Identifying Urban Heat Effect through Satellite Image Analysis: Focusing on Narayanganj Upazila, Bangladesh

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Abstract

The rapid growth of population and land use cover change are closely connected. Narayanganj Sadar Upazila is the first Growing City in Bangladesh. Land use and land cover change are very first. Global warming, increased greenhouse gas emissions, and other environmental issues have become critical issues to address in recent times. Because of the Unplanned Expansion of urban areas, the LULC pattern is changing, and this kind of adverse (LST increasing, Heat Island Growth) impact is increasing. In this area, the amount of vegetation is decreasing day by day. The objectives of this study are to identify land use land cover (LULC) dynamics for the year 2001 to 2021, identify Urban Heat Islands from the value of land surface temperature (LST) and identify hotspots based on normalized difference vegetation index (NDVI), normalized difference built-up index (NDBI), normalized difference water index (NDWI) and land surface temperature (LST) doing weighted overlay among them. To determine the land cover pattern, and change at Narayanganj Upazila in the years 2001, 2011, and 2021, the land cover type was divided into four categories (build-up, vegetation, water bodies, and barren soil) in geographic information system (GIS) and Earth Resources Data Analysis System (ERDAS) Imagine 2014. The overall accuracy of LULC in 2001, 2011, and 2021 was 90.08, 91.34, and 92.02, respectively. And the value of the kappa coefficient for the years 2001, 2011, and 2021 was 0.91, 0.89, and 0.90, respectively. This study demonstrates an increase of 14.22% in built-up area and destruction of 15.5% of vegetation, 3.26% of barren soil, and 1.05% of the waterbody in the previous 21 years in Narayanganj Upazila. This study will help the administration, agricultural directorates, Pourashava office, and city corporation authority to take necessary measures to mitigate the adverse impacts of land cover change. They can make new rules and regulations on the construction of buildings, restrictions on filling water bodies and measures to conserve vegetation.

Keywords: *Land Surface Temperature, Normalized Difference Built-up Index, Normalized Difference Water Index, Normalized Difference Vegetation Index, Weighted Overlay.*

1. Introduction

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The rapidly growing urban population significantly changes land use and land cover and negatively affects urban land surface temperature [1-3]. Changes in land use and land cover enhance climate change by reducing biodiversity and causing urban heat islands (UHI) in cities by elevating the land surface temperature [4]. Changes in the land use land cover and land surface temperature are the most common research topics for remote sensing (RS) experts [5]. During the previous decade, the global urbanization has appeared as the primary driver of environmental, social, and demographic change [6-7]. Because of urbanization, categories of land use and land cover like vegetation, waterbody, buildup, and cropland are rapidly changing [8, 5]. Normalized Difference Vegetation Index which describes the status of vegetation using a combination of the red and the near-infrared band of satellite imagery, is the most extensively used catalog [9]. This rapid growth brought city expansion and transformation of different LULC and affected the land surface temperature in the Narayanganj Upazila. Unmonitored land use land cover modification enhances built-up areas by doing displacement of the green cover and creating environmental damage through the effects of growing urban heat island. Geographic information system (GIS) and remote sensing (RS) are common techniques for investigating changes in land use land cover and the land surface temperature. Researchers throughout the world have employed a variety of mathematical indicators for a better understanding of change in the land use land cover pattern [10]. Over the previous few decades, the world's urban population has grown at a quicker pace [11]. During the period 2000 to 2015, towns around the world grew at a rate of 1.5 percent in a year, whereas in developing countries, urban growth was at a rate of about 2.6 percent per year (WUP, 2018). In previous research work, the maximum researcher showed the impact of land use land cover pattern change on the rising of land surface temperature. The research gap is that a few studies have been done related to urban heat island growth from land use and land cover pattern change using land surface temperature (LST) and normalized difference vegetation index (NDVI) but we have used indices normalized difference vegetation index (NDVI) as well as normalized difference built-up index (NDBI), normalized difference water index (NDWI) and land surface temperature (LST). The use of two additional indices aided in obtaining a trustworthy outcome in this work. This study area is totally new in which no research has been conducted. Weighted overlay among normalized difference vegetation index (NDVI), normalized difference built-up index (NDBI), normalized difference water index (NDWI), and land surface temperature (LST) has been carried out to discover the combined hotspot. The growth of population in the urban area causes large-scale changes in urban land use and land cover pattern, resulting in various of ecological and environmental issues [12-13]. The change in land use and land cover pattern in the area of urban regions further has an impact on the standard of living in cities by modifying the environment, deteriorating then air quality, and increasing the frequency of extreme weather occurrences such as high-intensity precipitation and the establishment of urban heat island (UHI) [14-15]. During the period 1958 to 2007, the average temperature throughout Bangladesh rose by 0.1030 degrees Celsius per year, while in Khulna, the rate was 0.0070 degrees Celsius per year [16]. But, due to rapid environmental change, the average temperature increase rate in Khulna from 2003 to 2018 was 0.041620C/year [17].

The objective of this study was to identify land use land cover dynamics for the year 2001 to 2021, and to identify Urban Heat Island from the value of Land Surface Temperature. In this research, the response to Urban Heat Islands (UHI) growth and Hotspot because of land cover change has been delineated. By doing a linear regression we can see the relationship between the UHI and Land Cover change. It shows which type of land cover change is mostly responsible to grow UHI and Hotspot in the study area. This study will help the administration, agricultural directorates, pourashava office, and city corporation authority to take necessary measures to mitigate the adverse impacts of land cover change. They can make new rules and regulations on the construction of buildings, restrictions on filling water bodies and measures to conserve the vegetation.

2. Data and Methods

2.1 Study area

Narayanganj Upazila is a first growing upazila in Narayanganj district. About 14.22% of built-up areas increased in the last 21 years (2001-2021). The vegetation cover has declined to 15.5%, and LST has increased to 3.57 degrees celsius. Narayanganj Upazila is one of the upazila of Narayanganj district. It is surrounded by Dhaka in the northwest, Munshiganj in the south, Sithalakkha river in the east, Buriganga river covers some part of the west boundary and Dhalesshari river on the south-west side. It is located at 23° 37' 21.5076" N and 90° 29' 59.2584" E. The distance from district Sadar is about 1 km. This consists of 07 unions. The size of the area is 113.98 sq. km. The population is about 13,23,600. The annual population growth rate is 1.49%. Total agricultural land is about 43.78 sq.km, and total forestland is 12.91 sq.km. Population density is 6000 per sq. km. The literacy rate is about 62.7%. The average maximum temperature is about 32.3 degrees celsious; the average lowest temperature is 16.2 degrees Celsius, and the average annual rainfall is 219.45mm (Source: BMD).

