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LAND USE LAND COVER CHANGE AND ITS RELATIONSHIP WITH LAND SURFACE TEMPERATURE IN SUNAMGANJ SADAR

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ABSTRACT

The urban areas of Sunamganj Sadar are growing rapidly as to meet the necessity for residential and institutional purposes for increasing population. This incident is accelerating the process of clearing the vegetated areas and reducing the agricultural lands which is the prime source for driving this area's economy. The purpose of this study is to analyze the change in land use land cover (LULC) and to determine the relationship of estimated land surface temperature (LST) with normalized difference vegetation index (NDVI), normalized difference built-up index (NDBI) in the study area. Remote sensing and geographical information system (GIS) techniques were used to create LULC, NDVI, NDBI maps. Landsat 7 (ETM+) and Landsat 8 (OLI_TIRS) images were used for 2000 and 2020 respectively. Results obtained have revealed that there is significant decrease in forest area. On the other hand, area covered by water body and fallow land has shoot up remarkably. Results also showed that the maximum LST of winter season for the study area increased by 9.99 ℃ and minimum temperature increased by 8.94 ℃ over 21 years. From the analysis of linear regression analysis, it was found that LST tends to correlate positively with NDBI in both 2000 (R^2 = 0.6679) and 2020 (R^2 = 0.5156) year. Negative trend has been observed in relationship of LST with NDVI throughout the study except relation between LST and NDVI (R^2 = 0.0034) in the year of 2020 which is very insignificant. Since the LULC pattern is changing with

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the passage of time and strong relationship has been found between LST and other indices, proper planning and execution is a must to arrest the rising temperature and to start new urbanism.

Keywords: Remote Sensing, GIS, Land Use, Land Cover, Climate Change

1. INTRODUCTION

Land is a natural resource that influences the lifestyle of people from different walks of life. It sings the song of life more precisely (Das, 2015). So, the land usage should be more precise. Land cover is the physical cover observed on the Earth's surface. Land use refers to its function (Duhamel, 2012). Land use and land cover are the fundamental component of earth's climate, ecology, and human society (Ganasri et al., 2013). Rapid urbanization tends to decrease green areas into cities as well as quality of water is deteriorating day by day (Rahman et al., 2021). The changes in land use land cover refers to loss of agricultural lands, loss of forest lands, increase of barren area and increase of impermeable surface of the area because of the built-up area (Rahman et al, 2012). Natural calamities and human activities effects land use land cover changes. Decrease in vegetation cover by human activities causes change in terrestrial ecosystem (Kazemzadeh et al., 2021). Bangladesh being a country of rapidly increasing population, the land use for households is increasing and agricultural land is decreasing. The arable land for Bangladesh was 0.06 ha per person in 2014 and 0.049 ha per person in 2016 (World Bank collection of development indicators). This clear declination of agricultural land and other changes in land usage is becoming a major issue for economy, climate and ecology from local to global scale (Rai et al., 2017). By using remote sensing techniques, documenting LULC systematically over past several decades and analyzing the change is important for understanding the consequences of these changes for human welfare (Lepers et al., 2005). Al-khaqani (2018) studied change detection in land cover for selected area from the province of Najaf for the period from (2001-2006) by remote sensing data using (NDVI), (NDBI) and (NDWI) indexes. Liu, et. al. (2018) used spectral and NDVI values to calculate the change magnitudes of land cover. NDWI is an indicator of moisture content in vegetation (Chen et al., 2016). It is used to monitor changes in water content of leaves, using near-infrared (NIR) and short-wave infrared (SWIR) wavelengths. MIR band is used instead of near-infrared (NIR) in case of calculating MNDWI. Chen et al. (2006) used NDVI, NDBI, NDBaI and NDWI to examine the relationship of LST with LULC changes.

The increasing surface temperature in urban areas due to conversion of vegetated surfaces to impervious surfaces (Mallick et al., 2008) and transformation of vegetated and wetland into agricultural land or bare waste land (Pal and Akoma, 2009) is the most imperative problem in the earth. So, it is a very important factor of environment and climate. Different study reviewed (Mahdy et al., 2024) and uses (Mahdy et al., 2024) downscaling techniques to predict surface air temperature while Momeni and Saradjian (2007), studied surface emissivity estimation as a

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significant factor for the land surface temperature estimation from remotely sensed data. Rasul (2020) assessed spatial relationship between LST and remote sensing LULC indices at the global and continental scale. Fathima (2018) found out land surface temperature is influenced by various factors like precipitation and albedo, which differs from normal atmospheric temperature. At spatial level, land surface temperature plays an important role in depicting the temperature of the area.

Many researchers have investigated the relationship between LST and NDVI. Relationships were found different in different location and climate. Bajaj et al. (2012) and Liang et al. (2009) strong linear inverse relationship. Sumida et al. (2018) found weak positive relationship between LST and NDVI whereas Zhang et al. (2008) found no relationship between them. Many investigations have revealed that the land surface temperature increases with the increasing temperature (Amiri et al., 2009; Baker et al., 2002). Exceptions have also been observed in arid and semi-arid regions. Rasul et al. (2016) found decrease in temperature with increasing build-ups during daytime. Remote-sensing techniques were found to be efficient, especially in reducing the time for analysis of urban expansion and are useful tools to evaluate the impact of urbanization on LST. Anbazhagan and Paramasivam (2016) shows remote sensing TIR as a part of the electromagnetic spectrum as one of the best observations of Land surface temperature (LST).

Most of the studies have been carried out using NDVI ranges for LULC classification. This study also aims at classifying LULC using NDVI ranges from Landsat 7 (for 2000) and Landsat 8 (for 2020) data. Whole study along calculation of different indices was done using Geographical Information System and remote sensing techniques. The specific objective of this research is to study land use land cover changes in Sunamgonj Sadar Upazilla, Sylhet and to examine the relationship between LST with NDVI and NDBI values.

