International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 7 ǁ 2021 ǁ PP. 77-83

Temporal analysis of Normalised Differential Built up Index and Land Surface Temperature and its link with urbanisation: A case study on Barrackpore sub-division, West Bengal

Dr Rimi Roy[1] and Suhel Sen[2]
[1](Department of Geography, Vivekananda College, Madhyamgram, West Bengal, India)
[2](Department of Geography, Vivekananda College, Madhyamgram, West Bengal, India)

Abstract:
Urbanisation is one of the backbones of development. This phenomenon has been occurring at an accelerated rate with increase in population and at the same time is also triggering the problem of urban heat island which leads to a marked rise in the temperature within the urban areas. Barrackpore sub-division in North 24 Parganas of West Bengal has experienced urbanisation and has also experienced a subsequent rise in urban heat island incident since past few decades. An attempt has been made in this paper to analyse the temporal scenario of urbanisation and heat island effect through the application of geospatial techniques. By using such techniques, Normalised Difference Built up Index (NDBI) Land Surface temperature (LST) maps of the study area were generated for the year 1999 and 2010 and a correlation between the two was computed. The study revealed that with change in time, there has been an increase in the built-up area and heat island phenomena and there exists a very strong positive relationship between the NDBI and LST. The study also revealed that urbanisation has played a dominant role for such increasing trend of NDBI and LST values.
Keywords: *Urbanisation, NDBI, LST, Positive relationship.*
Software used: *ERDAS Imagine 2014 and ArcGIS 10.3*

Date of Submission: 06-07-2021 Date of acceptance: 19-07-2021

I. INTRODUCTION

Urbanisation act as the major indicator of development. With change of time, population is increasing rapidly and the rate of urbanisation is also getting accelerated at same pace. In spite of being an important indicator of human development, urbanisation is triggering the problem of urban heat island within the city area (Roy Dey & Basak, 2020) and leads to environmental degradation (Chatterjee, 2020). The transformation of natural landscapes into urban landscapes through concretization is allowing more heat to get trapped within the city area. Roads, pavements, skyscrapers and cemented construction in the urban areas allow more heat to get trapped within it during the day time and this additional heat raises the temperature of the cities in comparison to their rural surroundings giving rise to urban heat island. An attempt has been made in this paper to analyse the temporal scenario of the Normalised Difference Built Up Index (NDBI) and urban heat island of Barrackpur sub division of North 24 Parganas of West Bengal for the years 1999 and 2010. A relationship between NDBI and urban heat island has also been drawn and the role of urbanisation for such higher NDBI and LST values has also been discussed. The task has been done by using geospatial technique by using multi-temporal Landsat 5 images for the years 1999 and 2010. The main objectives of the study are highlighted below: -

1. To analyse the trend of NDBI of the study area in two years selected for study.
2. To analyse the trend of LST of the study area in the two years selected for study.
3. To derive the relationship between NDBI and LST of the years taken for study.
4. To analyse the relationship of urbanisation with NDBI and LST for the years under study.