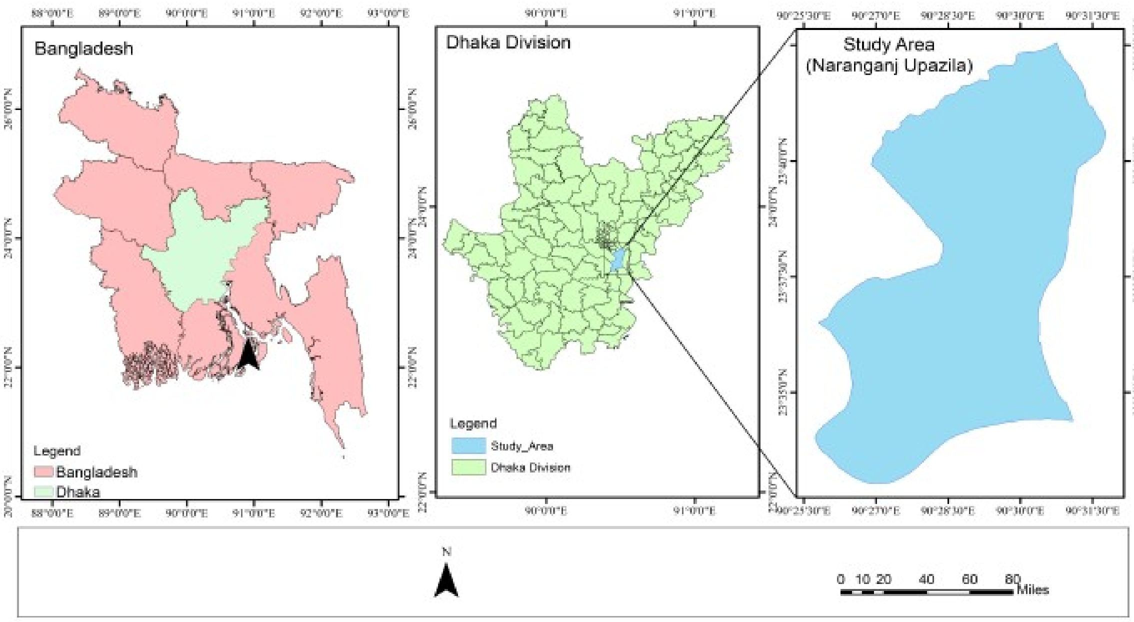

Figure 1: Study area map

2.2 Data collection

The methodology used here to determine land cover changes is based on a comparison of satellite images from different years. Landsat TM satellite imagery from the years 2001, 2011, and 2021 is used to inquire about the dynamics of LULC pattern change in Narayanganj Upazila. The selection of timeline stands for massive change occurred during this timeline. Table-1 shows the spatial and radiometric properties of these images. These years have been used because the collected image of these years is more visualized than others. So, this is comparatively advantageous, and more accuracy has come from this study. Map Projection system of the images collected from a satellite is Universal Transverse Mercator (UTM) inside Zone 46 N-Datum and of the co-ordinate system World Geodetic System (WGS) 84 with a pixel size of 30m.

Table 1. Characteristics of satellite data used

Instrument	Image taken date	Sensor	Spatial resolution
Landsat 5	12 april, 2001	TM	30
Landsat 5	19 may, 2011	TM	30
Landsat 8	24 june, 2021	ETM+	30

Source: USGS

The collected pictures are taken from these dates because the quality of the satellite image was comparatively better than the others. These pictures were less troubled by the effect of the cloud. In April, May, and June month the condition of the sky is more apparent than in other months. The better-quality images were taken from such dates for this study.

2.3 Land cover classification

To categorize and select the area of interest (Narayanganj Upazila), an image-enhancing technique was used while creating a land cover map. The most common methods for enhancing Landsat images are contrast enhancement, saturation, color, intensity, and density slicing, among others. Landsat photos were enhanced in this study by generating a composite band combination. Landsat satellite images were radiometrically and atmospherically corrected. In this work, composite band combinations like natural color composite, true-color composite, false-color composite, etc., were used for determining the type of land cover in Narayanganj Upazila. Red, Blue, Green, and NIR bands were used for Landsat 5 TM images of 2001, 2011 and Landsat 8 OLI images of 2021, finding true color during data processing in Earth Resources Data Analysis System (ERDAS) Imagine 2014. To determine the land cover pattern, change at Narayanganj Upazila in the years 2001, 2011, and 2021, the land cover type was divided into four categories (build-up, vegetation, water bodies, and barren soil) (Table 2) in ArcGIS and ERDAS Imagine 14. The overall accuracy of LULC in 2001, 2011, and 2021 was 90.08, 91.34, and 92.02, respectively. And the value of the kappa coefficient for the years 2001, 2011, and 2021 was 0.91, 0.89, and 0.90, respectively.

2.4. Land Surface Temperature (LST)

Equation 1-5 is used to estimate the LST.

$$L\lambda = A\lambda + ML * QCAL \tag{1}$$

Lλ = Spectral Radiance of TOA (W/ (m2 × sr × µm))

ML =The band's multiplicative scaling factor for radiance

AL = The band's additive scaling factor for radiation

QCAL = In Digital Numbers, the quantized calibrated pixel value.

Table 2. Description of land cover type used

Types of land cover	Description
Built-up	Industrial, residential, commercial, transportation network and other infrastructures
Vegetation	Forest regions, trees, and grassland
Barren soil	Landfill sites, open space, and playgrounds
Waterbody	River, wetlands, canal, pond, lake