2. MATERIALS AND METHOD

2.1 Study Area

Sunamganj Sadar Upazila is an Upazila of Sunamganj district, sited at 25°04'N 91°24'E geographically. It is situated in the northeastern part of Bangladesh. Being a haor basin area, the main source of income is from agriculture (62.06 %), non-agricultural laborers 6.45 %, industry 0.85 %, commerce 10.96 %, transport and communication 1.65 %, service 5.01 %, construction 0.69 %, religious service 0.42 %, rent and remittance 2.08 % and others 9.83 %. The climate of this area is a tropical monsoon climate. August is the warmest month of the year and the average temperature in August is 28.4 °C. The lowest average temperatures in the year are observed in January and it is around 18.4 °C. The driest month is December with 6 mm of rainfall on average and the greatest amount of precipitation occurs in June with an average of 712 mm (https://en.climate-data.org).

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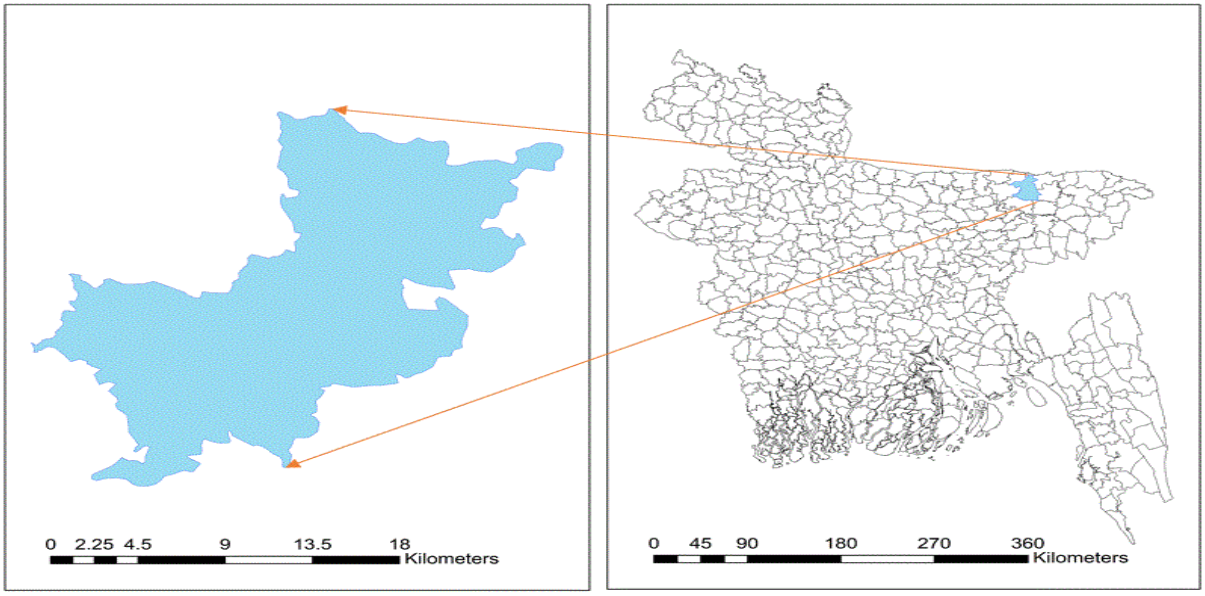

Figure 1: Geographical location of the study area.

2.2 Software Used

Following software's are used in the present work

1. ArcGIS 10.5
2. Google Maps
3. Google Earth Pro
4. Microsoft Office 2016
5. Microsoft Excel 2016

Arc GIS software was used to complement the display and processing of the satellite data. Google Maps was used for plotting the x-y coordination of different points on the boundary line of Jamalgonj Upazila. Google Earth Pro was used in the study to select the study area according to the plotted boundary points. Microsoft Office 2016 was used for the purpose of writing the thesis paper. Microsoft Excel 2016 was used for the analysis of obtained data from Satellite data.

2.3 Methodology

The following flow chart indicating the working procedure followed within the study.

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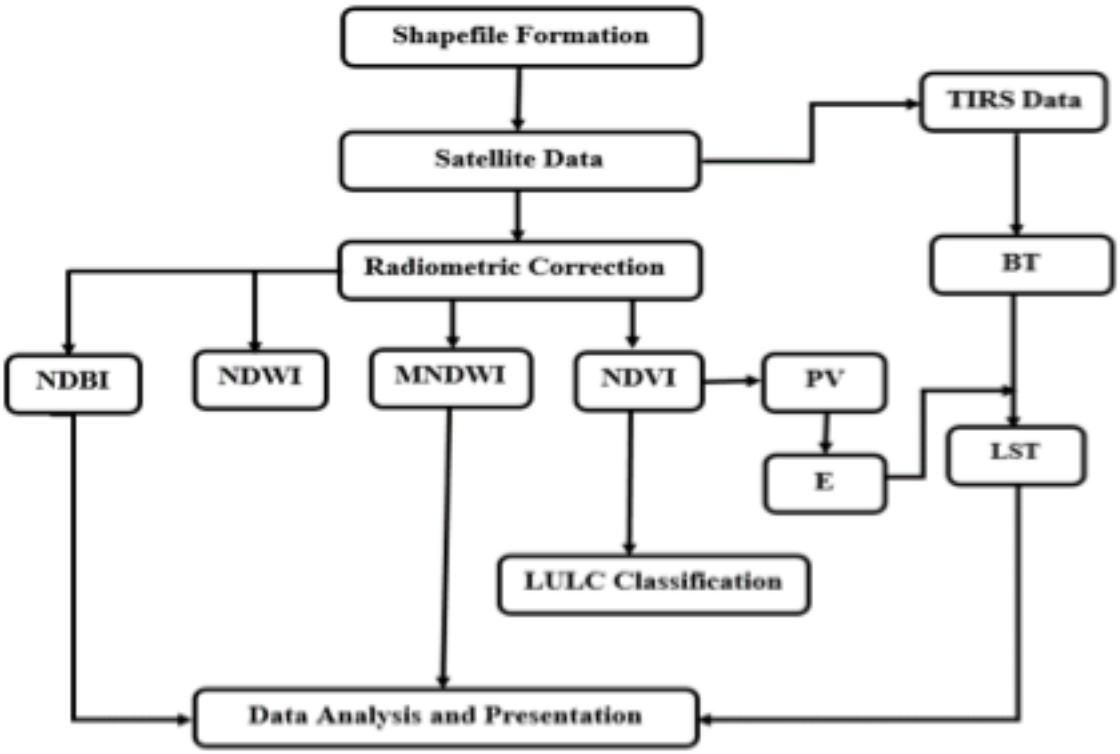