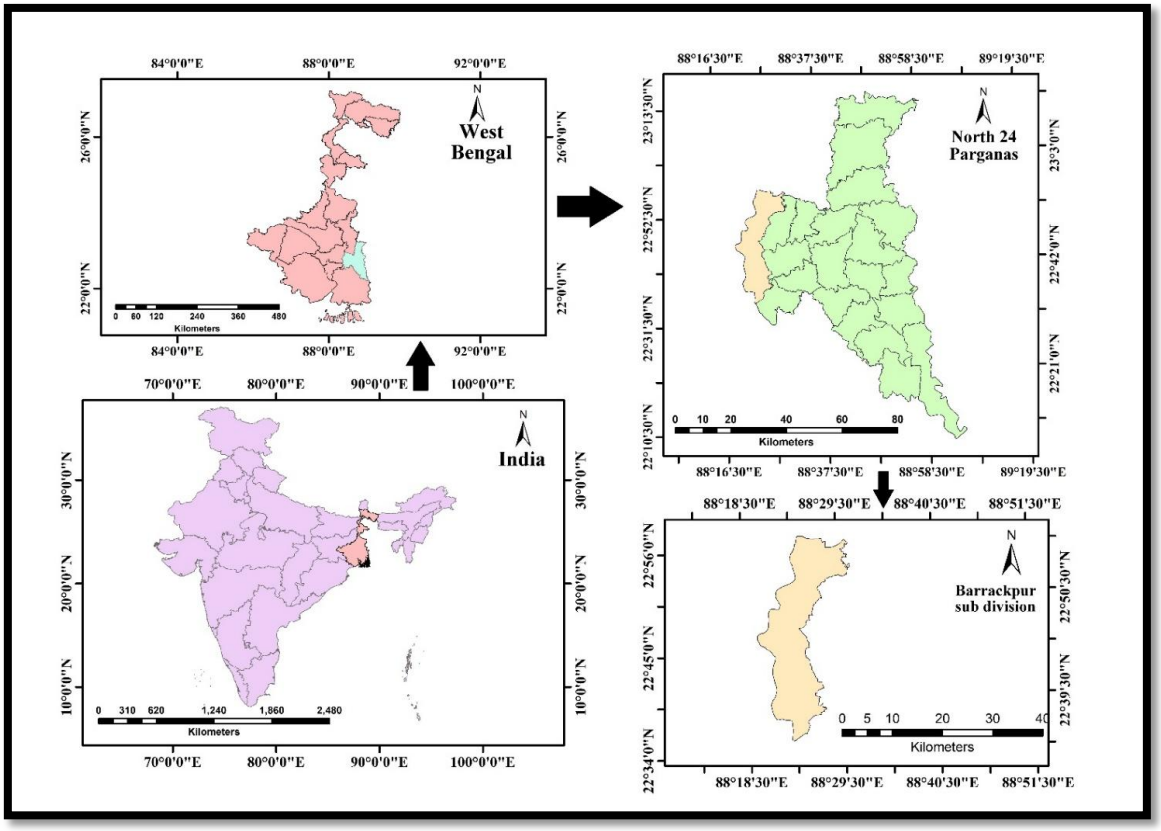

Figure 1: Location Map of Study Area

II. METHODOLOGY

In order to fulfil the task, Landsat 5 Thematic Mapper Satellite images were downloaded from USGS Earth Explorer for the years of 1999 and 2010. NDBI and Land Surface Temperature maps were prepared using proper algorithms using ERDAS Imagine 2014 and ArcGIS 10.3 software. Graphs were prepared in MS Excel. Finally, maps and graphs were analysed to arrive at the necessary results.

Table 1: Details of Satellite images downloaded

Acquisition date	Sensor and Satellite	Reference System/path/row
1999/12/25	Landsat 5 TM	UTM -45N/138/44
2010/02/06	Landsat 5 TM	UTM-45N/138/44

Source: USGS Earth Explorer

III. RESULTS AND DISCUSSIONS

Since the study is based on a temporal context, two years of 1999 and 2010 were taken for study and the following trend was noticed.

Year 1999:

In 1999, it can be seen that areas having lower NDBI values (-0.48 to-0.09) are seen in the form of pockets with its maximum concentration in the eastern part (Fig 1A). Areas with moderate NDBI values (-0.08 to 0.09) can be seen dominating the central portion of the map with small patches and pockets in the north east and southern portion (Fig 2A). However, areas having high NDBI values (0.1 to 0.59) can be seen in the north of the study area due to the occurrence of fallow lands. Higher values are also seen in patches along the bank of river Hugli and again a higher concentration is seen in the southern portion of the area due to dominance of built-up areas.

In 1999, it is also seen that areas having higher NDBI values are exhibiting higher Land Surface Temperature (Fig 2B) and hence it can be said that areas with higher NDBI values are indicating the occurrence of heat islands.

