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Urban Heat Island Effect and Climate Change: An Assessment of Interacting and Attainable Variations in Indian Cities: Study of Gorakhpur

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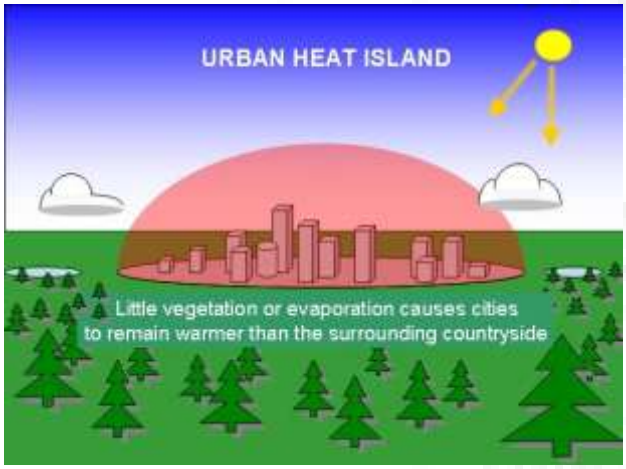
Abstract: ***Climate change in cities is driven by two distinct phenomena, one in operation at the size of the world as a fulland thedifferentin operation at the size of cities and regions. The worldatmospheric {phenomenon} could be a climate phenomenon through that the presence of "greenhouse gases" within the Earth's atmosphere traps outgoing energy and thereby warms the atmosphere. A natural warming mechanism, while not the operation of a worldwideatmospheric phenomenon the temperature of the world would approximate that of the Moon, rendering the world inhospitable to life. Since the beginnings of the economic Revolution, increasing emissions of greenhouse emission and different greenhouse gases have served to boost the natural atmospheric phenomenon, resulting ina rise in world temperatures over time. In addition to changes in the composition of the worldwide atmosphere, changes in land use at the size of cities additionally contribute to rising temperatures,called the urban heat island (UHI) impact, the displacement of trees and alternative natural vegetation by the development materials of urban development will increasethe quantityof warmth energy that's absorbed from the Sun and hold on in urban materials, like concrete, asphalt, and roofing shingle. Four specific changes in urban environments drive the urban heat island impact, including 1) The loss of natural vegetation; 2) The introduction of urban construction materials that areadditionaleconomical at riveting and storing thermal energy than the natural landscape; 3) High-density urban morphology that traps solar radiation; and 4) The emission of Unwanted heat from buildings and vehicles.***

Keywords: Climate Change, Urban Heat Island, Greenhouse Gases, temperature, Environment



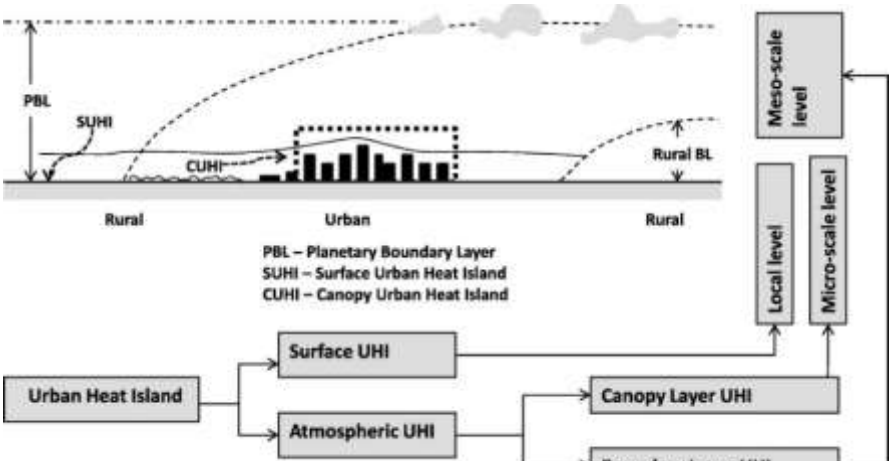
(http://www.weatherquestions.com, n.d.)
Figure 1: Phenomenon of Urban Heat Island Effect