Figure 2: Operational procedure of present research

2.4 Formation of Shapefile

In this research, Shapefile was prepared through a long process, because Esri provided Upazila Shapefile, which does not represent the actual area of the study location. Esri provided Upazila Shapefile of Sunamganj Sadar covers an area of 445 sq. km, but the actual area of Sunamganj Sadar Upazila is 276 sq. km. The steps include as follows,

1. Collection of spatial value
2. Collection of the spatial values in MS Excel
3. Opening the resultant file with ArcGIS
4. Exportation of data as Shapefile
5. Opening the Google Earth Pro
6. Saving the polygon
7. Exportation of Final Shapefile

2.5 Data Collection

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In estimating land use land cover changes, land surface temperature (LST) and different index values of the Sunamganj Sadar Upazilla adopted the Landsat satellite images (Landsat ETM+ and OLI_TIRS). From 2000 to 2020, a range of satellite images of Landsat data chosen for this study was highlighted in Table 1.

The chosen images have to conform to the following set of criteria (Tan, San Lim, Mat Jafri, & Abdullah, 2010); (1) satellite images of cloud coverage should be <10 % or cloud-free in the study area and (2) the availability of selected satellite images should be in long time series for at least 5 years and above between two imageries to maximize the separability and differentiate their different land-use classes. For this study, only the imageries data that have complied with both criteria will be chosen for use. Landsat 7 and Landsat 8 OLI thermal infrared data with 120 and 100 cm special resolution respectively were used for local scale studies (Guha et al., 2018).

Table 1: Specification of the Landsat Image Used

Acquisition Date (dd/mm/year)	Landsat No	Type of Sensor	Cloud Coverage (%)
27/02/1990	7	ETM^{+}	0.00
11/02/2020	8	OLI_TIRS	0.08

2.6 Radiometric Correction

A sensor records the intensity of the electromagnetic radiation for each pixel as a digital number (DN). These digital numbers can be converted to more meaningful real-world units like radiance, reflectance or brightness temperature. Sensor specific information is needed to carry out this calibration. In the case of Landsat data, the metadata file contains this information. Most image processing software packages have radiometric calibration tools. The process of radiometric correction of Landsat 7 and Landsat 8 is different.

2.7 Derivatives for Calculating different indices

NDVI calculated for Landsat 7 & 8 using equation 1.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)} \quad (1)$$

NDBI calculated for Landsat 7 & 8 using equation 2.

$$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)} \quad (2)$$

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2.8 Calculation of Land Surface Temperature (LST)

Land Surface Temperature (LST) is calculated using the equation (3).

$$LST = \frac{BT}{1+\left(0.00115*\frac{BT}{1.4388}\right)*\ln(E)} \quad (3)$$

In this study, Land Use Land Cover is estimated on the basis of the NDVI index.

Table 2: Selected NDVI ranges of the study

Land-use Type	NDVI Range
Water Body	<0.101093265
Fallow Land	0.101093265~0.212020785
Grass Land	0.212020785~0.3242035
Ag. Land	0.3242035~0.5251349
Forest	>0.5251349

3. RESULTS AND DISCUSSION

3.1 Land use land Cover Change

To analyze the changes in temperature and land use changes in the study area, the NDVI, NDBI were used to correlate them with derived LST. These indices can be applied to categorize different types of land use by the suitable threshold value of NDBI, NDVI etc. (Zha et al., 2003). For example, NDVI > 0.2 and NDBI < 0 may be used together to extract vegetation. NDVI < 0 and NDBI < 0 may be used together to extract water bodies whereas 0 < NDVI < 0.2 and NDBI > 0.1 may be used together to extract built-up areas and bare land. (Chen et al., 2006). Using threshold values for classification may cause confusion because of atmospheric effect of the study area.

3.1.1 Land use land cover of 2000

The following table 4.1 shows the area covered and percentage of total area covered by different categories of land use in 2000.

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Table 3: Land use land cover of 2000

NO.	CATEGORIES	AREA (SQ. KM.)	AREA IN PERCENTAGE
1	Water Body	6	2.17
2	Fallow Land	11	3.98
3	Grass Land	57	20.65
4	Ag. Field	195	70.65
5	Forest	7	2.55
TOTAL		**276**	**100**

Water is the most important natural resources of any locality. Area covered by water body was found 6 sq. km. which is 2.17 % of the total area. Fallow land was found 11 sq. km. in 2020. It is 3.98 % of the total area and includes buildups, bare land, rocky areas and roads. As seen in table 3, grass land covered 20.65 % of the total area and it is 57 sq. km. in area. The area covered by agricultural land has been found highest and it is about 70.65 % of the total area. From the table 4.1, the total area of agricultural land in 2000 was 195 sq. km. Forest area has been found scattered all over the study area in 2000. The amount of forest area has been found 7 sq. km. which is almost 2.55 % of the total area.