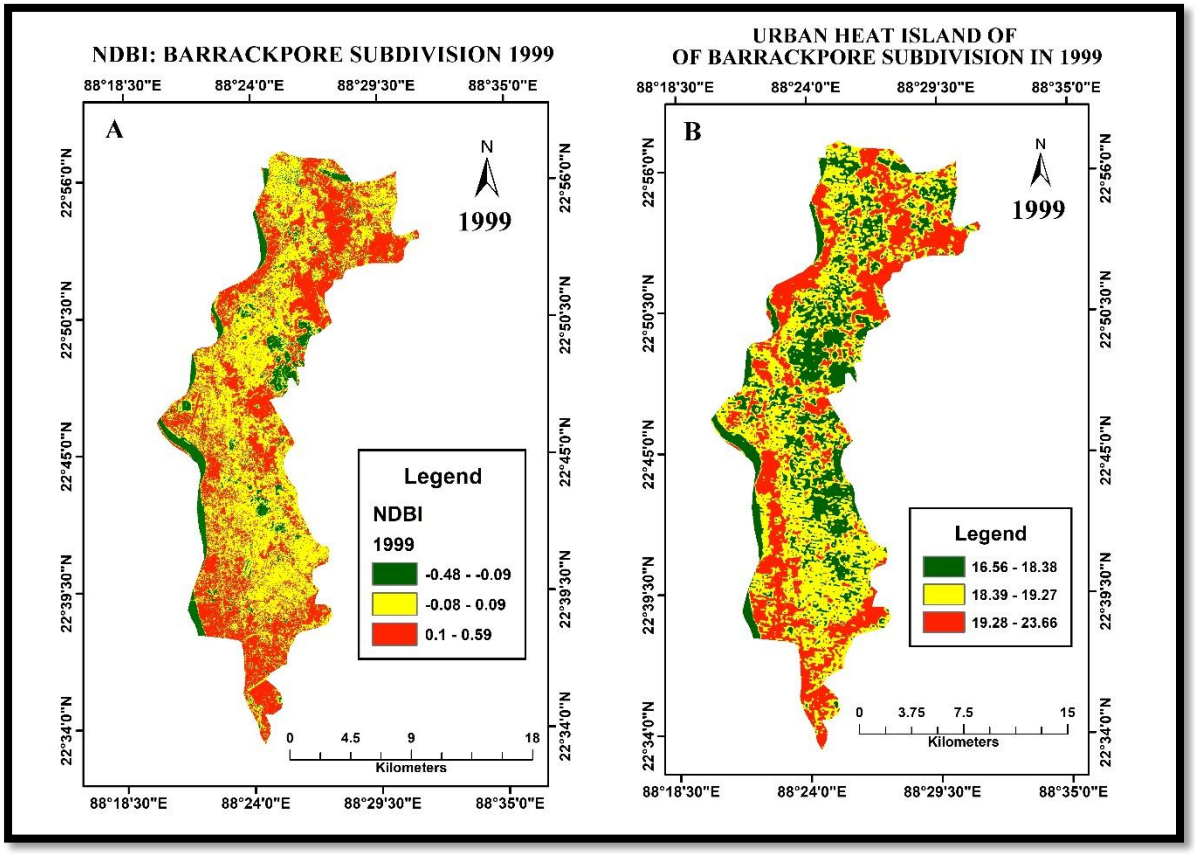

Figure 2: NDBI and Urban Heat Island scenario of Barrackpore sub-division in 1999

Year 2010:

In 2010, it can be seen that areas having lower NDBI values (-0.5 to-0.07) are seen in the form of pockets with its maximum concentration in the eastern part (Fig 3A). Areas with moderate NDBI values (-0.06 to 0.01) can be seen dominating the central portion of the map with small patches and pockets in the north east (Fig 3A). However, areas having high NDBI values (0.11 to 0.59) can be seen in the north of the study area due to the occurrence of fallow lands. Higher values are also seen in patches along the bank of river Hugli and again a higher concentration is seen in the southern portion of the area due to dominance of built up areas.

In 2010, it is also seen that areas having higher NDBI values are exhibiting higher Land Surface Temperature (Fig 3B) and hence it can be said that areas with higher NDBI values are indicating the occurrence of heat islands.

