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# Impact of Spatio-temporal Variation of Land Features on Temperature Rise: A Study on Dibrugarh District, Assam, India

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**ABSTRACT**

Urbanization is a significant human activity that changes the Earth's land landscape and the degree to which urbanization affects temperature variation depends critically on the built environment, population density and size, human activity, and socioeconomic characteristics of a metropolis. It has long been known that patterns of LULC and thermal characteristics are related, and this link can be used to examine how urbanization affects the urban thermal environment. This research uses a time series of Sentinel and Landsat satellite images to examine the traits of urban growth and how they affect the surface temperature of the land in Dibrugarh District of Assam, India, between 1993 and 2023. The Normalized Difference Vegetation Index (NDVI) has been falling to the negative side, and less green, healthy vegetation has been recorded. Only the year 2003 recorded the availability of healthy vegetation ranging above 0.6 in the NDVI matrix. Due to deforestation and other anthropogenic activities, the average earth surface temperature went up to 0.96 °C from 1993 to 2023, with an average of 0.04 °C annually. These are the results of decreasing green vegetation. The LULC data show an increase of 177.155 $km^2$ of built-up areas with a significant decrease in waterbodies and green vegetation. Although the climatic condition of the district is totally dominated by the monsoon, this temperature rise may cause problems in the near future and will impact agriculture and environmental sustainability.

***Key words:*** *Land-use and Land-cover (LULC), Normalized Difference Vegetation Index (NDVI), Land Surface Temperature, Urbanization, Sustainable environment.*

## Introduction

Urbanization generally refers to the concentration of the human population in discrete areas (Fonseka, *et al*., 2019). This leads to the transformation of land for residential, commercial, industrial, and transportation purposes. Such changes may alter the natural system, giving rise to issues like poor air and water quality, insufficient water availability, and high energy consumption, which leads to the generation of a new phenomenon popularly known as heat islands (Tam, *et al*., 2015). The term heat island is generally associated with the rising temperature of urban areas compared to the surrounding areas due to the concretization of the land surface (Chapman, *et al*., 2017). Such an activity leads to the trapping of the sun because construction materials such as asphalt or concrete have the capacity to absorb 95% of the sun's energy. By observing the pattern of the global temperature in recent years, it can be seen that the temperature and urbanization are positively correlated. Since the Industrial Revolution, Earth's air

([1]Research Scholar, [3]M.Sc. in Geography) temperatures have been rising. While natural variability plays some part, the preponderance of evidence indicates that human activities, particularly emissions of heat-trapping greenhouse gases, are mostly responsible for making our planet warmer.

According to NOAA's 2023 Annual Climate Report, the combined land and ocean temperature has increased at an average rate of 0.11° Fahrenheit (0.06 °C) per decade since 1850, or about 2° F in total. The rate of warming since 1982 is more than three times as fast: 0.36° F (0.20 °C) per decade. Such an increase in temperature may be linked directly or indirectly to the rising population pressure in urban areas (Wang, *et al*., 2014). Fossil fuel use also increased after the war (5 percent per year), boosting greenhouse gases. According to the 2017 U.S. Climate Science Special Report, if yearly emissions continue to increase rapidly, as they have since 2000, models project that by the end of this century, global temperatures will be at least 5 degrees Fahrenheit warmer than the 1901-1960 average and possibly as much as 10.2 degrees warmer. If annual emissions increase more slowly and begin to decline significantly by 2050, models project temperatures would still be at least 2.4 degrees warmer than the first half of the 20th century and possibly up to 5.9 degrees warmer.

In India, global warming has been manifesting in recent years. There is a notable warming trend in northwestern India, beginning in the 1970s and accelerating in the 2000s and 2010s, the study has found. The decadal mean of the daily maximum temperature for April and May in the 2010s was 40 to 42 degrees over large parts of India. In the 1950s, the area with this high temperature was limited, with only a small spot in south-central India touching 41 degrees. The region with a temperature over 40 degrees began to expand in the 1970s and 1980s, while the region with a temperature more than 41 degrees in south-central India has enlarged (Amirtham, 2016).