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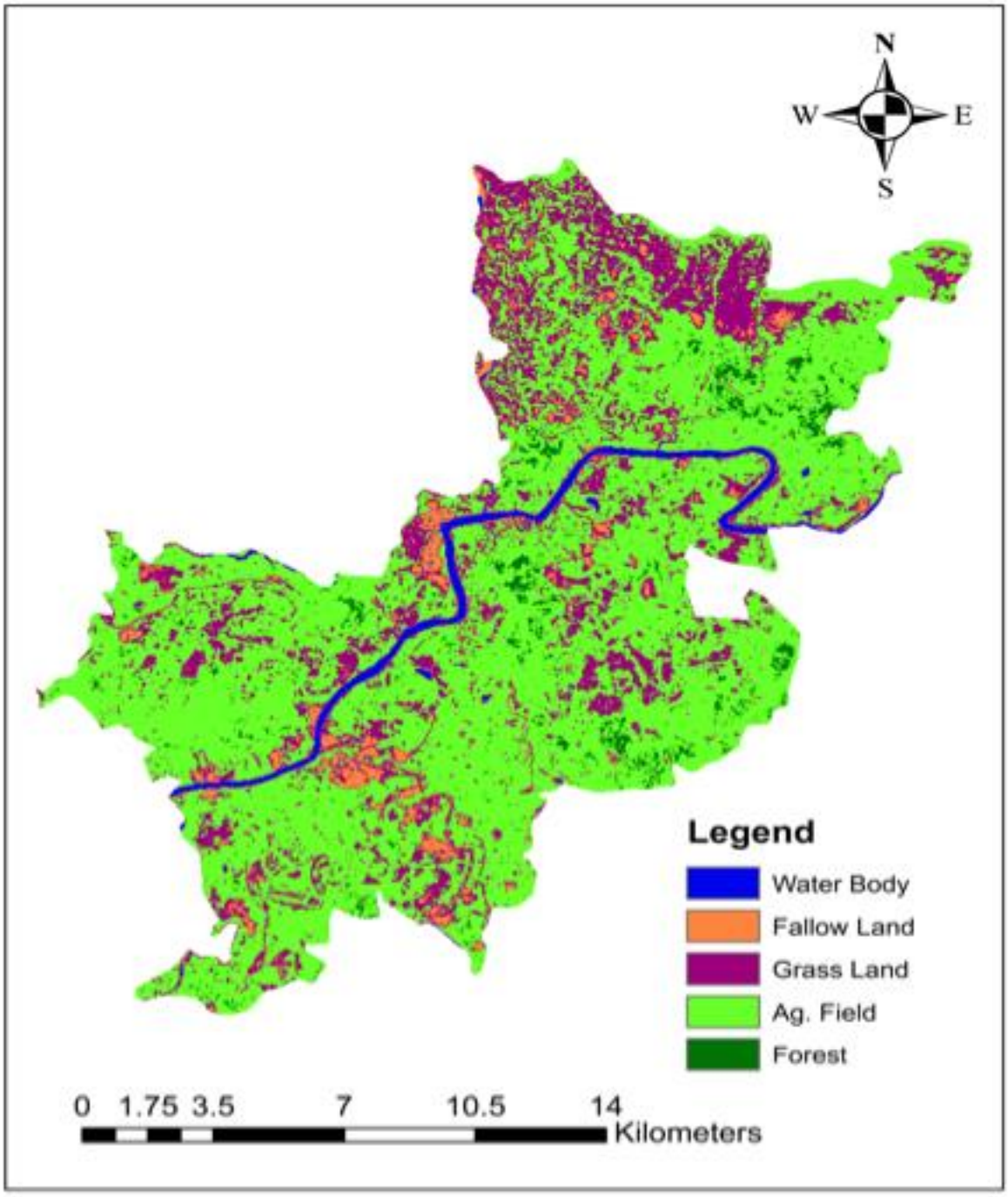

Figure 3: Land Use Land Cover Map of 2000

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3.1.2 Land use land cover of 2020

The following table 4 shows the area covered and percentage of total area covered by different categories of land use in 2020.

Table 4: Land use land cover of 2020

No.	Categories	Area (sq. Km.)	Area in percentage
1	Water Body	14	5.07
2	Fallow Land	32	11.59
3	Grass Land	88	31.88
4	Ag. Field	141	51.09
5	Forest	1	0.37
Total		**276**	**100**

Table 4 shows the results of land use land cover analysis of the study area in 2020. The area covered by water body was found 14 sq. km. and 5.07 % of the total area. Water bodies have been observed scattered throughout the study area. Fallow lands have been found 11.59 % of the total area and that is 32 sq. km. Water body and fallow land has been observed together in most of the places. The lands which are covered by small grasses only are categorized under the category grass land. Area found under this category was 88 sq. km. and 31.88 % of the total area. Agricultural land area has been found covered largest area of the study area in 2020. The area covered by agricultural land was 141 sq. km. and it is about 51.09 % of the total area. The area of forest was found lowest among all types of LULC. It is on the verge of extinction. Only 1 % of the total area is covered by forest. An area of 0.37 sq. km. was found covered by it.

