*IOSR Journal of Applied Physics (IOSR-JAP)*
*e-ISSN: 2278-4861.Volume 10, Issue 3 Ver. III (May. – June. 2018), 56-62*
*www.iosrjournals.org*

# Probable Environmental Impact Analysis through Change in Land Use Pattern and Urbanization by Geospatial Technique

Dr. Abhijit Pandit
*Asst. Prof., Amity Institute of Applied Sciences, Amity University, Kolkata*
*Corresponding Author: Dr. Abhijit Pandit*

***Abstract**: Encroachment of human settlement with the expansion of city area became the major concern for the environment and climate. The expansion by sprawl in planned pattern occupied the north-eastern fringe of Kolkata by development of New Town area. The entire development impacted the rise of temperature along with impervious surface area which could be considered as the prime parameters in analyzing the Urbanization and present day environmental condition. The Geospatial Technique helps in analyzing the land use change pattern over the years with incorporation of Landsat8 OLI of 2018, Landsat 7 ETM+ of 2010 satellite data along with software modeling and interpretation. The Built-up area Index (BI) along with Land Surface Temperature(LST)Index on temporal and spatial scale can justify the rate of increase in urbanized area along with rise of temperature by correlation analysis method. The study depicts the analysis of Urban Heat Island condition and its predicts probable impact on future climatic condition of Newtown location in Kolkata.*

***Key Words:** Environment, Urbanization, Built-up area Index, Impervious Index, Land Surface Temperature Index, Urban Heat Island*

---

Date of Submission: 15-06-2018 Date of acceptance: 30-06-2018

---

## I. Introduction

The continuous increase of temperature in urban areas along with increase percentage of impervious cover due to human encroachment is taking toll on the environment and climate. The rapid conversion of natural vegetative cover and wetland by development of transport and communication system from the city towards semi-urban areas by construction of metro railways, major arterial roadways, recreation centres, commercial and residential complexes also disturbing the balance of ecosystem. This scenario is prominent by expansion of the Kolkata City towards the eastern fringe by the conjunction of Rajarhat, Newtown and its surrounding areas in North 24 Parganas district Map of West Bengal of India. This phenomena fulfils the condition of Urban Heat Island (UHI) study which was intiated by Nieuwolt (1966) to analyse the scenario of southern Singapore. Later on many research and studies were conducted on UHI as well as the vertical and horizontal expansion of urban areas by putting importance on temperature change in specific area over the years Cao et al. (2008).The land use classification system also plays a pivotal role by segregation of unit of land for particular type of land use with areal coverage. These land use classes provides a clear picture of spatial as well as temporal change through conversion of natural land by anthropogenic processes from the past to present years. This change adversely impacts the climate, environment and ecology of an area which justifies the reason of decrease rate of evapotranspiration, increase in temperature and degradation of vegetal cover as well as wetland. The Geospatial Technology along with its sound data Landsat ETM+ and Landsat OLI and modelling through the analysis of thermal band over specific period of time clearly highlights the temperature change in urban area by application Land Surface Temperature Index.The application of Normalized Difference Builtup Index also states the spatial and temporal change by extraction of built-up areas over the years with Shortwave Infrared Wavelength Band and Infrared Band. The Normalized Difference Vegetation Index indicates the health of vegetation cover over the years with the application of Infrared and Red Wavelength. The comparative study between Vegetation Index and Surface Temperature Index, Builtup Area Index indicates provides clear picture of Urban Heat Island. The empirical analysis by statistical calculation justifies the outcome of Geospatial analysis.

## II. Study Area

The study area Rajarhat and surrounding is The Block Development Community which belongs to Barasat Sadar Subdivision of North 24 Parganas which located at 22°36′37″N 88°31′37″E.The area is situated at the eastern part of The Hooghly River in Gangetic Delta plain. The soil type is dominated by Gangetic influence and mostly alluvial in nature. The elevation of the area approximately 5-30ft.The monsoonal climatic change affects the rainfall variation through out the area. The maximum rainfall occurs during the month of August. Maximum temperature exceed 40 °C (104 °F) during May–June and Winter prevails from the month of

December to early February. The area is influenced by Tropical wet to dry climate. According to 2011 Census the population density is 2,700/km$^2$ and approximated area 69.09 km$^2$.The Newtown is a planned city in satellite pattern which has occupied the north-eastern area of Rajarhat. The area is considered as Information Technology hub and was planned since 1990s by conversion of cultivable land and water bodies into built up land.