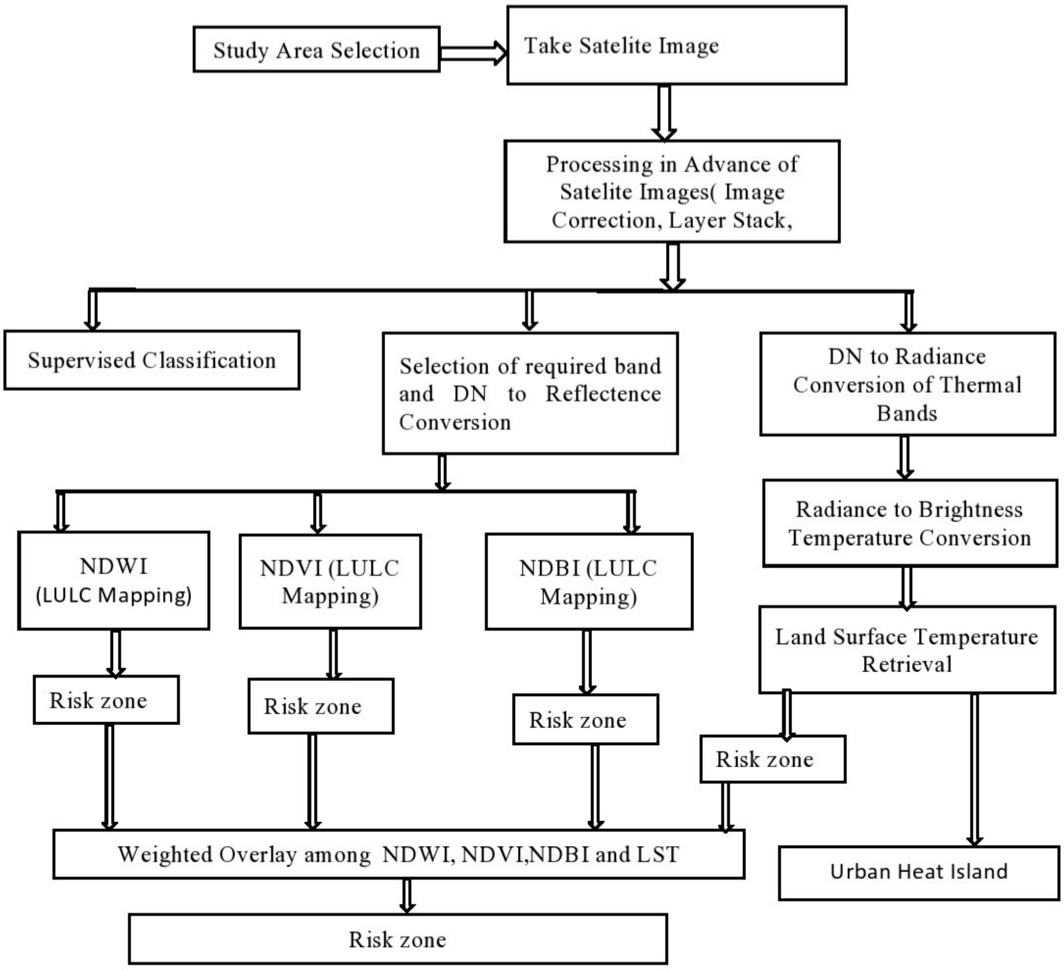

Figure 2: Methodological flow

The TOA spectral radiance (Lλ) measurements are translated into another variable called At-Satellite Brightness Temperature in the second stage (TB)

$$TB = \frac{k2}{\ln(k1/L\lambda + 1)} \quad (2)$$

Where,

TB =At-Satellite Brightness Temperature, in Kelvin (K)

k_1, k_2= Thermal conversion constants for the band

Finally, the TOA Brightness Temperature will be converting to land surface temperature values (LST) using the formula.

$$LST = \frac{TB}{(1 + (\lambda * TB/\alpha)) * \ln\varepsilon} \quad (3)$$

LST = Land Surface Temperature in Kelvin (K)

λ = the wavelength of radiation emitted

α = hc/k (1.438 × 10-2 mK)

h = 6.626 × 10-34 J s-1, and c = 2.998 × 108 m s-1

k = Constant of Boltzmann(1.38 × 10-23 J K-1)

ε = Emissivity of Surface

$$\varepsilon = 0.004 * pv + 0.986 \quad (4)$$

Pv is the vegetation proportion derived from Equation 5.

$$Pv = \left(\frac{NDVI - NDVI_{min}}{NDVI - NDVI_{max}}\right)^2 \quad (5)$$

273.15 was subtracted from the kelvin value to produce the land surface temperature values in Celsius (°C) .

2.5. Normalized Difference Vegetation Index (NDVI)

$$NDVI = \frac{NIRBand - Re\ dBand}{NIRBand + Re\ dBand} \quad (6)$$

NIR Band and RED Band are used to calculate NDVI. The NDVI ranges from -1 to + 1, with values near -1 indicating a lack of vegetation and values around + 1 indicating good vegetation.

2.6. Normalized Difference Water Index (NDWI)

$$NDWI = \frac{Green - NIR}{Green + NIR} \quad (7)$$

Green and NIR wavelengths were used to calculate NDWI. The NDWI ranges from -1 to +1, with values near -1 indicating a shortage of water bodies and values around + 1 indicating a large number of water bodies.

2.7. Normalized Difference Build-up Index (NDBI)

$$\text{NDBI} = \frac{SWIR - NIR}{SWIR + NIR} \tag{8}$$

Shortwave Infrared and Near-Infrared were used to calculate the NDBI. The NDBI ranges from -1 to + 1, with values near -1 indicating no built-up area and values near + 1 indicating a dense buildup region.

2.8. Urban Heat Island

An urban heat island (UHI) is an urban section that is much heated than its surroundings as a result of human activity.

$$\text{UHI} = \text{LST} - (\mu + 0.5\sigma)$$
(9)

Where,

μ=LST mean value and

σ= LST standard deviation

2.9. Weighted Overlay

Risk susceptibility has been identified based on the value of NDBI, NDWI, NDVI, and LST. When the value of NDVI and NDWI is -1 to -0.7, then it is considered as risky zones. But when the value of NDBI is 0 to +1, then it is considered as risky zones. At the same time, when the land surface temperature is more than 28 degrees celsius, then it is considered the risky zones. Finally, the weighted overlay was conducted to identify the combined hotspot where NDBI, NDVI, NDWI, and LST took influence factor values 38, 19, 11, and 32, respectively (Table 3).

Table 3. Average Influence % of indexes based on expert opinion

Index	Influence (%)
NDVI	19
NDBI	38
NDWI	11
LST	32

The influence factor value was given based on the expert's opinion. The values were collected from the experts and then averaged according to a separate index and then put in ArcGIS when a weighted overlay was conducted.

3. Results and discussion

3.1 Analysis of LULC change pattern

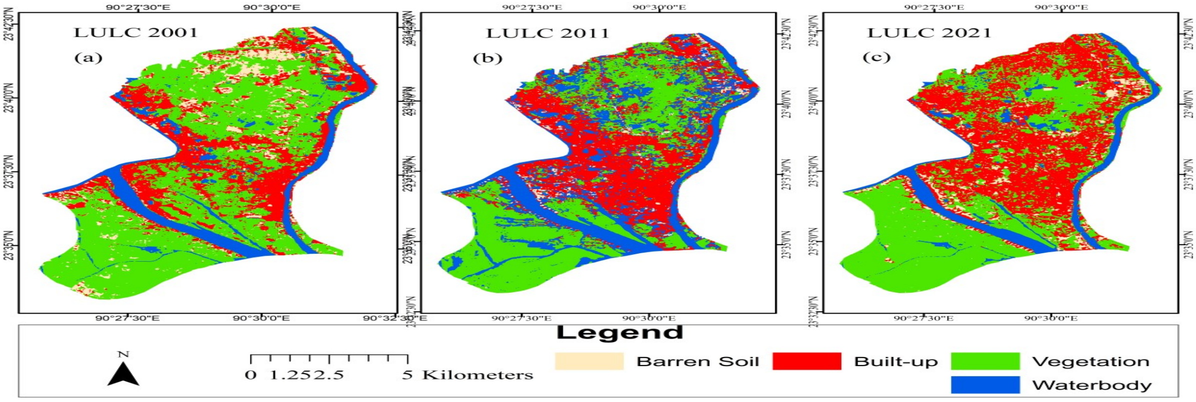

Figure 3: LULC map of narayanganj upazila for 2001, 2011 and 2021.

From Table 4 and Figure 3, between 2000 and 2011, there is a decrease in barren soil, cropland area, and vegetation area to 6.19%, 12.70%, and 4.10%, respectively, and an increase in build-up and waterbody to 5.78% and 17.21 respectively. At the same time, between 2011 and 2021, there is a decrease in cropland and waterbody to 6.38% and 18.27%, respectively, and an increase in barren soil, build-up, and vegetation to 2.93%, 8.43%, and 13.28%, respectively. At the same time , between 2001 to 2021 there is an increase of 14.22% buildup area and a decrease of barren soil, vegetation, and waterbody to 3.26%, 16.2% and 1.05% respectively.