1. Introduction

Heat islands develop once an oversized quantity of the natural land cover in an area is replaced by built surfaces that catch incoming solar radiationthroughout the day and so re-radiate it in the dark. This slows the cooling method thereby keeping night time air temperatures high relative to temperatures in less urban areas. This increase in urban air temperatures as compared to encompassing community likewise as rural temperatures is observedbecause the heat island effect. Heat islands of varied extent and magnitude areas certained in most urban areas within the world.(William D. Solecki, 2004)

As urban inexperienced area will effectively scale back the heat island development, thus students from domestic and foreign area unit the wide concern the connection between the vegetation cowl and therefore the urban heat island. because the speedy development of remote sensing technology, that brought nice convenience for large-scale, continuous study of heat island impact. Currently, the first analysis means that with remote sensing knowledge is to investigate the relation of NDVI and therefore the ground temperature or brightness temperature to review urban heat island impact. The results show that there was a transparent correlation between the heat island impact and vegetation cowl, the correspondence relation model.(Voelkel, 2018)

Many analysis solely studies the connection between NDVI and therefore the temperature on an explicit amount failed to study the connection changes at totally different times. With the impact of urbanization and warming, whether the connection between NDVI and temperature can change? This paper exploitation towards remote sensing knowledge and analyse the constant changes of the model between NDVI and radiance temperature, there is a preliminary dynamic study for the connection changes between vegetation cowl and concrete heat island development.



(https://ascelibrary.org, n.d.)
Figure 2: Relation of UHI to various layers

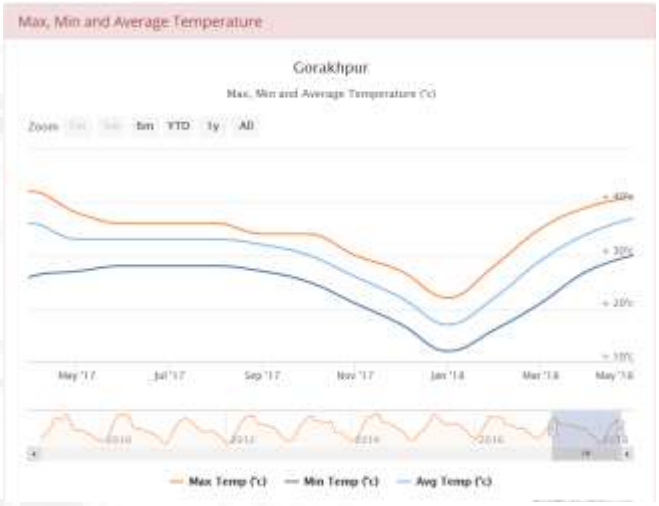
2. Introduction to Study Area

The study examines the urban heat island effect (UHI) of the larger Gorakhpur region Even not properly urban. Gorakhpur is one of the important city of Uttar Pradesh state because of its location and character. It is a famous Religious and Tourist place. Gorakhpur region is one of the vastly developing region in north India. Industrial development, retail market and other kind of economic activities are developing very fast in larger scale at this region, as well as employment opportunities are increasing day by day in larger scale too. These conditions are responsible of carrying a huge a population in this region, again there is production of some others demand related to this condition. Lots of the agricultural land being converted into non-agricultural land in term of development and its related demand.

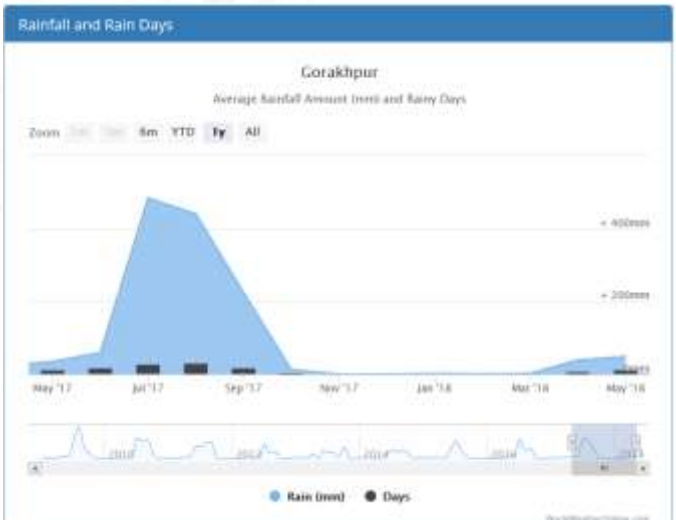
Figure 3: Boundary of Gorakhpur according Gorakhpur Development Authority