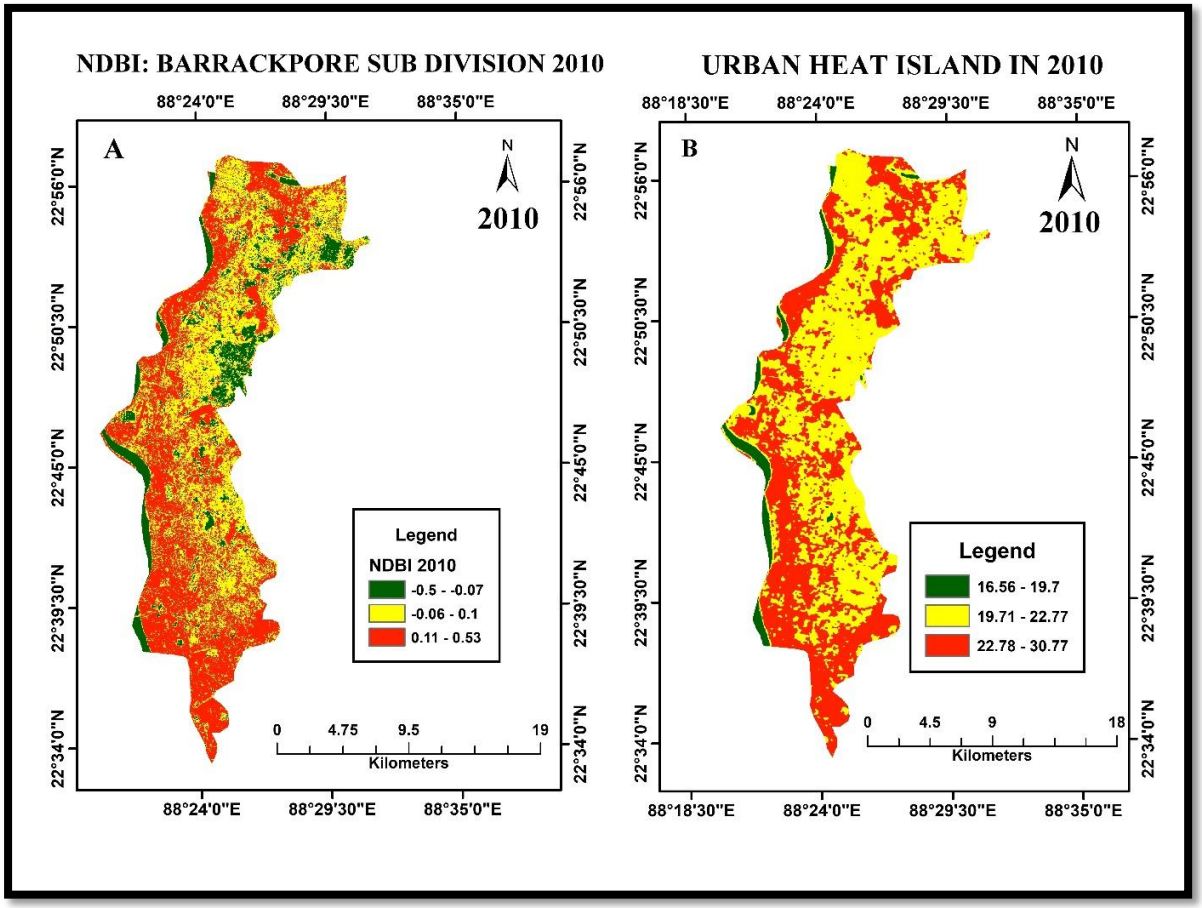

Figure 3: NDBI and Urban Heat Island scenario of Barrackpore sub-division in 2010

Analysis of NDBI and land surface temperature in temporal perspective:

From the above discussions, it has become clear that Barrackpore sub division has experienced higher NDBI and higher Land Surface Temperature (Heat Islands) due to prevalence of built-up areas and occurrence of fallow lands. It has also been seen that with change in time there has been a subsequent rise in the total area having higher NDBI values and heat islands between 1999 and 2010 (Shekhawat, Dadhich, & Goyal, 2018).
In 1999, the total area having higher NDBI value was 131.89 square kilometres and in 2010 this area increased to 153.66 square kilometres (Fig 4)