After a small reduction in temperature in the 1990s, the region with temperatures greater than 40 degrees has expanded dramatically in the 2000s and the 2010s. According to the 2011 census, only 31 percent of the population of India lives in urban areas (Sussman, *et al*., 2019; Mohan and Kandya, 2015). According to the UN's estimates, the urban population of India will be less than 35 percent in 2020 and approximately 40 percent in 2030. By 2030, another 225 million people will be added to the Indian urban areas; this is more than the combined population of Japan and Germany. (Ali, 2020) The size of the country's urban population increased from 11 percent in 1901 to 31 percent in 2011. Here, it can be concluded that with the increasing trends of urbanization, there has been an increase in the temperature over the years (Argüeso, *et al*., 2014).

Climate change projections for Assam indicate that the mean average temperature is likely to rise by 1.7-2.2 degrees Celsius by the mid-century with respect to 1971–2000. The rising urban population as a result of migration from other states has been pressurizing the state in terms of the limited area avail-

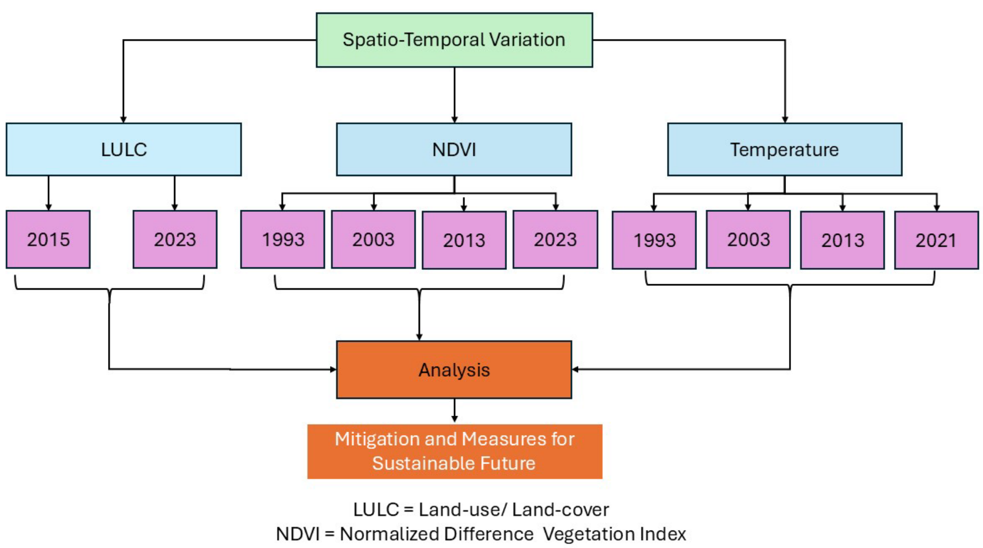


**Fig. 1.** Methodology Flowchart

able. This leads to haphazard urbanization and expansion of the cities. The rise in the standard of living has been directly linked with the increasing number of vehicles that are the producers of greenhouse gases, leading to record-breaking temperatures in recent years.

## Methodology and Data Collection

The secondary material gathered from numerous reliable sources serves as the sole foundation for this investigation. This study examines the relationship between urbanization and rising temperatures in Assam's Dibrugarh District. It is also dependent on human factors, such as the growth of built-up regions and the decline of green vegetation. The Landsat satellites' bands 5 and 4 have been used to compute the NDVI. The Sentinel database provided the land-use and land-cover data, which were then processed using remote sensing and GIS tools (ArcGIS and QGIS). The NASA Power database has been utilized to obtain average monthly and annual land surface temperature data for various years spanning from 1993 to 2021. After compiling all of these characteristics, a final spatiotemporal analysis was completed.