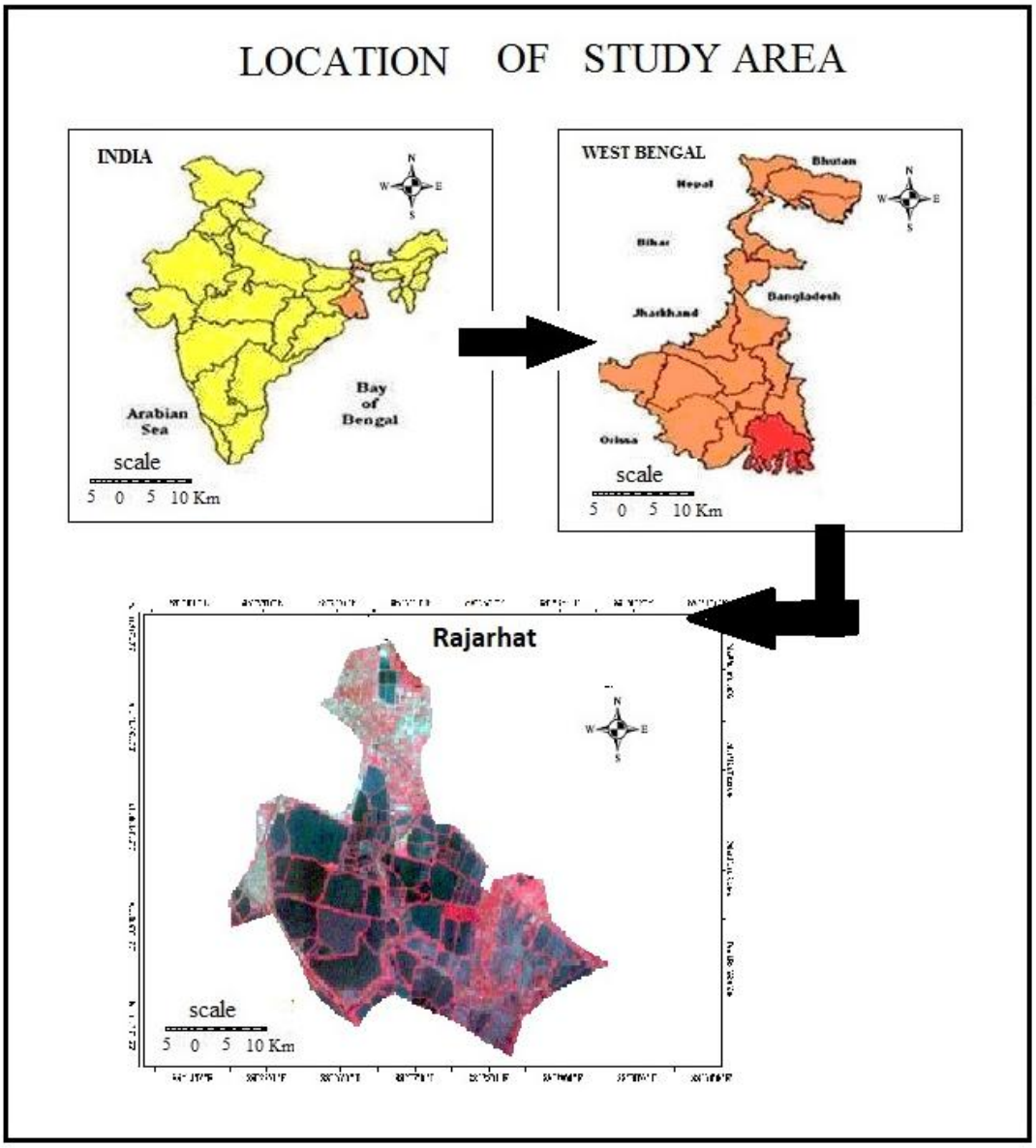


**Figure.1.Location Map Of The Study Are**

### 3.Data and Methodology

The study can be carried out based on the both primary and secondary data collected from different government authorities. The different software and data uses are given in the tabulated form(table 1):