The development practices are increasing as per demand but not in a good planning way. There is a development but lack in planning, which is again responsible for poor urban and regional planning practices.

The lack is not only in planning practices but also the operational and management activities, as result there are increasing of climatic degradability.



(worldweatheronline.com, n.d.)
Figure 4: Maximum, Minimum and average temperature of Gorakhpur (2017-18)



((worldweatheronline.com, n.d.), n.d.)
Figure 5: Average rainfall and Rainy days in Gorakhpur (2017-18)

The rapid development of remote sensing technology makes it convenient for large-scale study of urban heat island effect, some research extract NDVI and other vegetation index, and analysis the relationship between NDVI and

radiance temperature or ground temperature to study the relationship between the urban heat island effect and vegetation. Based on May 15, 2018 in Gorakhpur's LandSet8 Thermic Mapper (TM) images as the data source it was analysed. Landsat imagery include Eleven bands, the resolution were 30 meters. The major application of image is extract NDVI with the fourth band and fifth band, while use the tenth band and eleventh band of remote sensing data to extract radiance temperature as well as other temperature studies.

Need

Urban heat islands will cause deterioration of the living surroundings, increase in energy consumption, elevation in ground-level gas, and even a rise in mortality rates. It is apparent that the advantages of mitigation of UHI square measure large, and notably for a developing tropical country like India, the study during this field will motivate timely intervention in urban policies to lead to energy savings and outside the thermal comfort.

3. Research Method and Data Processing

The research method and data processing were totally based on the Remote Sensing Techniques. Geographical Information System (GIS) methodology was used mainly and the study done with the help of Landsat-8 imagery.

Image Processing

For this study, LandSet8 data is the basic data of this paper, band combination should be processed before data use, make the eleven single band images to a multiband image, to extract NDVI of the study area.

It's necessary to do geometric correction after band combination so that the object on the image can be associated with its actual location, providing location information for analysis of the data. In the process of correction, there is the use of vector data prepared by Gorakhpur Development Authority as the reference, choose precise positioning as control point such as the crossing point of Ramgarh Taal, then use the method of neighbouring to do the Geometric correction.

After the correction of the image data process border clipping with the vector data of the Gorakhpur border, only retain the scope of Gorakhpur on the remote sensing images. This step is aimed at when select characteristic section ensure that choice is within the framework of Gorakhpur.

NDVI extraction

NDVI: Normalized Difference Vegetation Index, like other vegetation indexes, shows the rate of vegetation cover, it is the most extensive application amongst all vegetation index. NDVI can be used to detect the growth of vegetation, and vegetation coverage, and so on. The calculation formula of NDVI for TM data:

NDVI=(NIR-R)/(NIR+R)

In the formula: NIR is the grey value of the near-infrared band, R is the Grey value of red-band.

NDVI is within the range [1, 1], and negative is for the cover of cloud, water, snow, the high reflectivity of visible light; 0 is for rock or bare soil, and so on, NIR and R are approximate equivalents. Positive is that there is vegetation cover, and with the coverage increases, NDVI will increase too. It's generally believed that when the NDVI <0.1, vegetation is sparse.