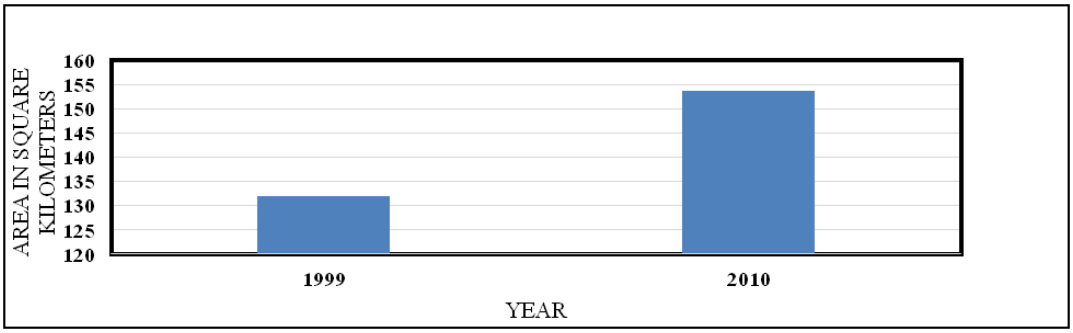

Figure 4: Temporal change of areas with higher NDBI values between 1999 and 2010

Similarly, an increasing trend in areal coverage of urban heat island has also been noticed. In 1999, total area experiencing urban heat island effect in Barrackpore sub division was 95.21 square kilometres and in 2010, this areal coverage has increased to 139.63 square kilometres (Fig 5). The highest temperature within the study area in 1999 was 23.6°C and it increased to 30.7°C in 2010.

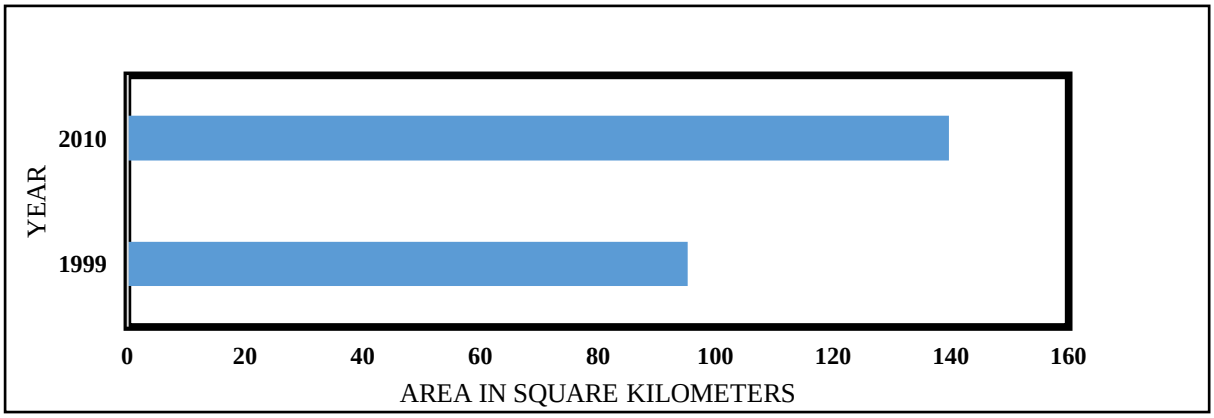

Figure 5: Temporal change in Heat Island areas between 1999 and 2010

Hence, it can be seen that there has been an increase both in areal coverage of NDBI and Heat Islands between the years 1999 and 2010. It is also seen that in 1999, about 72% of total area with higher NDBI has experienced the urban heat island effect. In 2010, this share increased to become 91%.

Relation between NDBI and heat island:

From the above discussions, it has become clear that area under high NDBI values and heat island have increased with time. In 1999, the total area having higher NDBI value was 131.89 sq km and in 2010 this area increased to 153.66 square kilometers. Similarly, an increasing trend in areal coverage of urban heat island has also been noticed. In 1999, total area experiencing urban heat island effect in Barrackpore sub division was 95.21 square kilometers and in 2010, this areal coverage has increased to 139.63 sq km. Both these phenomena have been exhibiting a rising trend (Fig 6).