Table 4. Area of land Cover to 2001, 2011 and 2021

Year LULC	**2001** Percentage	**2011** Percentage	**2021** Percentage
Barren Soil	8.64%	2.45%	5.38%
Built-up	24.80%	30.59%	39.02%
Vegetation	54.35%	45.04%	38.15%
Waterbody	11.60%	28.82%	10.55%
Total	100.00%	100.00%	100.00%

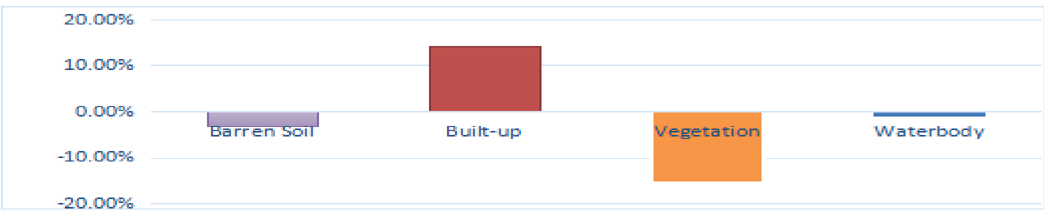

Figure 4: Change direction of LULC between 2001 to 2021

From Table 4, it is seen that LULC change direction study indicates a significant change in LULC over the last 20 years (2001 to 2021) using ArcGIS analysis. Here, there is a reduction in barren soil, vegetation, and waterbody to 3.26%, 15.5% and 1.05% respectively and an increase in build-up area to 14.22%.

3.2 Assessment of NDBI

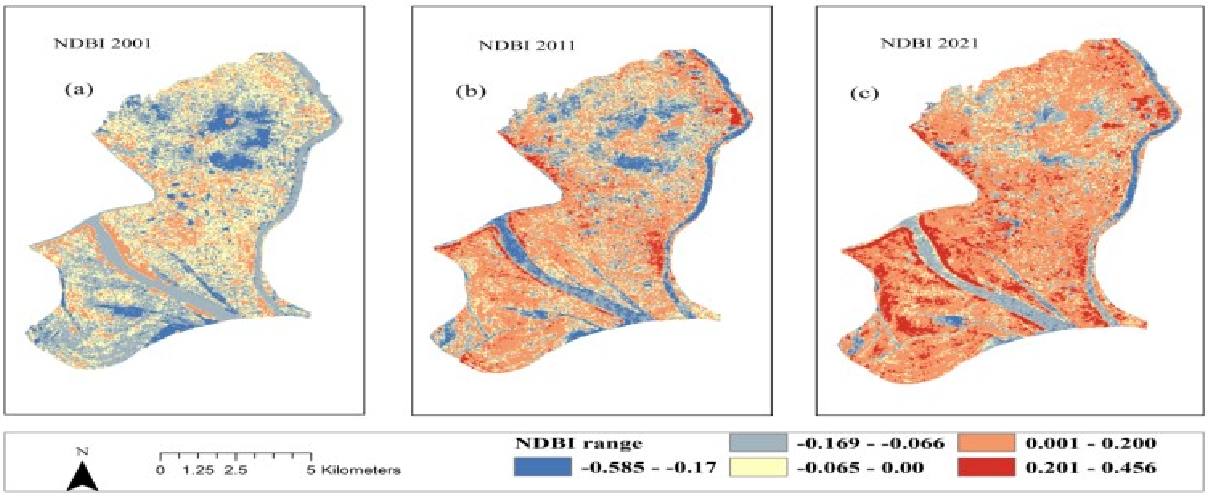

Figure 5: Normalized Difference Buildup Index

In Figure 5, we can see that the amount of build-up area is more than in the years 2001 and 2011. The amount of build-up area with the range of 0.201 to 0.456 is seen more in 2021. So, we can conclude that the value of NDBI is increasing day by day in the study area, which is 14.22 percent increase in a built-up area (Table 6). The NDBI value grew across the study area during the study period. The NDBI values are increasing every day in this study area. The increasing value of NDBI contributes to increasing the LST during the research period in the study area. There is a higher value of NDBI in 2021.

3.3 Assessment of NDVI

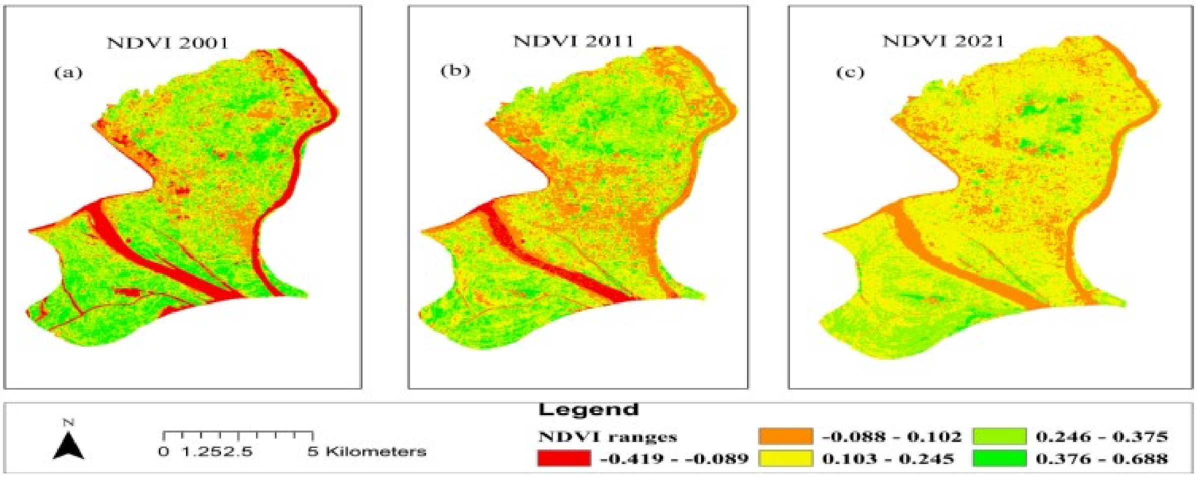

Figure 6: Normalized Difference Vegetation Index

Figure 6 interprets the declination vegetation area. If we see NDVI 2001, 2011, and 2021 NDVI maps, we can visualize that the amount of vegetation in 2021 is less than in 2001. The decreasing value of NDVI contributes to an increase in the LST in the study area over the study period. There is a lower value of NDVI in 2021. In Figure 6, we can see that the amount of vegetative cover is less in 2021 compared to vegetation cover in 2001 and 2011. The amount of vegetative area in the range of 0.376 to 0.688 is seen less in the year 2021, which indicates the declination of vegetation in the year 2021.