**Table 1: Data & Software to be Used**

| | **Type of Data & Software** |
|---|---|
| **Data to be Used** | **Landsat ETM+ satellite data of year 2010 from Earth Explorer(USGS Glovis)** |
| | **Landsat OLI satellite data of 2018from Earth Explorer(USGS Glovis)** |
| | **Google Earth Data of 2018** |
| **Software to be Used** | Arc GIS 10.4 |
| | Erdas Imagine 2014 |
| | Statistical Software |
| | Global Positioning System |

**3.1Methods**

The methodology developed in this study is pertaining to analysis based on various operations on graphic and non graphic data. The entire Process is summarised in the explanation.

**3.1.1. The Land use Classification System**

Classification over the Multi temporal images of Landsat ETM+ of the year 2010 and Landsat OLI of 2018 were run on Image processing software Erdas Imagine 2014 with maximum likelihood classifier and training set were provided on real field knowledge of landuse over the study area. The conversion of area from natural land to built up area were marked from the raster attribute table. The northern part of Rajarhat near Newtown and western part and eastern margin shows the expansion of urbanized area from the year 2010 to 2018.The change is significant on temporal and spatial scale.

**3.1.2. Indices Analysis**

**3.1.2.1Normalized Difference Vegetation Index**

This index deals with the Reflectance of green cover in Near Infrared Band based on structure and water content present in the cover and absorption of Red Band due to presence of chlorophyll in the vegetation. The vegetation health degradation was prominent due to encroachment of urban land from the year 2010 to 2018.

NDVI= NIR – R / NIR+ R (1)

(+1 = Good condition of vegetation health)

(-1 = Poor Condition in Vegetation Health)

**3.1.2.2Normalized differential built up index (NDBI)**

The NDBI was used to extract the built up area over the study area and have indices range from -1 to 1.In the Landsat ETM+ and Landsat OLI false colour imageries the high reflectance were observed at Band $5^{th}$ (1.55-1.75 µm) and Band $7^{th}$ (2.09-2.35 µm).In the OLI image Band 5 (0.85 - 0.88 µm) and band 6 (1.57 - 1.65 µm) are alike. The Built-up land use of the study area were heighted with high spectral reflectance Zha et al. (2003)

NDBI = (SWIR – NIR)/(SWIR + NIR) (2)

**3.1.2.3Land Surface Temperature Index(LST) for Landsat 8 OLI Satellite image**

Land Surface Temperature indicates the temperature of the ground surface. Sometimes it is considered as the mixture of vegetation and bare land temperature due to change in diurnal variation in illumination and other climatic effect. The LST represents surface air temperature of the study area.The modelling of LST were generated on Landsat ETM+ satellite data of 2010 and Landsat OLI 2018 satellite data to mark change in temperature variation due to urban land expansion over the study area. The process can be simplified as:

**a)LST Calculation for Landsat 8 OLI Satellite image**

**Step.1.Conversion of DN value to Radiance**

DN of Band 10 and 11 of Landsat OLI 2018 satellite data were respectively converted to TOA Reflectance.The Radiance values were collected from the Meta data of the satellite image.

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

where:

$L_\lambda$ = TOA spectral radiance (Watts/( m2 * srad * µm))

$M_L$ = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)

$A_L$ = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the bandnumber)

$Q_{cal}$ = Quantized and calibrated standard product pixel values (DN)

**Step.2 Conversion of Reflectance to Brightness Temperature Values**

The reflectance values were converted to Brightness temperature.The values of K1_CONSTANT_BAND_10, K2_CONSTANT_BAND, K1_CONSTANT_BAND and K2_CONSTANT_BAND_11 were collected from Meta data of the satellite image.

$$T = \frac{K2}{ln\left(\frac{K1}{L_\lambda} + 1\right)} \quad (4)$$

*where:*
T =Top of atmosphere brightness temperature (K)
$L_\lambda$ =TOA spectral radiance (Watts/( m2 * srad * μm))
$K_1$ =Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number)
$K_2$ =Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number)

The final results were derived by showing Maximum and minimum range of temperature. The temperature were converted to degree Celsius from Kelvin.