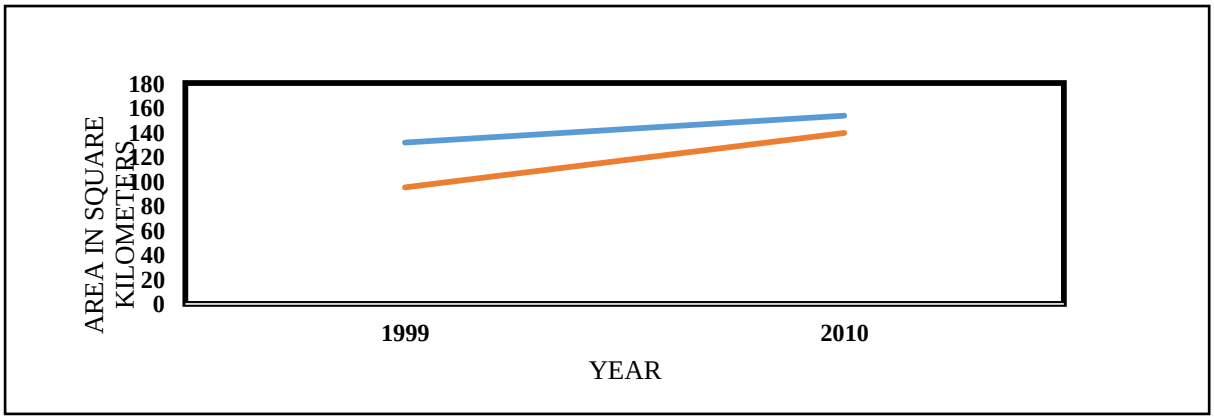

Figure 6: Relation between NDBI and Heat Island of Barrackpore Sub division

There exists a strong positive correlation between NDBI and urban heat island in both the years of 1999 and 2010 with R^2 values of 0.951 and 0.977 respectively (Malik, Shukla, & Mishra, 2019). (Fig 7)

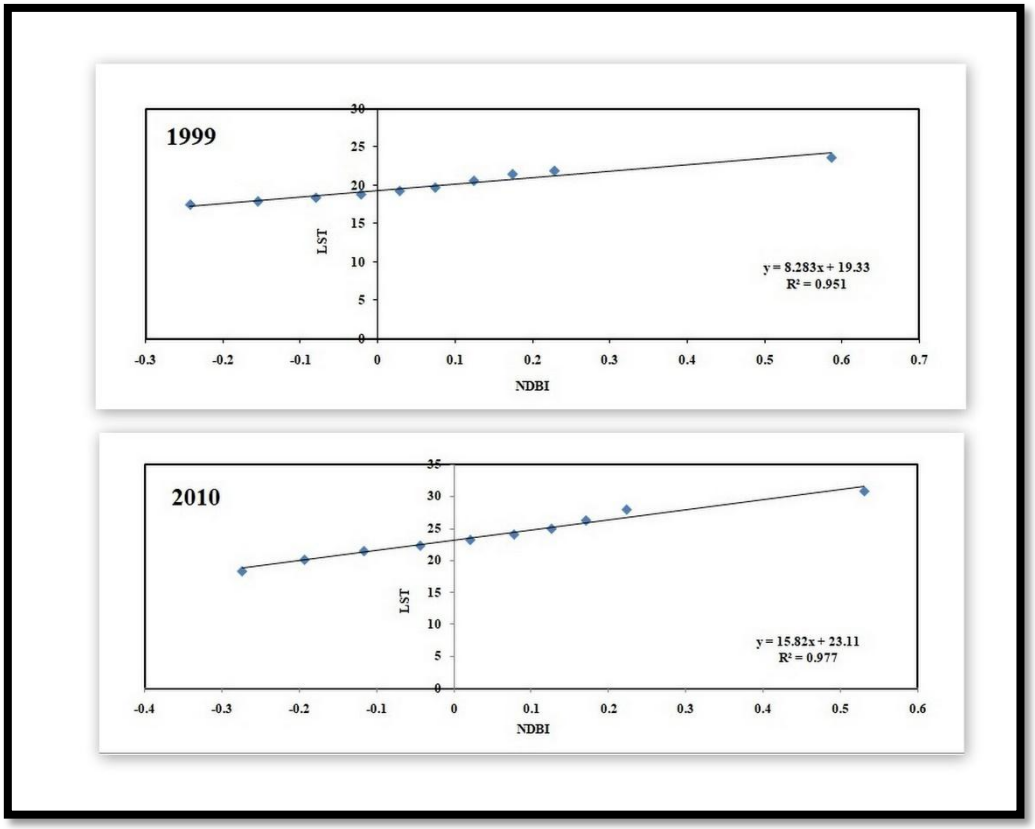

Figure 7: Existence of Correlation between NDBI and Heat Island of Barrackpore sub division

Role of urbanisation for higher NDBI values and heat island:

High NDBI values and high urban heat island effect are considered to be closely linked with the phenomenon of urbanisation. When urbanisation takes place, there is increase in built up areas within a region. With increase in built up area in a region, NDBI values increase. Increase in built up areas also increases the incidence of urban heat island.