3.4 Assessment of NDWI

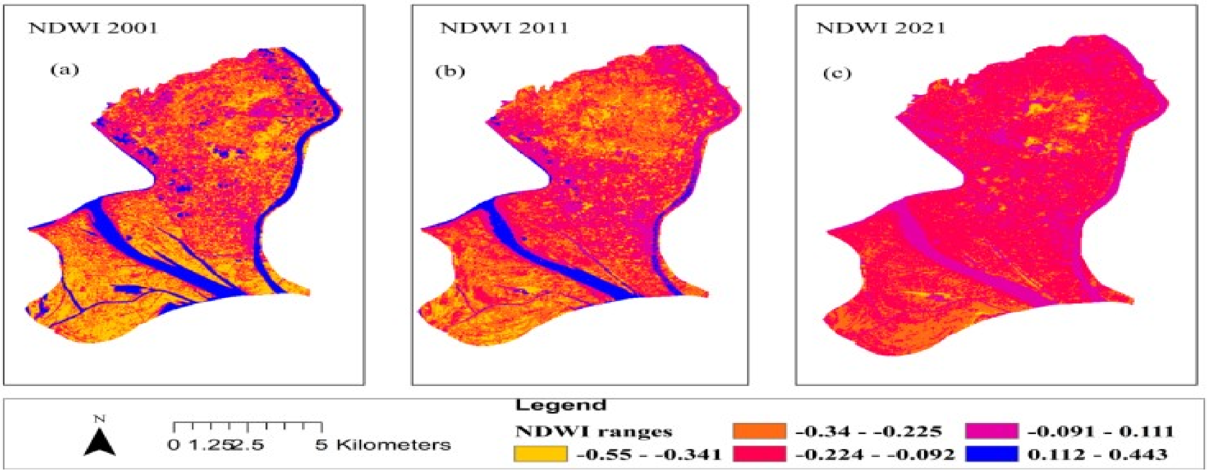

Figure 7: Normalized Difference Water Index

In Figure 7, we can see that the amount of waterbody is more in 2021 compared to the amount of waterbody in 2001 and 2011. The amount of water bodies in the range of 0.112 to 0.443 is seen less in the year 2021 than in the years 2001 and 2021. So, it is concluded that NDWI is decreasing, and the area with the lower value of NDWI is increasing across the study area day by day.

3.5 Assessment of LST

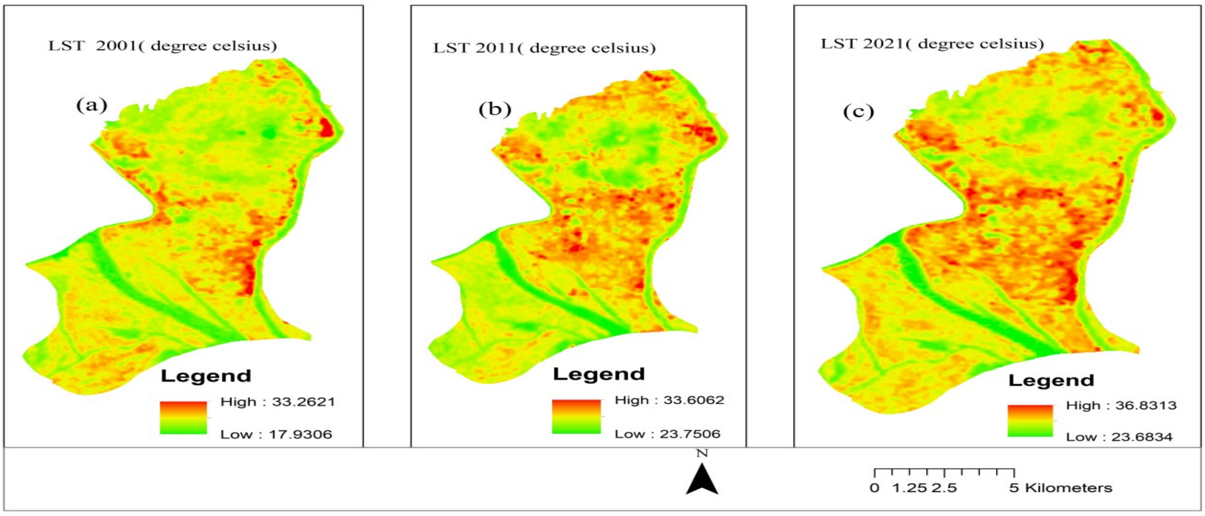

Figure 8: Land Surface Temperature

In Figure 8, the lowest LST for the 3 years are 17.93, 23.52 and 23.68. Here the lowest temperature has been increased to 5.75 degree celsius. The highest temperature for the 3 years is 33.26, 33.60 and 36.83. Hence, the highest temperature has been increased to 3.57 degree celsius.

3.6. Assessment of UHI

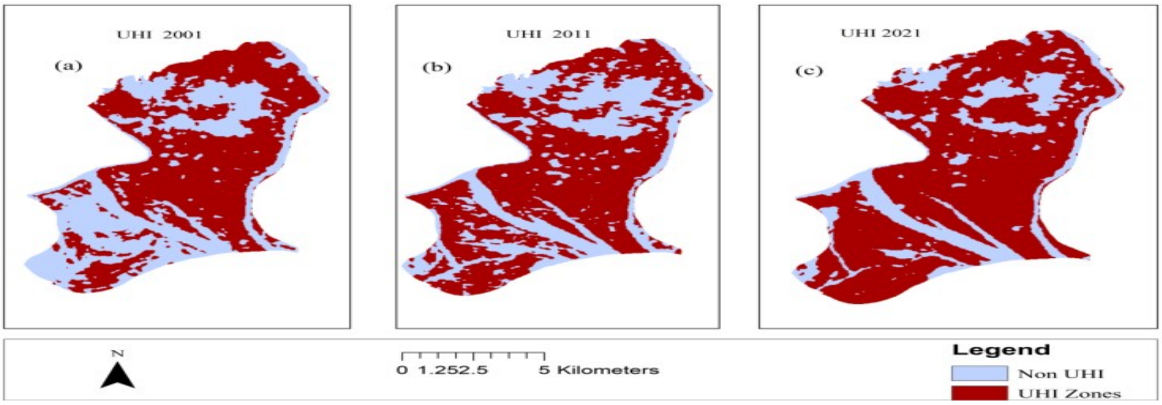

Figure 9: Urban Heat Island

Figure 9 shows that the red-colored places are urban heat island zones because the temperature in these areas is high compared to the surrounding areas. As the temperature is high in these places so it is colored red as red color usually indicates a bad condition or the severity of any issue.

3.7. Linear Regression

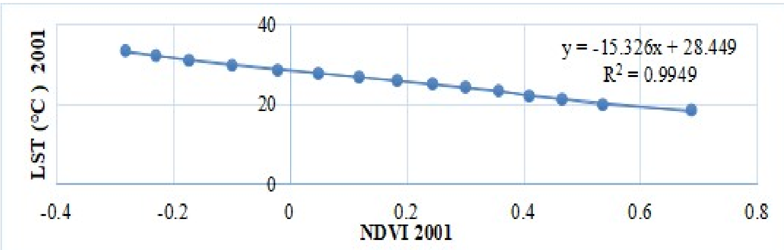

Figure 10: Correlation between LST and NDVI (2001)

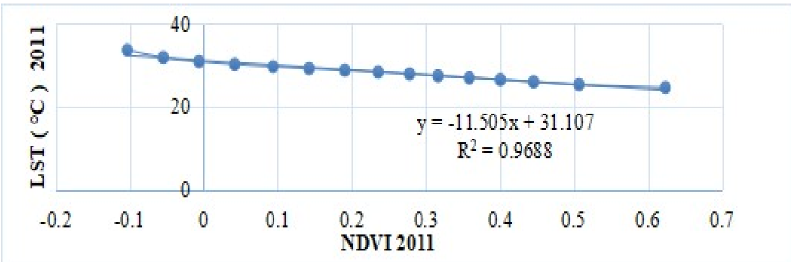

Figure 11: Correlation between LST and NDVI (2011)

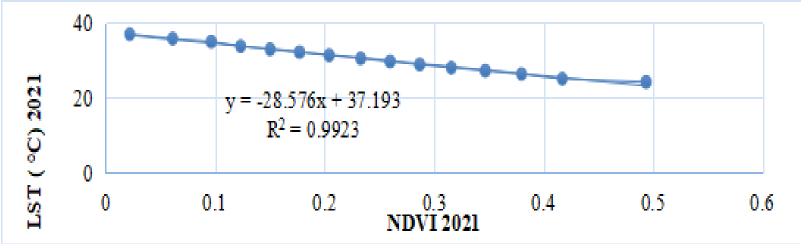

Figure 12: Correlation between LST and NDVI (2021)

The motive of doing this linear regression is to see the response of changing LST with the changing the values of NDBI, NDVI, NDWI for the years 2001, 2011, and 2021.