**b)LST Calculation for Landsat 7 ETM+ Satellite Image**
**Step.1.Conversion of DN values to Radiance**
The DN values were collected from meta data file and converted to radiance values.

$$L_\lambda = ((LMAX_\lambda - LMIN_\lambda)/(QCALMAX - QCALMIN)) * (QCAL - QCALMIN) + LMIN_\lambda \quad (5)$$

Where:
$L_\lambda$ is the cell value as radiance
QCAL = digital number
$LMIN_\lambda$= spectral radiance scales to QCALMIN
$LMAX_\lambda$ = spectral radiance scales to QCALMAX
QCALMIN = the minimum quantized calibrated pixel valuetypically = 1)QCALMAX = the maximum quantized calibrated pixel valu(typically = 255)

**Step.2.Radiance to Satellite Brightness Temperature**
The emissivity was corrected Artis and Carnahan (1982).and calculation was followed by

$$T = \frac{K2}{Ln\left(\frac{K1}{L_\lambda} + 1\right)} \quad (6)$$

TB=At-satellite brightness temperature (K)
Lk= Spectral Radiance in W.m2.sr1.lm1
K1 and K2 =K2 and K1 are two pre-launch calibration constants.
(For the Landsat 7 ETM+6.2 band, these compute to 1282.71 K an 666.09 W.m2.sr1.lm, respectively). The Land Surface Temperature was calculated by Artis and Carnahan (1982).

$$LST = T_B/[1 + \{(\lambda * TB/\rho) * \ln \epsilon\}] \quad (7)$$

where St = land surface temperature (LST) in Kelvin, k = wavelength of emitted radiance in meters (for which the peak response and the average of the limiting wavelengths (k = 11.5 lm) (Markham and Barker, 1985) is used, q = h * c/r (1.438 * 102m K), r = Boltzmann
constant (1.38 * 1023 J/K), h = Planck's constant (6.626 * 1034 J s),
and c = velocity of light (2.998 108 m/s) and e = emissivity (ranges between 0.97 and 0.99)
The Land Surface Emissivity was calculated as: Land surface emissivity = 0.004*Pv+0.986 (8)

Where Pv was calculated from NDVImin and NDVImax. The LST result was converted to degree Celsius from Kelvin.

### 3.1.3. Statistical Analysis of Surface Temperature by Empirical Method

The surface temperature was derived statistically by applying mathematical formula by derivation to check analysis or fluctuation of Temperature over the year from satellite derived information.

## III. Results and Discussion

### 4.1. Landuse Classification and Change Detection of Rajarhat Area and surrounding

The Landuse Classification was generated with six classes on the study area like: Wetland with Vegetal Cover, Roadways, Densely Populated Area, Densely Populated Area, Dispersed Builtup land, Fallow Land. The change of spatial extent over temporal period were visible in the attribute table of supervised classification by application of maximum likelihood classifier. From the year 2010 to 2018 the wetland with vegetal cover were converted to built up area huge percentage such as 86%,Densely populated area expanded by 3.4%,Fallowland decreased by 9.4%,The dispersed settlement occupied in the south-eastern part of the study area. The northern side and western side of the area is dominated by high concentration of residential and as well as commercial, industrial buildings.