## Study area

Nestled in the easternmost region of Assam, the District of Dibrugarh is encircled by the districts of Dhemaji and a portion of Lakhimpur in the north, Sivasagar and a portion of Arunachal Pradesh state in the south, Tinsukia in the east, and Sivasagar in the west. The Brahmaputra River descends from the Arunachal Pradesh hills in the north and flows into the western region of Assam. There isn't an autonomous subdivision in Dibrugarh; there is just one sadar subdivision. Dibrugarh district is traversed by only one major highway, the NH-37. Dibrugarh and Dispur, the state capital, are 443 kilometers away by road.

# Results and Discussion

## Spatio-temporal Variation of NDVI

Developed as one of the first remote sensing analyti-

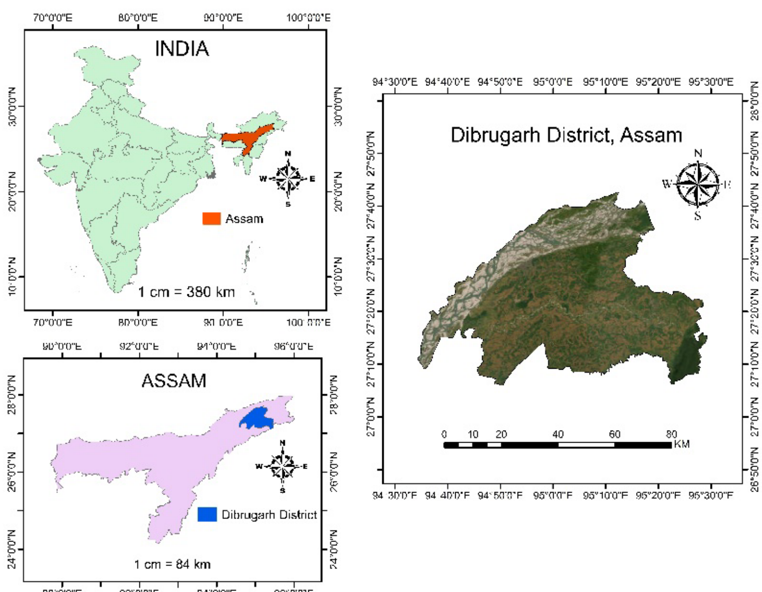


**Fig. 2.** Study Area

**Table 1.** Data Collection

| Parameters | Source | Resolution | Date |
|---|---|---|---|
| Landsat 5TM | USGS Earth explorer | 30 m | 19/12/1993 |
| Landsat 7ETM | USGS Earth explorer | 30 m | 15/12/2003 |
| Landsat 8 OLI | USGS Earth explorer | 30 m | 10/12/2013 and 30/12/2023 |
| LULC map | Sentinel 2B | 10 m | 2015, 2023 |
| Average Monthly Temperature | NASA Power | 10 m | 1993 to 2021 |

cal tools to streamline the complex processes of multi-spectral imaging, the Normalized Difference Vegetation Index (NDVI) is currently the most widely used index for vegetation evaluation (Huang, *et al*., 2021). The fact that any multispectral sensor operating in the visible and near-IR band can be used to calculate an NDVI accounts for its popularity and broad application. NDVI can calculated for Landsat satellites using the following way,

$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}} \text{ or } = \frac{\text{Band 5} - \text{Band 4}}{\text{Band 5} + \text{Band 4}}$$

Rather than showing positive green, healthy vegetation, the NDVI values in this study are typically found to be negative. One possible explanation is the existence of sizable regions with excessively low plant levels beneath sandbars. Another possibility is that there are lots of open spaces that are typically utilized for farming. Low NDVI data indicate the opposite situation in the Dibrugarh district, which receives over 250 cm of annual rainfall on average. It is possible that the Brahmaputra River receives the water directly from rains. Since there isn't much