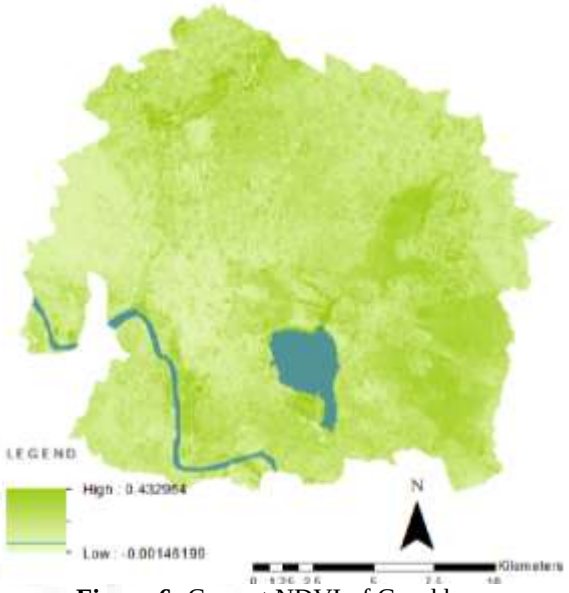


Figure 6: Current NDVI of Gorakhpur

For this study there is Landsat-8 image of May 15, 2018 has taken. The range of -0.00142 to 0.433 found from that analysis. Asit is very clear from above image that there is a large vegetation patch at eastern part, which is forest and again at north side there are some patch of vegetation cover. Mostly built-up areas are situated at city centre as well as south and western part. Those part contains very less vegetation cover. Day by day vegetation cover getting decreases.

Extraction of radiance temperature

In some of the case, there is use image data and meteorological data to inverse surface temperature, to study the relationship between urban heat island effect and NDVI. In this paper, there is all type of urban temperature have been studied for this analysis, the surface temperature inversion is also succeeded for the study, there is also the importance of radiance temperature. Although the radiance temperature is not the same value with ground temperature, with a strong correlation exists, the spatial distribution of radiance temperature can be a good fit for the ground temperature distribution in the space. Therefore, in this study radiance temperature can be used instead of ground temperature. Radiance temperature is coming from the tenth and eleventh band, which is the grey value of the TM data, radiance temperature is not equal to the actual temperature, it's slightly less than the actual temperature, but there is a certain correlation between them. The tenth and eleventh band of TM recorded the Digital Number value, cannot be directly applied to an analysis of heat island effect, Digital Number values should be transformed into radiance temperature for analysis. Which study the extract radiance temperature, firstly, the DN value of the individually both band should be converted to radiance Lb, the formula as follows:

For band 10 is 0.0003342*"band10"+1 and

For band 11 is 0.0003342*"band11"+1.

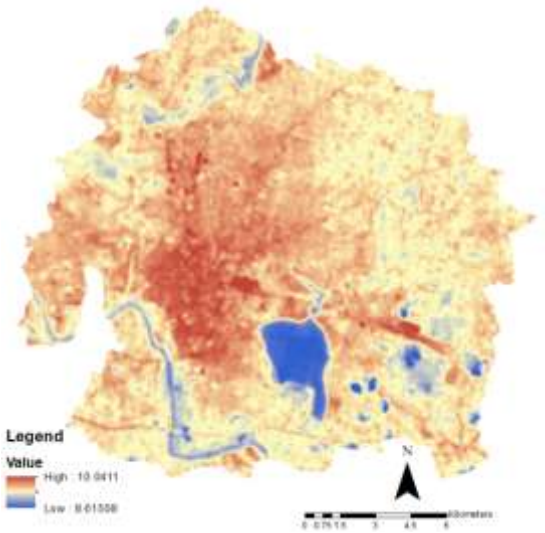


Figure 7: The distribution of radiance temperature in band 10.