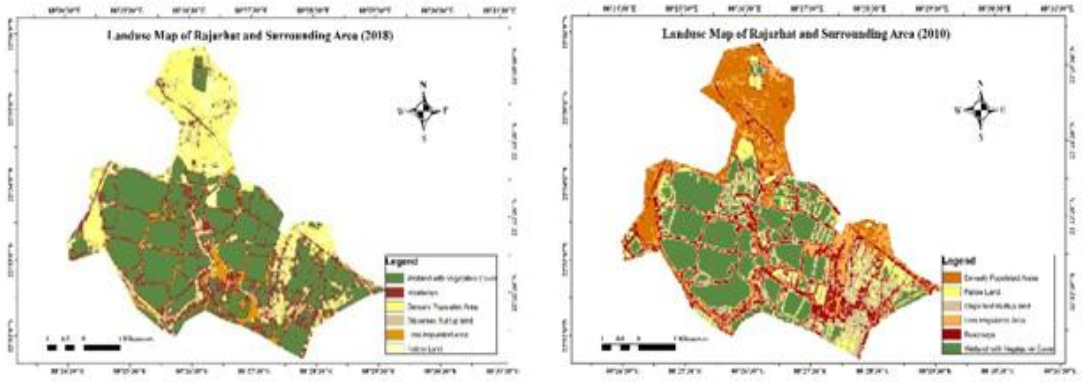


**Figure.2.Landuse Classification Map of year 2018, 2010**

### 4.2. Normalized Difference Vegetation Index

NDVI Index shows vegetal heath condition over Rajarhat and surrounding area. From the spectral reflectance of vegetation the NDVI range for the year 2010 was derived on Arc GIS software poor health 0.183 to good health upto 0.84.The high reflectance was noticed at the central to southern part of the area. Whereas in comparison the NDVI range for 2018 was derived as -0.083 to 0.35.The degradation of health was clearly marked over the years on the multi temporalsatellite images. .

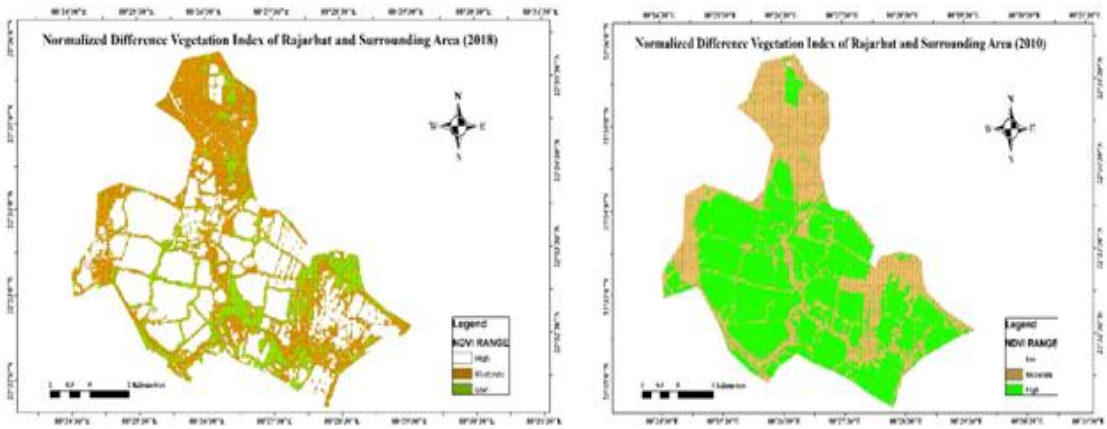


Figure.3.Normalized Difference Vegetation Index of 2018, 2010

**4.3. Normalized Difference Builtup Index**

The NDBI Index spectral reflectance shows moderate reflectance in the northern and western part of the study area. Low reflectance is visible near southern part. From the year 2010 to 2018 the expansion of built up area was clearly visible in both the years NDBI.NDBI was used to extract the built up area by using Shortwave Infrared wavelength in satellite images. This derived result of NDBI justifies the derived range and condition with NDVI on the study area. Both are indicating inverse relation with each other.