Figures 10, 11 and 12 show a decreasing trend of LST with increasing NDVI value based on regression analysis between LST vs. NDVI. It depicts the regression analysis for the years 2001, 2011 and 2021, which shows a negative association between LST and NDVI values. The increase of vegetation area influences to reduce in land surface temperature. The coefficient of determination (R2) value was calculated for 2001, 2011, and 2021 to 0.9949, 0.9688, and 0.9923, respectively, which demonstrates the significant relationship between NDVI and LST.

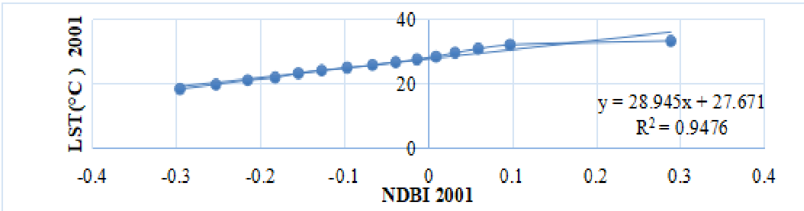

Figure 13: Correlation between LST and NDBI (2001)

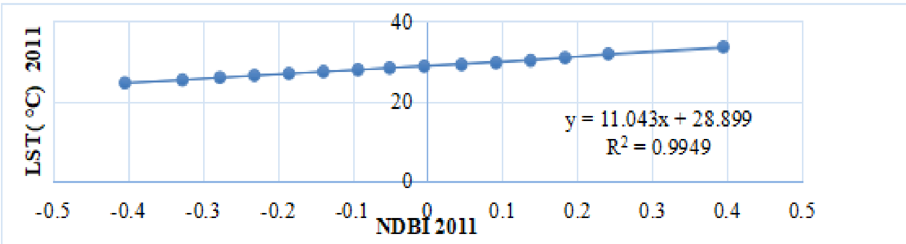

Figure 14: Correlation between LST and NDBI (2011)

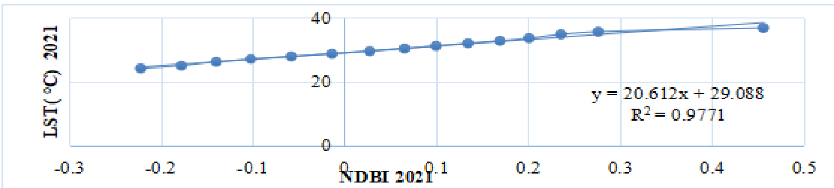

Figure 15: Correlation between LST and NDBI (2021)

Figures 13, 14, and 15 demonstrate the growing trend of LST with the increasing NDBI value based on the regression analysis between LST vs. NDBI. Figures 10, 11, and 12 depict the regression analysis for the years 2001, 2011 and 2021, which shows a negative association between LST value and NDBI values. The increase of buildup area influences the rise in surface temperature. The coefficient of determination (R2) value was calculated for 2001, 2011, and 2021 to 0.9476, 0.9949, and 0.9971, respectively, which demonstrates the significant relationship between NDBI and LST.

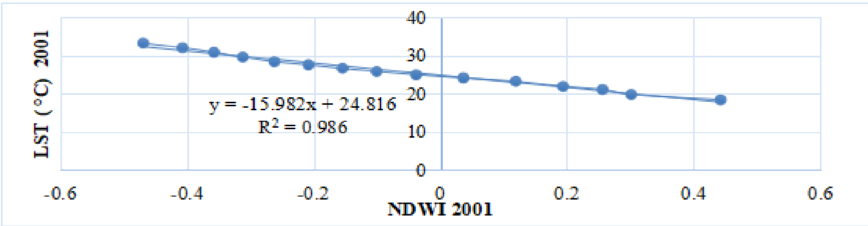

Figure 16. Correlation between LST and NDWI (2001)

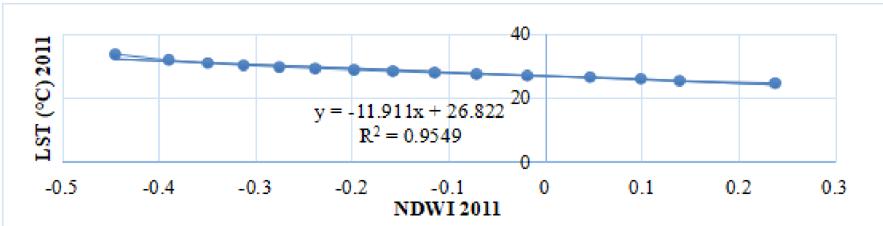

Figure 17.Correlation between LST and NDWI (2011)

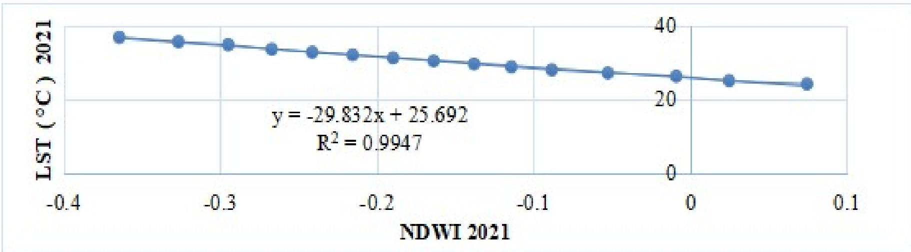

Figure 18. Correlation between LST and NDWI (2021)

Figures 16, 17, and 18 demonstrate an increasing trend of LST with decreasing NDWI value based on the regression analysis of LST vs. NDWI. Figures 5, 6, and 7 depict the regression analysis for the years 2001, 2011 and 2021, which shows a negative association between LST and NDWI values. The reduction of waterbodies affects the rise in the temperature of the surface. The coefficient of determination (R2) value was calculated for 2001, 2011, and 2021 to 0.986, 0.9549, and 0.9947, respectively, which demonstrates the significant relationship between NDWI and LST.

3.8. Assessment of Risk Susceptibility Growing from NDBI

The range of NDBI values is -1 to +1. A value near +1 means a high concentration of build-up area. A value near -1 means a low concentration of build-up area. Here we showed the NDBI between -1 to -0.7, -0.7 to 0, and 0 to +1 and their change in 2001, 2011, and 2021. To identify the risk susceptibility based on the build-up area, we have done three classes: low hotspot (-1 to -0.7, moderate hotspot (-0.7 to 0), and high hotspot (0 to +1). Here the area with high build-up has been identified.

