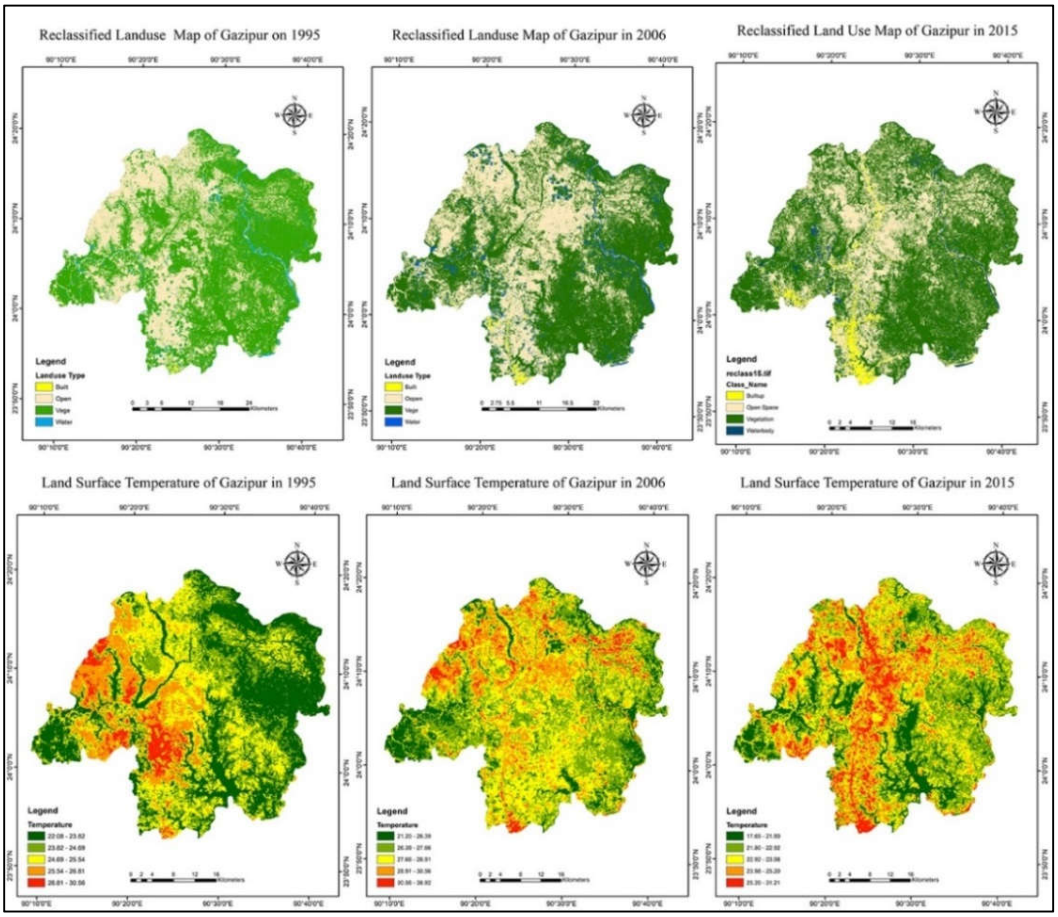

Fig. 2. Land use land cover and Land Surface temperature map of Gazipur from 1995 to 2015

In 2006 reclassified land use map of Gazipur it is clearly evident that most the land of Gazipur at that time was vegetation which was most prominent land use at the year 2006. The other land use type which was dominating at that time was open space. The least land use of that year was waterbody and buildup area which was in a very insignificant portion of the whole area. The land surface map of Gazipur for the same year that means 2006 indicates that the dominant temperature of the most of the land of that time was moderate which was between 27.60°C -30.56°C and it was mainly temperature of those area which has less dense vegetation and mostly open space. The lowest temperature was between 21.20°C -27.60°C which is the temperature of area with dense vegetation and waterbody. The highest temperature contained land use at that time was some open space and buildup area which ranges 30.57°C -38.92°C.