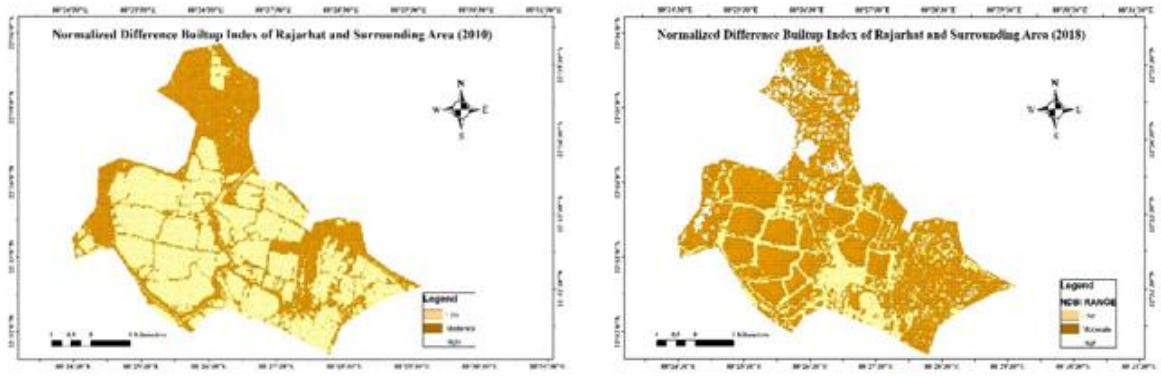


**Figure.4.Normalized Difference Built-up Index 2018 and 2010**

**4.4.Land Surface Temperature**

Land Surface Temperature of November,2010 shows maximum air temperature is 26°C and minimum is 21°C in the study area. Whereas the 2018,February satellite image LST reflects maximum air temperature is 36°C and minimum temperature 14°C.The blue colour in both 2010 and 2018 LST indicates high temperature. These derived temperature from the LST calculation was justified in comparison with change in Land use pattern from the year 2010 to 2018.Apart from the land use, rapid fluctuation in LST over the years established positive correlation with NDBI and negative with NDVI.

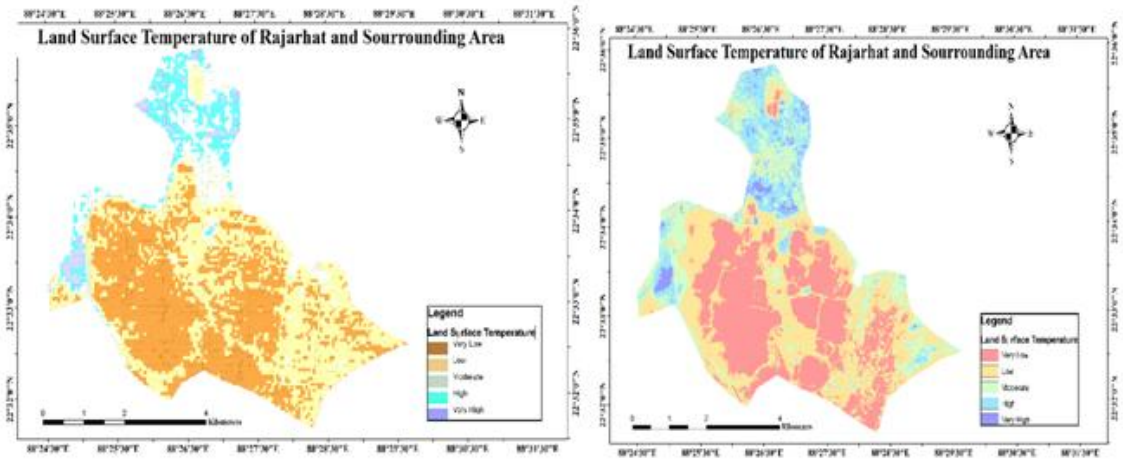


**Figure.5.Land Surface Temperature of from 2010 to 2018**

**4.5.Statistical Analysis of Surface Temperature by Empirical Method**

The surface temperature were derived empirically to match Software modelling of Land Surface Temperature which was presented through Table.2

**Table.2.Empirical Analysis of Land Surface Temperature of 2018 and 2010 by using Thermal Band Information**

| | **Landsat8 OLI of 2018** | | **Landsat 7 ETM+ of 2010** | |
|---|---|---|---|---|
| Parameter | BAND 10 | BAND 11 | BAND 61 | BAND 62 |
| LMAX | 0.18488 | 0.18488 | 17.04 | 12.65 |
| LMIN | 0.1 | 0.1 | 0.1 | 3.2 |
| QCALMAX | 255 | 255 | 255 | 255 |