The NDBI value between 0 to1 is seen more in the year 2021. That means the risky zones are increasing in the year 2021 as the NDBI is related to the growth of the hotspot. Figure 19 shows that the hotspot area increased tremendously from 2001 to the year 2021.

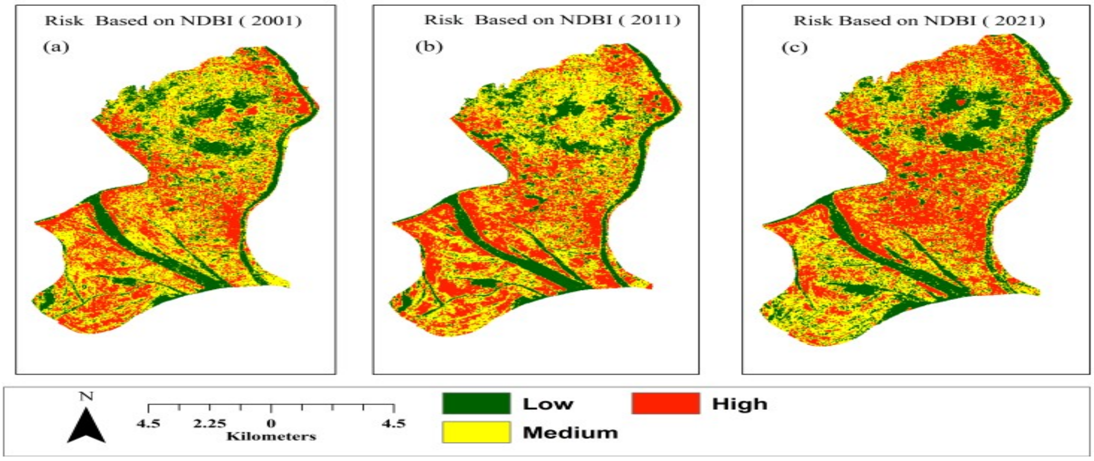

Figure 19: Risk zone based on NDBI

3.9. Assessment of Risk Susceptibility Growing from NDVI

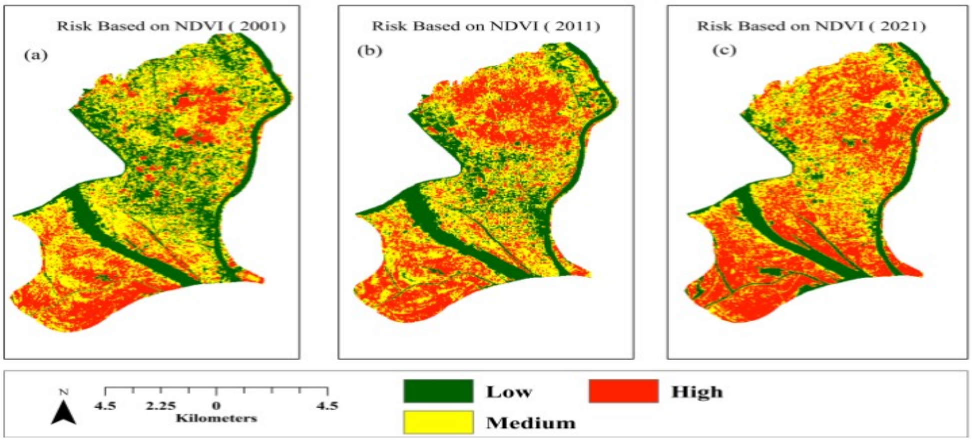

Figure 20: Risk zone based on NDVI

The range of NDVI values is -1 to +1. A value near +1 means a high concentration of vegetative cover area. A value near -1 means a low concentration of vegetative area. Here we showed the NDVI between -1 to -0.7, -0.7 to 0, and 0 to +1 and their change in 2001, 2011, and 2021. To identify the risky zones based on vegetative cover area we have done three classes: low risk (0 to +1), medium risk (-0.7 to 0) and high risk (-1 to -0.7). Here the area with lower vegetation has been identified. The NDVI value between 0 to 1 is seen less in the year 2021. That means the risky zones have increased in the year 2021 as the NDVI is related to the growth of the risky zones. Figure 20 shows that the hotspot area increased tremendously from 2001 to the year 2021.

3.10. Assessment of Risk Susceptibility Growing from NDWI

The range of NDWI values is -1 to +1. A value near +1 means a high concentration of water body area. A value near -1 means a low concentration of waterbody. Here we showed the NDWI between -1 to -0.7, -0.7 to 0, and 0 to +1 and their change in 2001, 2011, and 2021. To identify the risky zones based on waterbody area we have done three classes: low risk (0 to +1), medium risk (-0.7 to 0) and high risk -1 to -0.7). Here the area with a low waterbody has been identified. The NDWI value between 0 to 1 is seen less in the year 2021. That means the risky zones have increased in the year 2021 as the NDWI is related to the growth of the risk susceptibility. Figure 21 shows that the risky areas increased greatly from 2001 to the year 2021.