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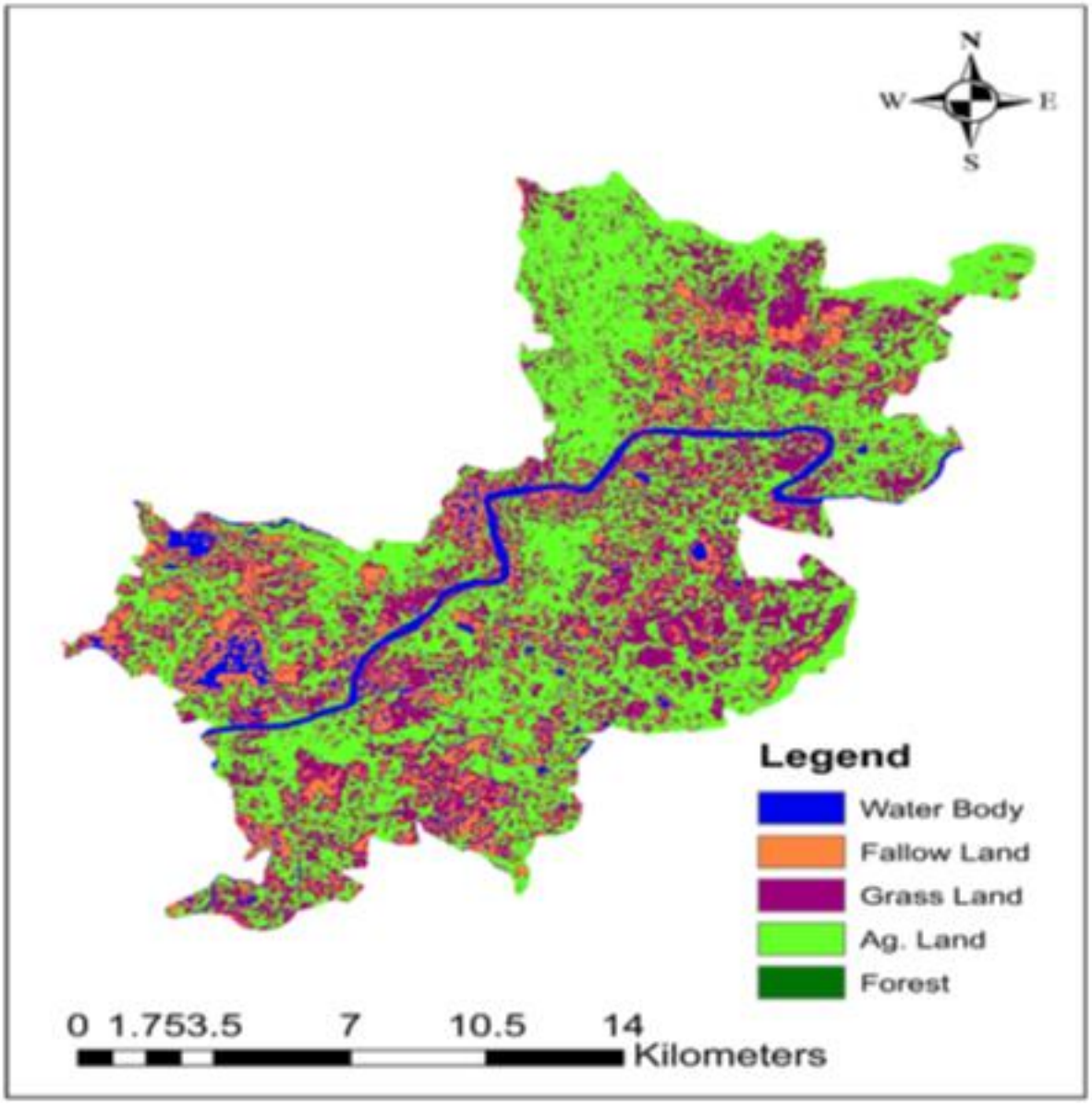

Figure 4: Land use land cover map of 2020

3.1.3 Change detection in land use land cover (2000-2020)

The figure 5 shows the changes in land use land cover from 2000 to 2020. It has been found that water body, fallow land and grass land has increased whereas the area covered by forest and agricultural land has decreased. Water body has increased from 6 sq. km. to 14 sq. km. which is almost 133 % of the year 2000. The area covered by category fallow land has increased significantly. It has increased by 21 sq. km. which is 191 % increment. The category grass land

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which includes bare lands and build-ups mostly has also increased by 54 %. Agricultural land has decreased from 195 sq. km. to 141 sq. km., and it shrank by 28 %. Land covered by forest has drastically changed. The amount of forest area was 7 sq. km., and it has been found 1 sq. km. in 2020. This change is almost 86 % and threatening for the environment.