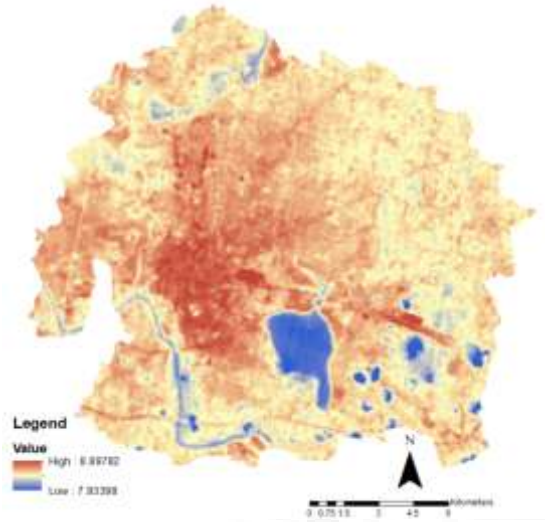


Figure 8: The distribution of radiance temperature in band 11.

At band 10 there is maximum radiance temperature is 10.0411 and minimum is 8.61508.

And for band 11 there is maximum radiance temperature is 8.89782 and minimum is 793398.

Correspondence relation model of NDVI and radiance temperature

From the radiance temperature map and NDVI map, we can see that the lower radiance temperatures are mainly distributed in forest areas of city's south and east, there has well other vegetation cover, and the less human interference, while the higher values NDVI also distribute in this region, which suggest that there exists some relationship between them.

To objectively study the correspondence model between NDVI and radiance temperature, the researchers initially use the vector date of land use in Gorakhpur as reference, choose characteristic section in each category, NDVI and radiance temperature values are very similar in the same type of land use, they are no relation, just as shown in Figure 6,7 and Figure 8. Include a variety of land use types. The profile includes wetlands, grassland, water, construction sites, built-ups and other land-use types, with strong representation, NDVI and radiance temperature have a strong relation. So, we can discuss the relationship between radiance temperature and NDVI under different types of land use. Figure 6, 7and 8 are the distribution of the corresponding relation between NDVI and radiance temperature for current time.

Changes of Correspondence model between NDVI and Radiance Temperature

Although the regression model cannot show the relationship between NDVI and the real surface temperature, it can reflect a relation, confirmed that vegetation cover can effectively reduce the urban heat island effect. The relation between NDVI and radiance temperature become stronger, the changes between radiance temperature and NDVI is more regular. Determination coefficient of regression model reached about 0.5, which shows that NDVI has significant influence on the radiance temperature. From the value change, the impact of NDVI on radiance temperature become more obviously. The change of temperature is affected by many factors, the above-mentioned suggest that the significant of NDVI factors in temperature change become stronger. (Peng-fei Wu)

Through the comparison of characteristics profile for the Research shows that the radiance temperature and NDVI have obvious negative correlation; with the change of time, the range radiance temperature and the average value increase, determination coefficient and the slope of the regression equation will increase, which suggest that with the Increase of NDVI, the rate of the decrease of radiance temperature increase too. For the final observation there is process of finding of Average Land Surface Temperature, which can be get easily by these imaginaries.

Land Surface Temperature

Land surface temperature is however hot the “surface” of the planet would feel to the bit in an exceedingly specific location. From a satellite’s purpose of reading, the “surface” is no matter it sees once it's through the atmosphere to the bottom. It might be snow and ice, the grass on a field, the roof of a building, or the leaves within the cover of a forest. Thus, the land surface temperature isn't identical because the air temperature that's enclosed within the daily weather report.(Zhao-Liang Li, 2013)

LST could be a mixture of vegetation and vacant soil temperatures. As a result ofeach respond apace to changes in incoming radiationthanks toinclemency and aerosol load modifications and variation of illumination, the LST displays fast variations too. In turn, the LST influences the partition of energy between ground and vegetation and determines the surface air temperature. For the calculation of LST there are various steps followed:

Satellite Brightness temperature

For band 10 is 1321.08/Ln(774.89/”band10radiance”+1) – 272.15

For band 11 is 1201.14/Ln(480.89/”band10radiance”+1) – 272.15

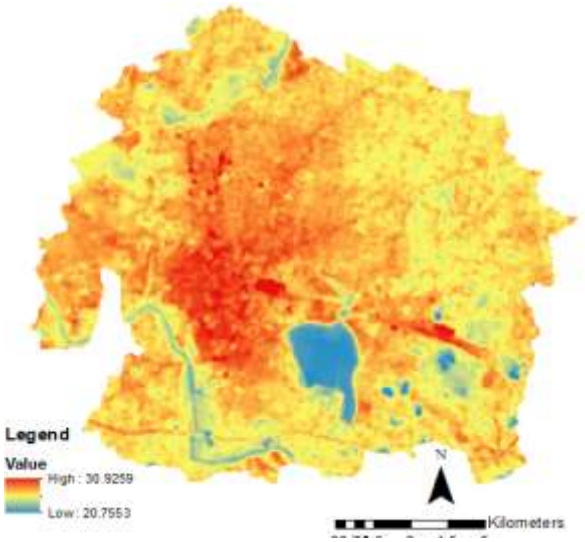


Figure 9: The distribution of satellite temperature In band 10.

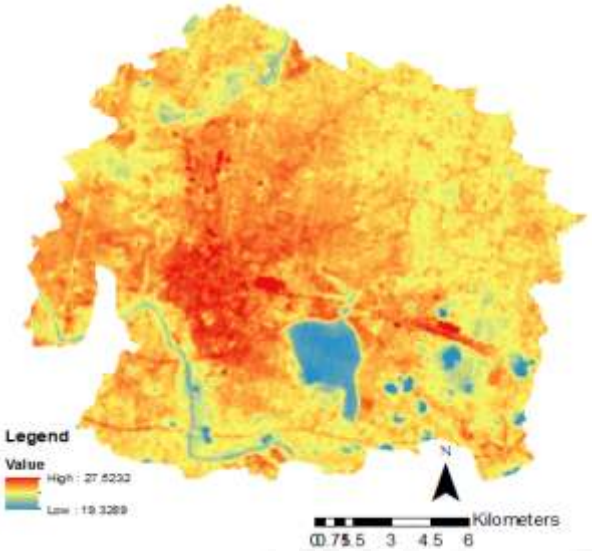


Figure 10: The distribution of satellite temperature In band 10

Mean Satellite temperature

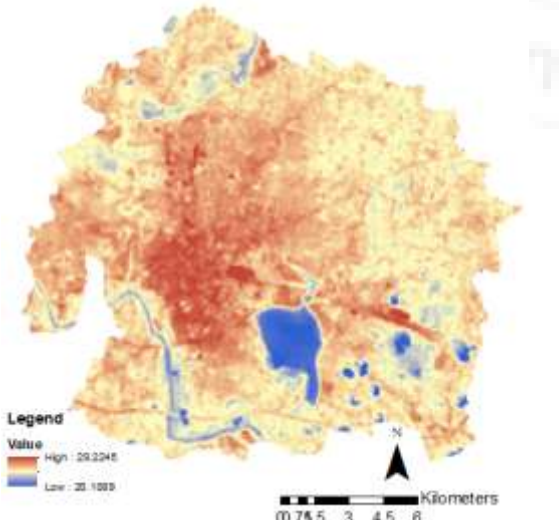


Figure 11: Average distribution of satellite temperature

Proportion of Vegetation
(NDVI+NDVImin/NDVImax-NDvINmin)
Square ("NDVI"+0.00146199/0.432964-0.00146199)