**Table 2.** NDVI value with area covered of the year 1993 and 2003

| 1993 | | 2003 | |
|---|---|---|---|
| NDVI value | Area ($Km^2$) | NDVI value | Area ($Km^2$) |
| from -0.339 to -0.1134 | 535.7754 | from -0.4341 to -0.1028 | 599.5719 |
| from -0.1134 to -0.03806 | 891.1827 | from -0.1028 to 0.0179 | 947.5695 |
| from -0.0380 to 0.0337 | 840.402 | from 0.0179 to 0.054 | 802.3653 |
| from 0.0337 to 0.1844 | 931.0392 | from 0.054 to 0.232 | 871.49 |
| from 0.1844 to 0.5721 | 23.0882 | from 0.232 to 0.648 | 0.2997 |
| | 3221.488 | | 3221.2964 |

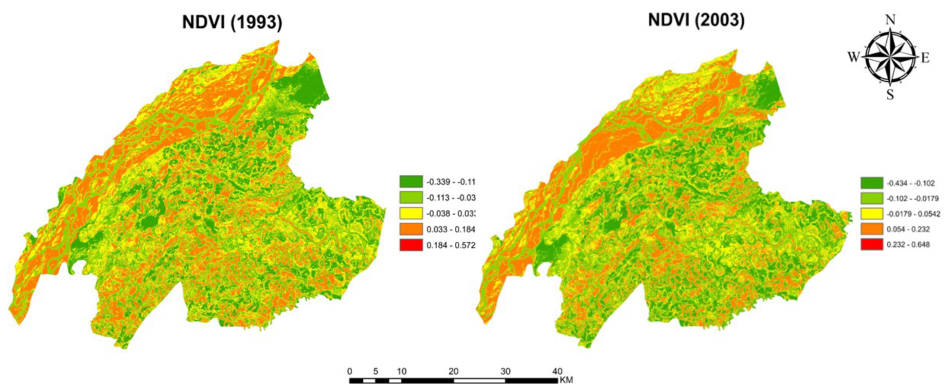


**Fig. 3.** Showing NDVI of year 1993 and 2003

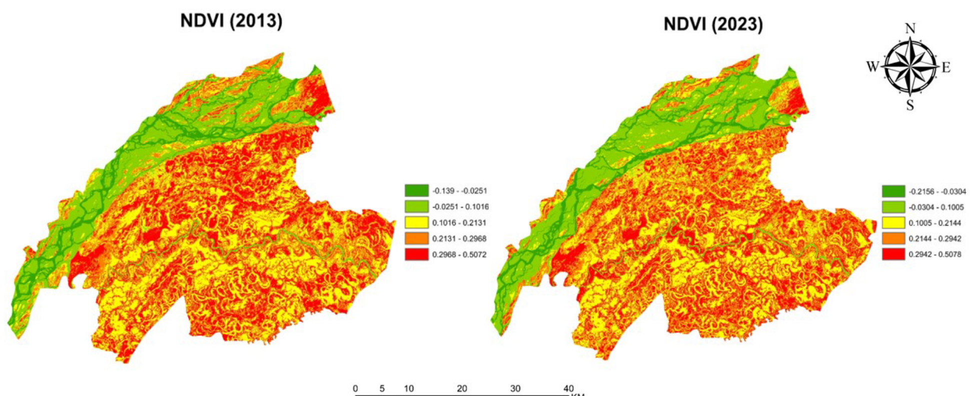


**Fig. 4.** Showing NDVI of year 2013 and 2023

**Table 3.** NDVI value with area covered of the year 2013 and 2023

| 2013 | | 2023 | |
|---|---|---|---|
| NDVI value | Area(Km$^2$) | NDVI value | Area(Km$^2$) |
| from -0.139 to -0.0251 | 193.2705 | from -0.215 to -0.0304 | 188.2602 |
| from -0.0251 to 0.01016 | 501.2631 | from -0.0304 to -0.1005 | 568.9035 |
| from 0.01016 to 0.2131 | 900.5136 | from 0.1005 to 0.2144 | 883.9368 |
| from 0.2131 to 0.2968 | 863.5356 | from 0.2144 to 0.2942 | 896.4117 |
| from 0.2968 to 0.5072 | 761.9157 | from 0.2942 to 0.507 | 684.3429 |
| | 3220.499 | | 3221.8551 |