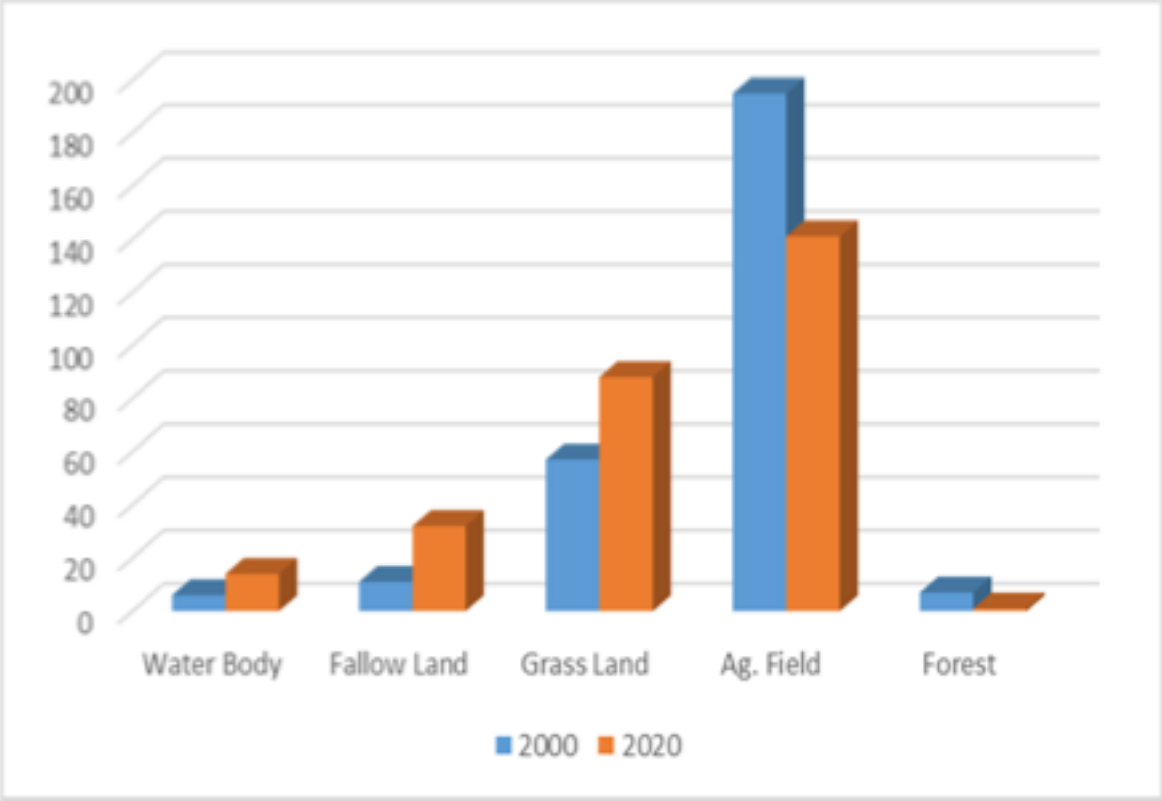

Figure 5: Changes in land use land cover from 2000 to 2020

3.2 Retrieval of Land Surface Temperature (LST)

3.2.1 Land surface temperature (2000)

Figure 6 is the outcome of LST of the study area in 2000. The highest temperature recorded in Sunamganj Sadar was 31.24°C and the lowest was 16.55°C. The western part of the study area was found to be the most temperate region. The temperature of water is usually lower than other kinds of land uses (Hathway and Sharples, 2012; Zhang and Huang, 2015). The areas covered by water body showed the lowest temperatures.

3.2.2 Land surface temperature (2020)

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The land surface temperature distribution in the month of February of 2020 is shown in the figure 7. The lowest temperature recorded was 25.49 ℃ and the highest was 35.48 ℃. Moderate temperature was found all over the study area.

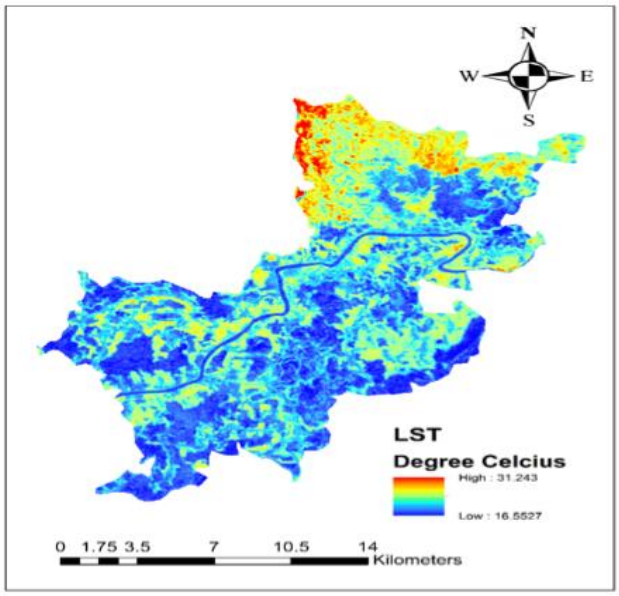

Figure 6: Land surface temperature map (2000)

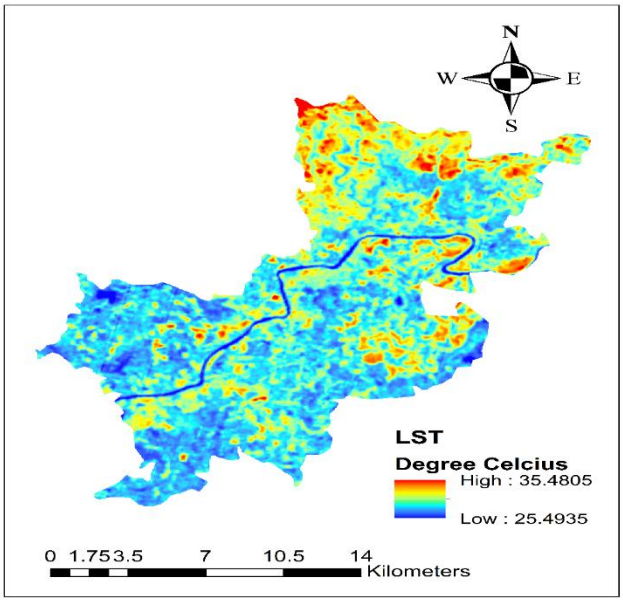

Figure 7: Land surface temperature map (2020)

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3.3 Change in land surface temperature (2000-2020)

The computed LST from the illustrated maps above represent the data of the month of February of 2000 and 2020 respectively. The temperature ranges from 16.55 ℃ to 31.24 ℃ in 2000 and 25.49 ℃ to 35.48 ℃ in 2020. This study revealed that the maximum LST for the study area went up by 9.99 ℃ over 21 years. The lowest temperature has increased too by 8.94 ℃. Five different categories like water body, fallow land, grass land, agricultural field and forest are indicated in this study. Highest temperature was recorded not on fallow land, but on grassland in 2000 whereas highest temperature of 2020 was recorded on outskirts of the city. The lowest temperature was recorded near river in both areas.

3.4 Relationships of LST with Different Indices

The relationship between land cover types and thermal signatures is the most efficient approach in understanding the way LST is affected by LULC changes. (Weng, 2001). So, the connection of LST to NDVI and NDBI is needed to be analyzed.

3.4.1 Relation between LST and NDVI

Normalized difference vegetation index is a standard way to measure healthy vegetation. The more the reflection of difference between near infra-red and red light, the more the value of NDVI. Figure 8 represents the NDVI map of the study area of 2000 and 2020 respectively. The highest value of NDVI of 2000 was found 0.631614 whereas 0.667002 for 2020. Although the highest values of NDVI were almost close, there were changes observed. The vegetation index of areas near Rangar Char, Ghasigaon, Fetargaon, Manmater kara and Uttar Muradpur has decreased.

The results found in linear regression analysis have been presented in the figure 9. The analysis revealed that NDVI in February 2000 is negatively related with LST. Coefficient of determination found 0.168 which represents moderately strong relationship. But in February 2020 the trend line was found slightly positive. The R2 value of 0.0034 represents almost no relationship between LST and NDVI which means LST and NDVI increase or decrease independently. Any kind of social forestry during 20 years of time span might affect the finding.