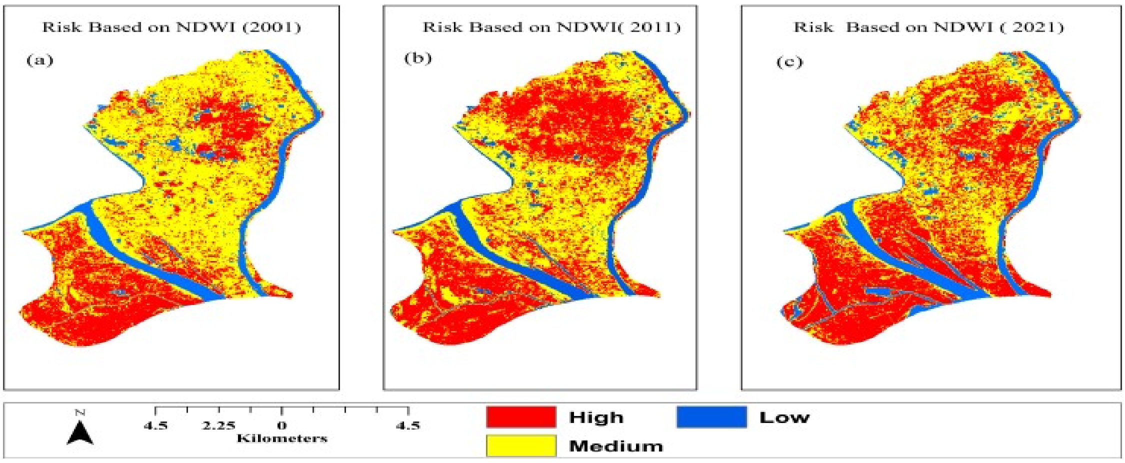

Figure 21: Risk zone based on NDWI

3.11. Assessment of Risk Susceptibility Growing from LST

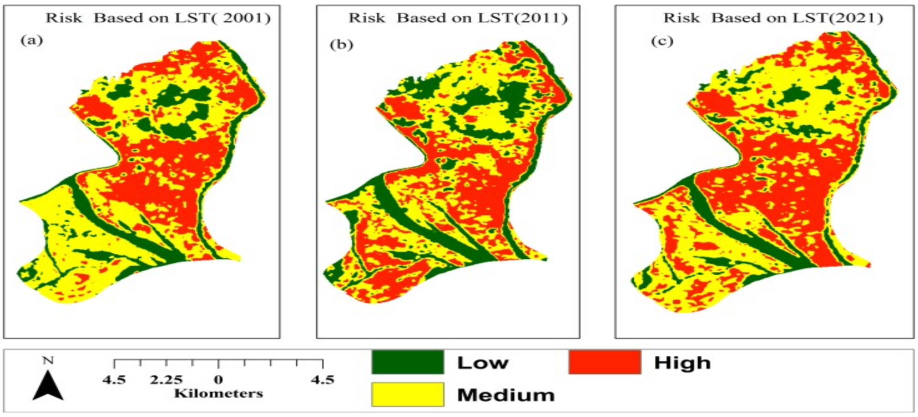

Figure 22: Risk zone based on LST

Here we have tried to show the areas with a land surface temperature of less than 24°C, 24°C to 28°C, and more than 28°C. Here we tried to show the area with more than 28°C increased or decreased in the year 2021 compared to 2011 and 2001. The hotspot according to the temperature of the land's surface has delineated (Figure 19). To do this, three classes of temperature were considered. One class is less than 24°C (low risk), 24°C to 28°C (medium risk), and more than 28°C (high risk). As can be seen in Figure 22, the hotspot zones have increased greatly in the year 2021 compared to the hotspot zones in 2001 and 2011.

3.12. Assessment of Risk Susceptibility from Weighted Overlay

To assess risk susceptibility from weighted overlay, we have given the influence factor to LST 32, NDBI 38, NDWI 11, and NDVI 19 based on the average value of the expert opinion. Then an overlay was made among NDWI 2001, NDBI 2001, NDVI 2001, and LST 2001. NDWI 2011, NDBI 2011, NDVI 2011 and LST 2011. NDWI 2021, NDBI 2021, NDVI 2021 and LST 2021. Then the final risky susceptibility based on the combination of the four indexes appeared. Figure 23 shows that there are fewer risky zones in 2001, but more risky zones in 2021. The red-colored portions are the combined risky zones. Preventive measures should be taken in these places.

In this study the risk susceptibility growth from normalized difference vegetation index (NDVI), normalized difference Built-up index (NDBI), normalized difference water index (NDWI) and land surface temperature (LST) was delineated and finally the combined risky zones by doing weighted overlay in ArcGIS the expected scenario of risk susceptibility we can see easily. The land use land cover (LULC) pattern change is the driving force toward this growth of risky zones. Here it was seen that the place with low vegetation, waterbody and high concentration of build-up area is responsible for the growth of risky zones. The study demonstrates a significant shift in land use and land cover of build-up land, vegetation, waterbody and barren soil land in the studied area. Because of the unplanned switch of land cover type into built-up areas, the average the degradation of vegetation, waterbody and barren soil and the increased of buildup area resulted in growing more risky zones in 2021 compared to 2011 and 2001. This study's appraisal of change in environment at the micro level which will help educate people about the importance of planned changes in land usage and will direct researchers' attention to the dynamics of land usage at the root level in order to reduce the negative impact to the environment.

Some methodological limitations like LST were calculated by taking data from satellite image processing by ArcGIS (geo-spatial planning tool) but failed to validate these data using LST measuring device. Because of lack of device it was not possible to validate the data that was used to calculate LST and then from this LST data, the UHI was delineated. The resolution of the satellite image is 30m which does not conserve the high-level resolution of the images which have collected. The researcher who will work on this related topic should use LST measuring device and need to use high resolution image rather than use of 30 m spatial resolution picture.

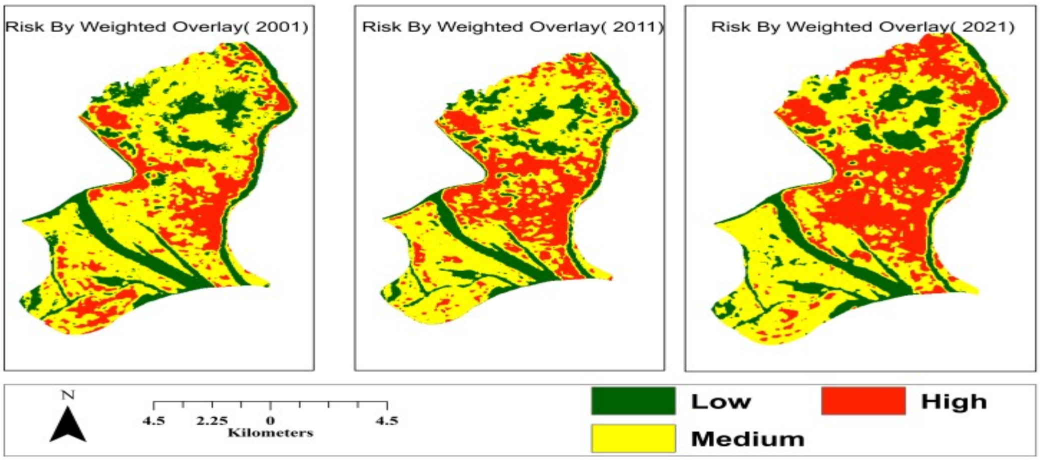

Figure 23: Risk zone from weighted overlay

3.13. Result Validation with the interview of the residents

The final output of the research has been checked by the stakeholders of the locality. They also argued that the zoning of the result is quite satisfactory and that they also feel so. It means that the real fact is also the same as the final output. Vegetation, Water area are decreasing in the high-risk zone while temperature has been increased in recent year. Hence, the model result is okay in this sense.

Table 5: Response of the stakeholders on the issues

Interviewer	Questions on	Remarks	
		Increase	Decrease
1	Vegetation		✓
2			✓
3			✓
4			✓
1	Water		✓
2			✓
3			✓
4			✓
1	Built-up		✓
2			✓
3		N/A	
4			✓
1	Land Surface Temperature (LST)	✓	
2		✓	
3		✓	
4		✓	

4. Conclusion

The study demonstrates a significant shift in land use and land cover of build-up land, vegetation, waterbody, and barren soil land in the studied area. There was an increase of 14.22% build-up area and destruction of 15.5% vegetation, 3.26% barren soil, 1.05% waterbody in the last 21 years in Narayanganj Upazila.The most noticeable observation was that the temperature of land surface has risen primarily in regions where the waterbodies and barren land have been converted to development areas. Overall, the study indicates that land cover is not changing in a planned manner throughout Narayanganj Upazila. As a result, environmental changes are occurring at the microlevel, such as fast increases in the surface temperature, air temperature, and landscape is changing. Because of the unplanned switch of land cover type into built-up areas, the average LST has risen by 3.57 degrees Celsius in the last 21 years. The degradation of vegetation, waterbody and barren soil and the increase of buildup area resulted in growing more hotspot in 2021 compared to 2011 and 2001. This study's appraisal of change in environment at the micro level will help educate people about the importance of planned changes in land usage and will direct researchers' attention to the dynamics of land usage at the root level to reduce the negative impact to the environment.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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