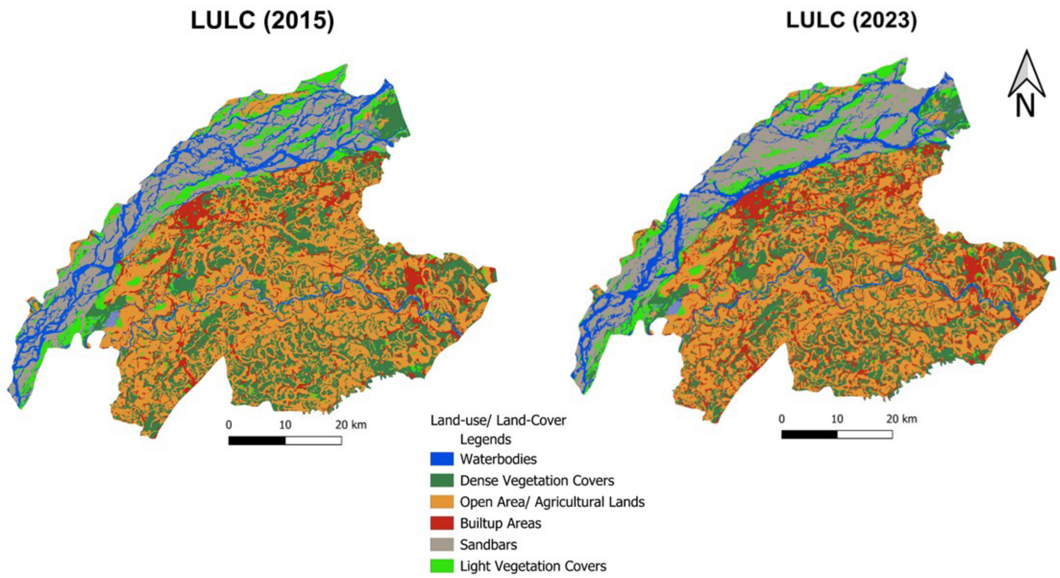


**Fig. 5.** Showing LULC of Dibrugarh District for the year 2015 and 2023

healthy green vegetation-the NDVI values in the NDVI matrix don't rise over 0.6, which is problematic for preserving the environment's quality.

**Change in Land-use/ Land-cover**

A significant part of reducing the effects of UHI is the modeling of potential surface temperatures utilizing the scope of LULC (Kalnay and Cai, 2003). This knowledge can be applied to the development of new land use strategies, city planning policies, and initiatives that lessen the UHI effect (Tran, *et al.*, 2017). The land-cover conversion is closely linked to the majority of significant regional climatic changes (Feddema, *et al.*, 2005). Urbanization effects must be taken into account while analyzing how LULC change affects UHI.Increased built-up and impermeable surface due to urbanization exacerbates UHIs (Fu and Weng, 2016).

An analysis of the LULC map of Dibrugarh throws light on the fact that the area occupied by the water bodies, vegetation cover, and open areas has been diminishing in the past decade, that is, from 2015 to 2023. A duration of eight years has been taken into account for a proper analysis of the data. A decrease in area of about 64.420 km$^2$ in terms of water bodies can be seen in recent times. In terms of the open area, a decrease of 58.42 km$^2$ is seen during the particular time period. There is a decrease of