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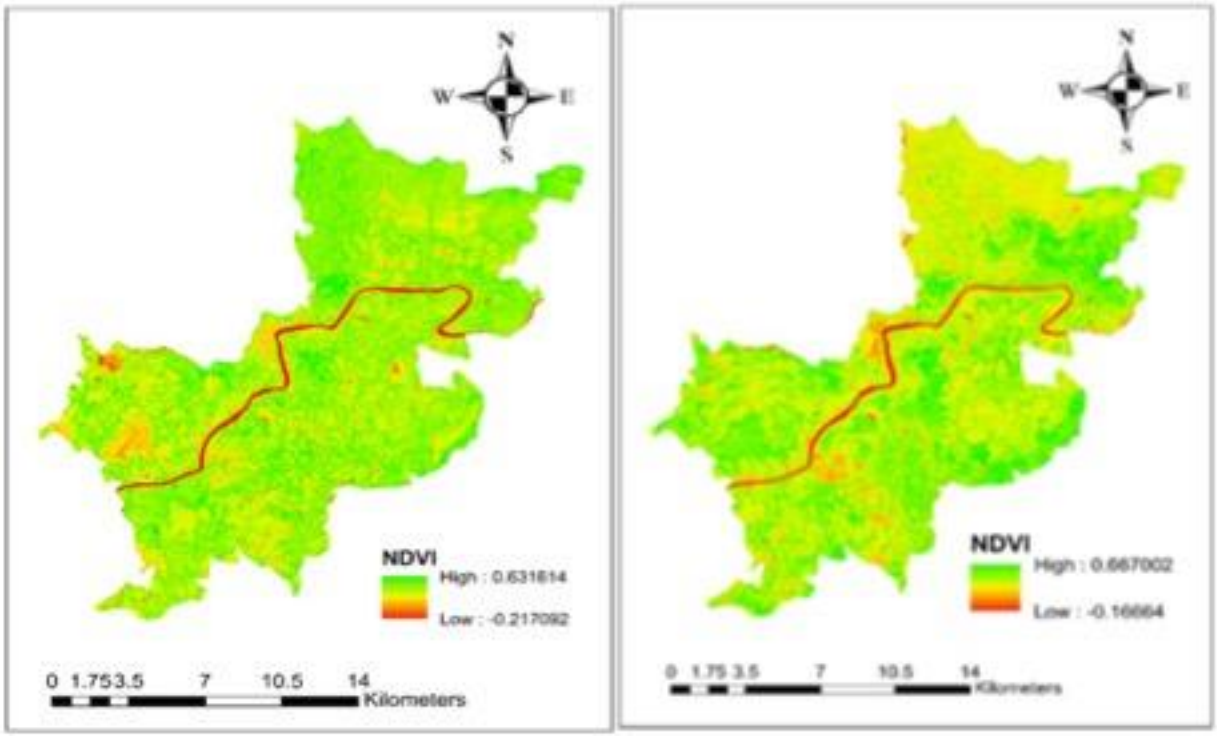

Figure 8: NDVI map for 2000 and 2020

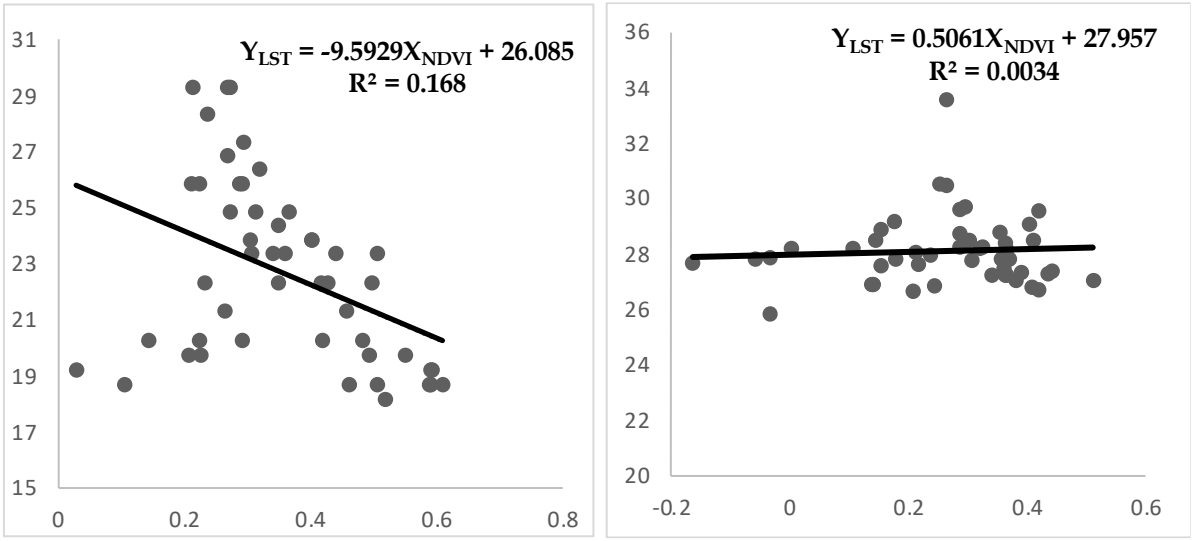

Figure 9: Linear regression analysis between LST and NDVI for 2000 and 2020

3.4.2 Relation between LST and NDBI

Normalized difference build-up index represents the number of build-ups in a certain area. Higher values of NDBI represent the higher amount of build-ups. Figure 10 represents the NDBI map of

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the study area of 2000 and 2020 respectively. The highest value of NDBI of 2000 was found 0.174813 whereas 0.138421 for 2020. The lowest value recorded was -0.681948 and -0.288765 for 2000 and 2020 respectively. The highest value of build-up index for 2020 got recorded in the town but for 2000 it got recorded in the outskirt outside the town.