From the land surface map of Gazipur for the year 2015 it can be said that in the portion of the area which contains waterbody and vegetation has the lowest land surface temperature than other areas and the dominant temperature of the of that year was low to moderate temperature which was between 17.65°C - 23.98°C. The highest land temperature at that time was between 23.98°C -31.21°C which was the land used for buildup area and open space. [Fig. 3] represented the percentage of land use and land cover change in different years in Gazipur. From the figure it can be said that there is an increase of vegetation in this period of time. vegetation increased in 2015 in 14.9% than 1995. A huge decrease in the waterbody in this time period where in 1995 there is 42.45% waterbody which reduce to 3.59% in 2015. There is also reduction in open space though it increases in 2006. A very small increase of buildup area in this time period.

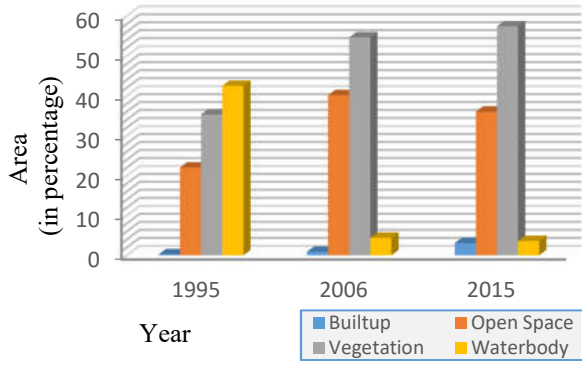

Fig. 3. Percentage of different LULC type

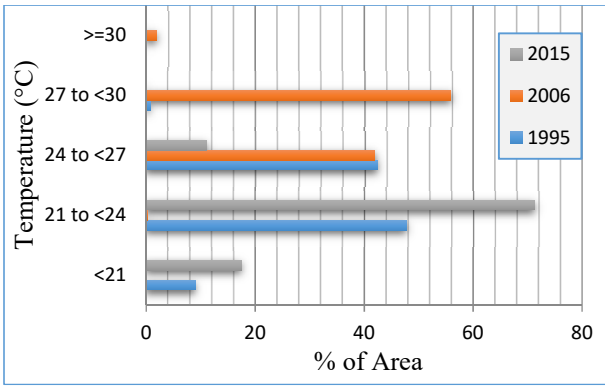

Fig. 4. Changing pattern of heat zone in Gazipur

[Fig. 4] shows the changing of heat pattern zone in Gazipur. From the figure it can be assumed that in the year 1995 temperature of most of the area was remain between 21-27 degree Celsius. In 2006 the land surface temperature of most of the area was between 24-30 degree Celsius. In 2015 the land surface temperature of most of the area was between 21-24 degree Celsius.

The land use change map and Table 1 showing the total area of change land use of Gazipur in between 2006-2015 that means land use change for a time period of 10 years. In this time period the most prominent land use change in this period is vegetation to open space which is about 780702 square km of the area**.** The dominating land use change is vegetation to buildup area which covered almost 261528 square km area and open space to vegetation which is about 202262 square km.