| | | | | |
|---|---|---|---|---|
| QCALMIN | 1 | 1 | 1 | 1 |
| K1 ( in $Wm^{-2}sr^{-1}\mu m^{-1}$) | 774.8 | 480.9 | 666.09 | 607.76 |
| K2(in K) | 1321.08 | 1201.14 | 1282.71 | 1260.56 |
| Radiance multiplier (m) | 0.0003342 | 0.0003342 | 0.0671 | 0.0372 |
| Radiance add(c) | 0.1 | 0.1 | -0.0671 | 3.1628 |
| Radiance leaving earth (Lλ) | 0.0003342DN+0.1 | 0.0003342DN+0.1 | 0.0671DN-0.0671 | 0.0372DN+3.1628 |
| Land Surface Temperature (T)(in K) | $\frac{1321.08}{\ln(774.8/ L\lambda +1)}$ | $\frac{1201.14}{\ln(480.89/ L\lambda +1)}$ | $\frac{1282.71}{\ln(666.09/ L\lambda +1)}$ | $\frac{1260.56}{\ln(607.76/ L\lambda +1)}$ |
| Land Surface Temperature (T)(in $^{O}C$) | T - 273 | T - 273 | T - 273 | T - 273 |

## IV. Discussion

From the above resulted parameter of Land use Classification, NDVI, NDBI, LST the decision could be followed that Rajarhat and its surrounding area might have started expansion with specific plan implementation by The Govt. of West Bengal. But this expansion is imposing serious threat to the environment and as well as the climate. The sharp air temperature increase from within the span of eight years along with random encroachment of human population from the core of the city towards the fringe area, uncontrolled migration at semi-urban region by pull factor are the indicator of non-judicial use of natural space. The inverse relation of NDVI and NDBI and NDVI with LST clearly satisfies the condition for Rajarhat and its surrounding area in progression of Urban Heat Island within very short span of time.

## V. Conclusion

The study finding could be concluded on the note that Rajarhat and its surround area requires immediate measures and policies by The Government to safeguard the environment and climate from further degradation. Hapazard vertical and horizontal development is going against the plan which was initiated by The Government. Environmental awareness is much in requirement to plan a sustainable development and save the balance of ecology in near future.

## Reference


[1]. Artis, D.A., Carnahan, W.H., 1982. Survey of emissivity variability in thermography of urban areas. Remote Sens. Environ. 12, 313–329.

[2]. Cao, L., Li, P., Zhang, L., Chen, T., 2008. Remote sensing image-based analysis of the relationship between urban heat island and vegetation fraction. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B7. Beijing 2008.

[3]. Effat, H., Hassan, O., 2014. Change detection of urban heat islands and some related parameters using multi-temporal Landsat images; a case study for Cairo city, Egypt. Urban Climate Urban Climate 10 (2014), 171–188.

[4]. Markham, B.L., Barker, J.K., 1985. Spectral characteristics of the LANDSAT Thematic Mapper sensors. Int. J. Remote Sens. 6, 697–716.

[5]. Nieuwolt, S., 1966. The Urban Microclimate of Singapore. J. Trop. Geogr. 22, 30– 37.Ogashawara, I., Brum Bastos, V.D.S., 2012. A quantitative approach for analyzingtherelationship between urban heat islands and land cover. Remote Sens. 2012 (4),3596–3618.

[6]. Pal .Swadesh,Ziaul S.K,2017.Detection of land use and land cover change and land surface temperature in English Bazar urban centre,The Egyptian Journal of Remote Sensing and Space Sciences 20,125–145

[7]. Ramachandra, T.V., Kumar, U., 2010. Greater Bangalore: emerging urban heat island. GIS Dev. 14 (1), 86–104.

[8]. Tan, K.C., San Lim, H., MatJafri, M.Z., Abdullah, K., 2010b. Landsat data to evaluate urban expansion and determine land use/land cover changes in Penang Island, Malaysia. Environ. Earth Sci. 60 (7), 1509–1521.

[9]. Zha, Y., Gao, J., Ni, S., 2003. Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. Int. J. Remote Sens. 24 (3), 583–594

[10]. Zhang, H., Qi, Z.F., Ye, X.Y., Cai, Y.B., Ma, W.C., Chen, M.N., 2013. Analysis of land use/land cover change, population shift, and their effects on spatiotemporal patterns of urban heat islands in metropolitan Shanghai, China. Appl. Geogr. 44, 121–133.


IOSR Journal of Applied Physics (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

Dr. Abhijit Pandit.” Probable Environmental Impact Analysis through Change in Land Use Pattern and Urbanization by Geospatial Technique .” IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 3, 2018, pp. 56-62.