The findings from linear regression analysis have been presented in figure 11. NDBI showed positive trend with LST. The value of LST increases with increasing NDBI value. R2 values 0.6679 and 0.5156 indicate strong correlation between these two variables.

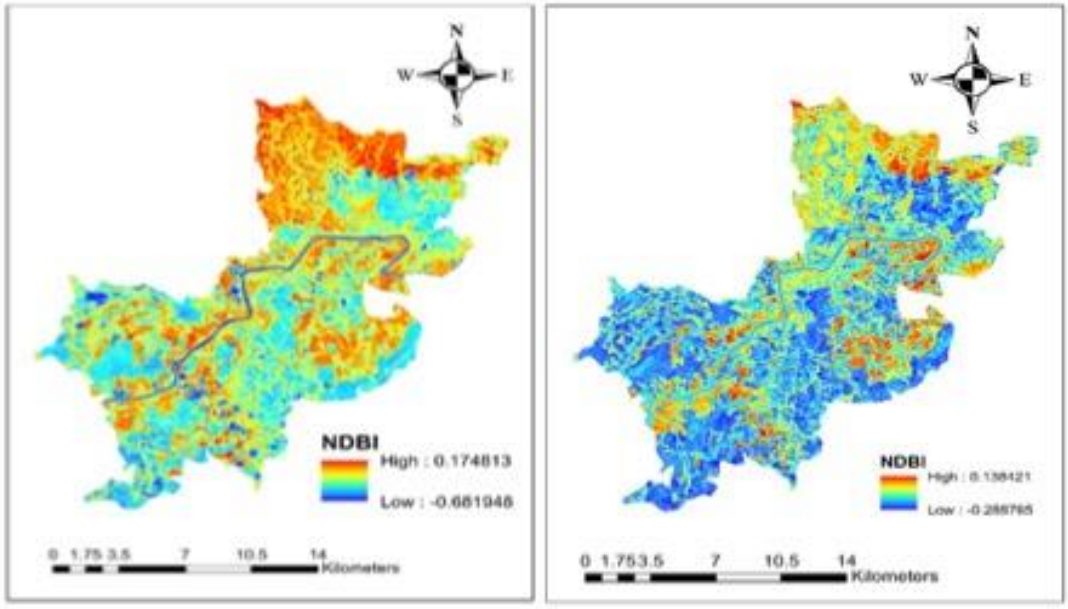

Figure 10: NDBI map for 2000 and 2020

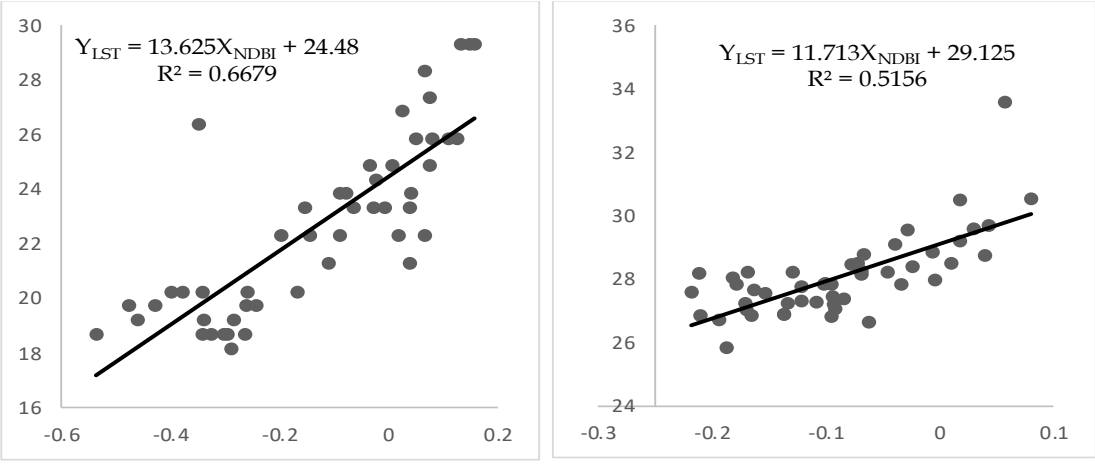

Figure 11: Linear regression analysis between LST and NDBI for 2000 and 2020

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4. CONCLUSION AND RECOMMENDATIONS

From the investigations done in this study, it is evident that the land use and land cover has changed a lot in 21 years. Changes in the LULC revealed that the area of agricultural fields and forests is turning into water body, fallow land and grass land. The boundless increment of fallow land, grass land and water body indicate the absence of proper design and planning. On the other hand, decrease in agricultural land and forest is being a threat to environment and economy. Studying the linear regression relationship of LST with NDVI and NDBI, it has been found that with decreasing index values, LST is increasing. It implies that land surface temperature is increasing with the decrease in vegetation and water contents. Relationship of LST with NDBI revealed that LST increases with increasing value of this index. It implies that land surface temperature is increasing with the increase in build-ups.

All the study findings conclude that these changes will adversely affect the ecosystem and environment which may be proved as a great obstacle for both urban growth and agriculture in near future. To arrest the rising temperature proper planning and execution is a crying need. Forest should be conserved cautiously. Because this valuable natural resource will be lost soon and no longer be able to contribute to make environment healthier if appropriate measures are not taken.

In this study, Data were collected from USGS. There are millions of pixel values in the satellite image. If any data is missing, USGS itself fills up the missing value with the help of surrounding values. Study will be more accurate if the data found are more accurate. Computation of linear regression analysis was done taking 100 random point values across the study area and MS excel was used. Taking more points and analyzing by better statistical software program i.e. Python, MATLAB etc. can make the result more accurate. Analysis can be done on seasonal basis also if scopes are available and a model can be developed to know the land surface temperature from different index values and vice versa.

Conflict of interest: Authors declare that they have no conflicts of interest or financial conflicts to disclose.

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