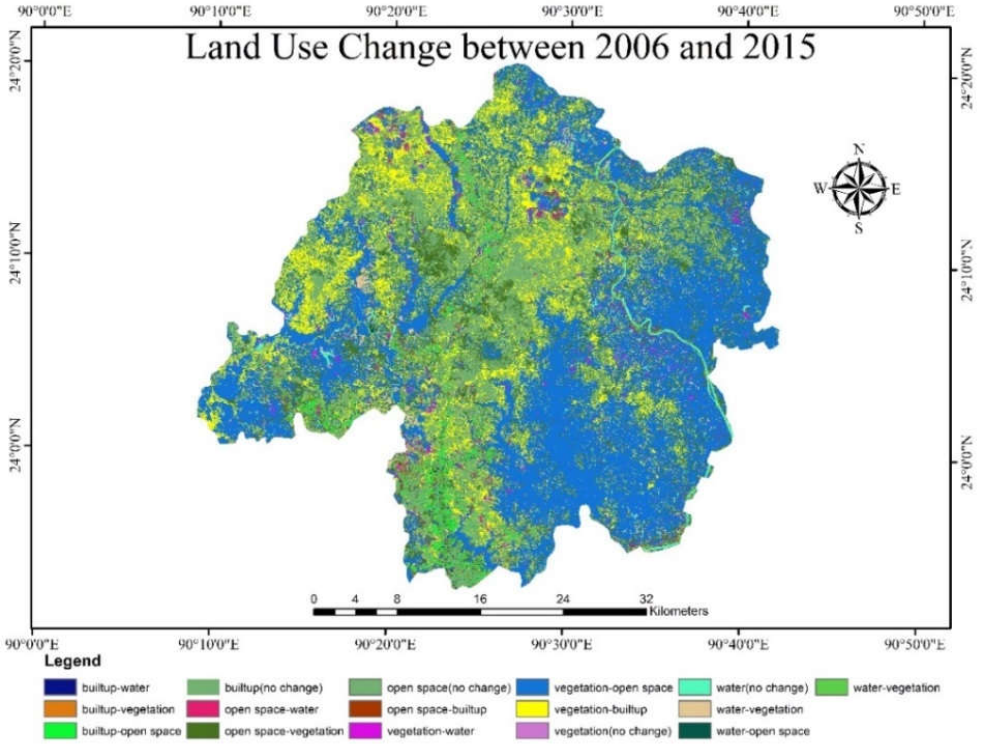

Table 1: Area of changed land use from 2006 to 2015

Land Use Change	Area (sq.km.)	Land Use Change	Area (sq.km.)	Land Use Change	Area (sq.km.)	Land Use Change	Area (sq.km.)
Built-up-Water body	3507	Open Space-Water body	15726	Vegetation-Water	29576	Water body (no change)	33405
Built-up-Vegetation	8423	**Open Space-Vegetation**	**205562**	**Vegetation-Open Space**	**780702**	Water body-Built-un	26055
Built-up-Open space	33102	**Open Space (no change)**	**447787**	**Vegetation-Built-up**	**261528**	Water body-Open Space	7319
Built-up(no change)	12698	Open Space-Built-up	3384	Vegetation (no change)	445	Water body-Vegetation	296

CONCLUSIONS

Gazipur is facing rapid land use change due to rapid urbanization. The main aims of this study is to reorganization of land use change in Gazipur city in the time period between 1995-2015 and also impact of land use change on the change of land surface temperature. From the study it is found that there is a change in land use pattern in this time period. Buildup area is increasing rapidly in Gazipur than earlier time. There is a decrease in the waterbody and vegetation in this time period. Waterbody is being decreased from 1206 Sq.km to 74 Sq.km. The situation is same for vegetation land cover which also have decreased at an alarming rate. Waterbody is greatly replaced by the buildup area. Also vegetated land is converted in the open space. As the land use of the area is changing rapidly it is affecting the land surface temperature of the area. Due to change of land use land surface temperature also increasing as the outcome of land use change. Over 10 years' temperature is changed from 26°C to 30°C. The land uses which were converted into buildup or open space are experiencing high temperature than earlier years. It indicates that there is relationship between land surface temperature and land cover changes. Vegetated and other natural areas enjoy lower surface temperature, than build up or open space areas with little vegetation.

REFERENCES

Ahmed, Bayes, Xuan Zhu, Shahinoor Rahman, and Keechoo Choi. 2013. "Simulating Land Cover Changes and Their Impacts on Land Surface Temperature in Dhaka, Bangladesh." : 5969–98.

He, J. F. et al. 2007. "Assessing the Effect of Land Use/land Cover Change on the Change of Urban Heat Island Intensity." *Theoretical and Applied Climatology* 90(3–4): 217–26.

Jianzhong, Yan, Zhang Yili, Liu Linshan, and Liu Yanhua. 2002. "Land Use and Landscape Pattern Change: A Linkage to the Construction of the Qinghai-Xizang Highway." *Journal of Geographical Sciences* 12(3): 253–65.

Lo, C P, and D A Quattrochi. 2003. "Land-Use and Land-Cover Change, Urban Heat Island Phenomenon, and Health Implications: A Remote Sensing Approach." *Photogrammetric Engineering and Remote Sensing* 69(9): 1053–63.

Station, Experimental, and Fujian Province. 2004. "Effects of Grassland Amelioration on Terrestrial Ecosystem Nutrients : A Case Study in Jianou Niukenglong Grassland Ecosystem Experimental Station , Fujian Province." 3(31105170): 313–22.

Trenberth, K.E. Climatology (communication arising): Rural land-use change and climate. Nature 2004, 427, 213