However, in Barrackpore sub division, two major factors were responsible for high NDBI values and greater incidence of urban heat island. They were prevalence of built up areas and presence of fallow land. In 1999 it is seen that, about 95.21 square kilometres area was under the effect of heat island while about 24.24 square kilometres of built-up area was located within this heat island area (25.79% of total built up area of 93.96 square- kilometres in 1999). In 2010, the area under urban heat island increased to 139.63 square kilometres and built-up area located within the urban heat island zones also increased to 63.27 square kilometres (57.91% of total built up area of 109.24 square kilometres in 2010). Similar observations were noticed in case of NDBI values. In 1999, about 131.89 square kilometres area was having high NDBI values and built-up area of about 30.28 square kilometres (32.23% of total built up area of 93.96 square kilometres in 1999) was located within the areas having high NDBI values. In 2010, the area having high NDBI values increased to become 153.66 square kilometres and there was also a significant rise in built up area located within the areas having NDBI values to 65.06 square kilometres (59.56% of total built up area of 109.24 square kilometres in 2010). Hence it can be concluded from the above discussion that urbanisation have become an important cause for higher NDBI values and heat island of the study area in 1999 and 2010. It is shown in table 2.

Table 2: Role of urbanisation in affecting high NDBI and Heat Island

PARAMETER	AREA IN 1999 (SQUARE KILOMETERS)	AREA IN 2010 (SQUARE KILOMETERS)
Areas under high NDBI values	131.89	153.66
Areas under Heat island	95.21	139.63
Total built up area	93.96	109.24
Built up area within high NDBI value zone	30.28	65.06
Built up area within Heat island	24.24	63.27

Major findings:

- There has been an increase in higher NDBI values between 1999 and 2010 in Barrackpore sub-division.
- There has been an increase in Urban Heat Island phenomena between 1999 and 2010 in Barrackpore sub-division.
- Areas with higher NDBI values have exhibited heat island effects in both the years and both these parameters have exhibited a rising trend between 1999 and 2010 and hence it can be said NDBI and heat island phenomena are directly related to each other. There exists a strong positive correlation between NDBI and LST in both the years taken for study.
- Urbanisation has played a vital role for higher NDBI values and heat island phenomena in both the years of 1999 and 2010 in Barrackpore sub-division area.

IV. CONCLUSION

It can be concluded by saying that with increase in urbanisation, the incidence of urban heat island will increase. So, the process of urbanisation has to be done in a planned way so that the thermal balance between the city and its adjacent areas can be controlled. This can only be achieved through proper planning strategies of the urban planners. If all these measures are properly taken, then we can move forward in achieving Sustainable Urbanisation.

REFERENCES

[1]. Adhikari AK, Roy TB (2020): **'Application of Geospatial Technology for Assessment of Urban Heat Island: A Case Study of Gangarampur Municipality, West Bengal, India'**. In: Kundu PK (ed) Sustainable Urbanization in East India, 1st edn. Levant Books, India, pp 298-309.

[2]. Chatterjee, S. (2020): **'Spatio-temporal Analysis of Vegetation Health in Siliguri Municipal Corporation Area: A Case Study through NDVI on LANDSAT Imageries'**. In: Kundu PK (ed) Sustainable Urbanisation in East India: Present Trends and Future Concerns. 1st edn. Levant Books, India, pp 358-371.

[3]. Macarof, P and Florian, S. (2017**): 'Comparison of NDBI and NDVI as Indicators of Surface Urban Heat Island Effect in Landsat 8 Imagery: A Case Study of Iasi. Present Environment and Sustainable Development**'. Present Environment and Sustainable Development. 11(2). pp 141-150

[4]. Malik, M S, Shukla, J. and Mishra, S N. (2019). **'Relationship of LST, NDBI and NDVI using landsat-8 data in Kandaihimmat watershed, Hoshangabad, India'**, Indian Journal of Geo-Marine Sciences. 48(01). pp. 25-31.

[5]. Roy TD, Basak A (2020). '**The Emergence of the Urban Heat Island through Remote Sensing Approach: A Case Study of Greater Siliguri, West Bengal, India**'. In: Kundu PK (ed) Sustainable Urbanization in East India, 1st edn. Levant Books, India, pp 349-357.

[6]. Shekhawat, N, Dadhich, A.P. and Goyal, R. (2018): **'Temporal Analysis of Land Surface Temperature and Land Use/ Land Cover using Remote Sensing'**, Journal of Civil Engineering and Environmental Technology. 5(2). pp. 71-77.