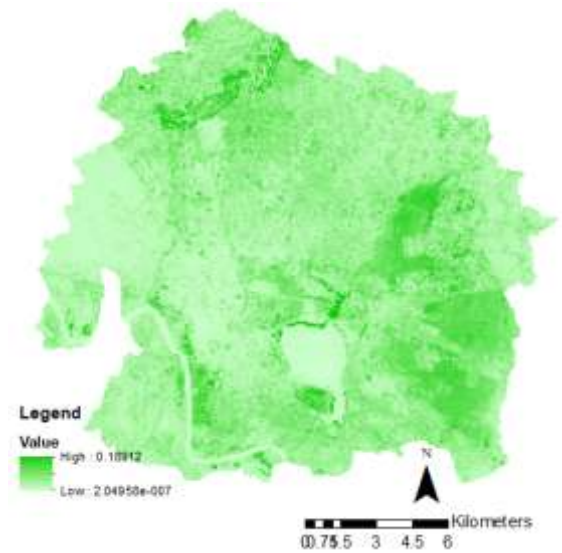


Figure 12: The distribution of Proportion of Vegetation

Land Surface Emissivity
e = 0.004Pv + 0.986

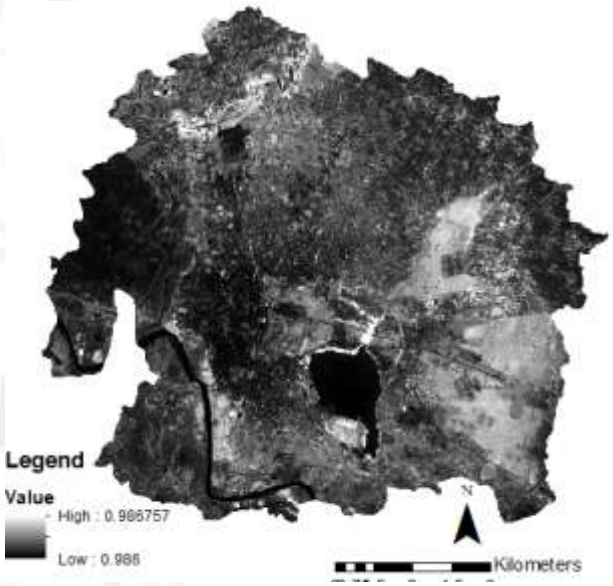


Figure 13: The distribution of land Surface emissivity

Land Surface Temperature
BT/1+ w * (BT/p) * ln(e)
Where:
BT= at satellite temperature
W= wavelength of emitted radiance (11.5micro metre)
P= h * c/s (1.438 * 10^-2 mK)
h= Planck's constant (6.626 * 10^-34 Js)
s= Boltzmann constant (1.38 * 10^-23 J/K)
c= velocity of light (2.998 * 10^8 m/s)
p= 14380

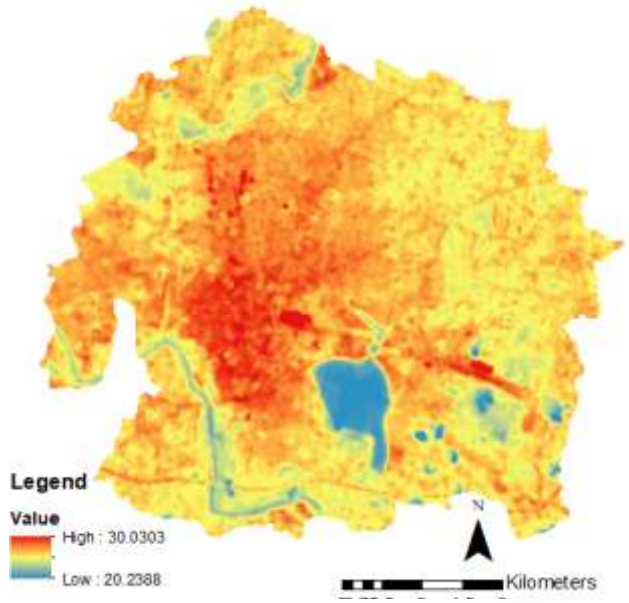


Figure 14: The distribution of land Surface temperature at band 10.