**Table 4.** Land-use classes with total area covered for the year 2015 and 2023 (in Km$^2$).

| Legend/Year | 2015 | 2023 |
|---|---|---|
| Waterbodies | 338.205 | 273.785 |
| Open area | 1636.71 | 1578.29 |
| Light Vegetation cover | 225.47 | 161.05 |
| Dense Vegetation | 434.835 | 322.1 |
| Built-up areas | 289.89 | 467.045 |
| Sandbars | 295.89 | 418.73 |
| Total Area | 3221 | 3221 |

about 64.42 km$^2$ in terms of light vegetation. In the context of dense vegetation, there is a decrease of 112.735 km$^2$. From the analysis, it can be concluded that there is a maximum reduction in area in terms of the light vegetation, accounting for 28.57% of the initially recorded data. On the other hand, the area under the label of built-up areas has been increasing. A total increase of about 177.155 km$^2$. The area under the sandbar has also been increasing, leading to a rise of 122.84 km$^2$. Therefore, it can be seen that the rise of the built-up area has been pushing the natural resource to certain reduction levels, creating pressure on the limited area.

### Land Surface Temperature

For residents and local governments in developing-nation cities, the acceleration of the effects of urban surface heat brought on by growing industrialization and urbanization is crucial today. Forests, mixed farmland, built-up regions, and water bodies have all been linked to urban surface heat, according to earlier major results (Nguyen, *et al*., 2022). The growth of artificial impermeable surfaces at the expense of natural surfaces and the migration of people are two effects of urbanization that keep up with socioeconomic progress (Chrysanthou, *et al*., 2014). With increasing urbanization, dwindling croplands, and expanding impermeable surfaces, the variety of land surface characteristics, such as environmental composition and the spatial organization of a city, is becoming increasingly complex. LST will therefore fluctuate rapidly in both location and time, resulting in more extreme urban heat island (UHI) effects and warmer temperatures in urban regions relative to adjacent non-urban areas (Chao *et al*., 2022).

**Table 6.** Average Land surface temperature for the year 1993, 2003, 2013, and 2021.

| Months/Years | 1993 | 2003 | 2013 | 2021 |
|---|---|---|---|---|
| January | 11.79 | 12.39 | 13.74 | 14.37 |
| February | 15.78 | 16.01 | 17.7 | 16.33 |
| March | 18.62 | 19.8 | 21.41 | 20.25 |
| April | 23.85 | 24.95 | 24.33 | 24.17 |
| May | 25.34 | 26.88 | 25.65 | 26.04 |
| June | 26.34 | 27.42 | 27.59 | 26.77 |
| July | 27.03 | 27.11 | 27.15 | 27.23 |
| August | 26.13 | 27.65 | 26.63 | 26.56 |
| September | 25.15 | 25.95 | 25.99 | 26.58 |
| October | 22.26 | 22.51 | 22.67 | 24.24 |
| November | 17.6 | 17.45 | 17.6 | 17.81 |
| December | 14.14 | 13.71 | 14.43 | 15.16 |
| Yearly Average | 21.19 | 21.84 | 22.09 | 22.15 |

Source: NASA Power

The above table no. 6 has clearly showed that the average temperature has increased almost for all the months from 1993 to 2021, and 0.96$^o$C has been increased within the time period of 30 years, and the average temperature increases almost 0.04$^o$C per year. Also, there is a change in the increase in seasonal temperature. It is due to changes in surface land features and landform changes caused by human activities such as deforestation and urbanization, and it is expected to cause more changes in the near future.

## Conclusion

Urban heat island phenomena present a compelling case for the linked issues of deforestation, increasing urbanization, and temperature rise. This study shows that the high density of population, lack of green space, and concrete infrastructure in cities all contribute to higher temperatures. The local climate is made worse by these factors, which poses serious problems for environmental sustainability, healthcare, and urban development and planning. Comprehensive programs to lessen the effects of urban heat islands in urban areas should include community involvement, rules that forbid harmful human behavior, progressive afforestation efforts, and sustainable development techniques. We may decrease the detrimental effects of urbanization on regional climates and increase cities' resilience to the consequences of climate change by putting these kinds of measures into practice.

### Conflict of Interest

Authors declares there is no conflict of interest.