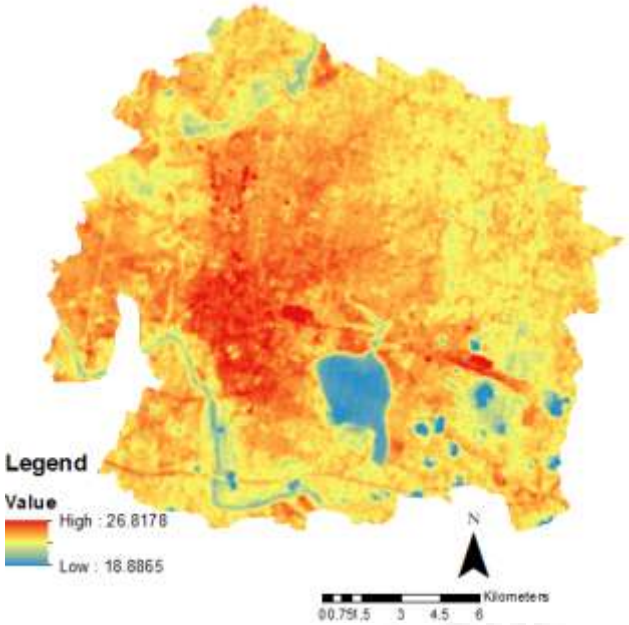


Figure 15: The distribution of land Surface temperature at band 10

Average Land Surface Temperature

For the final study of Land Surface temperature there are process of taking mean of LST of both band 10 and band 11. After taking the mean of these two, the final variations has analysed-

LSTmin- 19.6272 degree Celsius

LSTmax- 28.424 degree Celsius

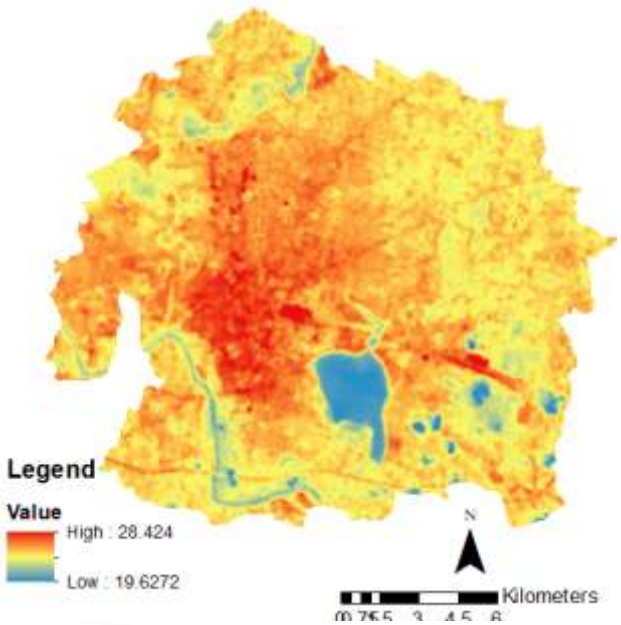


Figure 16: Average distribution of land Surface temperature

4. Conclusion and Discussion

In this paper, there are shown the Radiance temperature and the relation between radiance temperature and NDVI. And also the main effect of urban heat island effect study through main land surface temperature and its nature. Radiance temperature is additionally referred to as Brightness Temperature. The results showed that the vegetation cowl and radiance temperature have a considerable correlation, that's to mention, the upper the vegetation coverage, the lower the heat island effect, and contrariwise.

It is also shown that the correlation model between radiance temperature and NDVI is dynamic. With the time modification, the range of radiance temperature and therefore the average value increase and determination constant also can increase, that the NDVI modification can cause larger changes to radiance temperature.

This study is meant to explore the model between NDVI and temperature changes with time. heating, the heat island effect incorporates a larger impact on people's production and lifestyle, with the rise in temperature, whether or not the role of vegetation cowl in reducing urban heat island can amendment.

This analysis also shows that vegetation cowl in reducing the urban heat island effect includes a lot of distinguished role with warm temperature. In different words, an equivalent vegetation coverage will be to scale back urban heat island effect in high-temperature conditions.

These above elements and reasons are also responsible for the change in actual Land Surface Temperature, land surface temperature is just temperature based on the land surface when it get affected by the or get in the touch of other temperature index the it produces more urban heat island effect. These temperature Characters and NDVI are affected by many reasons, weather, atmospheric conditions, such as the difference of the date, might affect the accuracy of the

model, land use change in term of day to day urbanization and other practices.

There is only selected one image in each year as representative data, so the difference in remote sensing image itself is likely to affect the accuracy of the model.

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List of Figures