## References

Ali, M.E. 2020. Urbanisation in India: Causes, growth, trends, patterns, consequences & remedial measures.

Amirtham, L.R. 2016. Urbanization and its impact on urban heat Island intensity in Chennai Metropolitan Area, India. *Indian Journal of Science and Technology.???????????????*

Argüeso, D., Evans, J.P., Fita, L. and Bormann, K. J. (2014). Temperature response to future urbanization and climate change. *Climate Dynamics.* 42: 2183-2199.

Chao, Z., Wang, L., Che, M. and Hou, S. 2020. Effects of

Different Urbanization Levels on Land Surface Temperature Change: Taking Tokyo and Shanghai for Example. *Remote Sensing*. 12(12): 2022. https://doi.org/10.3390/rs12122022.

Chapman, S., Watson, J.E., Salazar, A., Thatcher, M. and Mc Alpine, C.A. 2017. The impact of urbanization and climate change on urban temperatures: a systematic review. *Landscape Ecology.* 32: 1921-1935.

Chrysanthou, A., Van der Schrier, G.E.J.M., Van Den Besselaar, E.J.M., Klein Tank, A.M.G. and Brandsma, T. 2014. The effects of urbanization on the rise of the European temperature since 1960. *Geophysical Research Letters.* 41(21): 7716-7722.

Feddema, J.J., Oleson, K.W., Bonan, G.B., Mearns, L.O., Buja, L.E., Meehl, G.A. and Washington, W.M. 2005. The importance of land-cover change in simulating future climates. *Science.* 310(5754): 1674-1678.

Fonseka, H.P.U., Zhang, H., Sun, Y., Su, H., Lin, H. and Lin, Y. 2019. Urbanization and its impacts on land surface temperature in Colombo metropolitan area, Sri Lanka, from 1988 to 2016. *Remote Sensing*. 11(8): 957.

Fu, P. and Weng, Q. 2016. A time series analysis of urbanization induced land use and land cover change and its impact on land surface temperature with Landsat imagery. *Remote Sensing of Environment.* 175: 205-214.

Huang, S., Tang, L., Hupy, J.P., Wang, Y. and Shao, G. 2021. A commentary review on the use of normalized difference vegetation index (NDVI) in the era of popular remote sensing. *Journal of Forestry Research*. 32(1): 1-6.

Kalnay, E. and Cai, M. 2003. Impact of urbanization and land-use change on climate. *Nature.* 423(6939): 528-531.

Mohan, M. and Kandya, A. 2015. Impact of urbanization and land-use/land-cover change on diurnal temperature range: A case study of tropical urban air shed of India using remote sensing data. *Science of the Total Environment.* 506: 453-465.

Nguyen, B.Q., Tran, T.N.D., Grodzka-£ukaszewska, M., Sinicyn, G. and Lakshmi, V. 2022. Assessment of urbanization-induced land-use change and its impact on temperature, evaporation, and humidity in central Vietnam. *Water.* 14(21):3367.

Sussman, H S., Raghavendra, A. and Zhou, L. 2019. Impacts of increased urbanization on surface temperature, vegetation, and aerosols over Bengaluru, India. *Remote Sensing Applications: Society and Environment.* 16: 100261.

Tam, B.Y., Gough, W.A. and Mohsin, T. 2015. The impact of urbanization and the urban heat island effect on day to day temperature variation. *Urban Climate*. 12: 1-10.

Tran, D.X., Pla, F., Latorre-Carmona, P., Myint, S.W., Caetano, M. and Kieu, H.V. 2017. Characterizing the relationship between land use land cover change and land surface temperature. *ISPRS Journal of Photogrammetry and Remote Sensing.* 124: 119-132.

Wang, Y., Ji, W., Yu, X., Xu, X., Jiang, D., Wang, Z. and Zhuang, D. 2014. The impact of urbanization on the annual average temperature of the past 60 years in Beijing. *Advances in Meteorology.* (1): 374987.