Urban Heat Island Study Based on Remote Sensing and Geographic Information System: Relationship between Land Cover and Surface Temperature

By Lili Somantri, Shafira Himayah

Sains Informasi Geografi, Universitas Pendidikan Indonesia

The 6th International Geography Seminar

"The Contribution of Geography to Improve Human Capacity Facing Natural Multi-Hazard Problem in Tropical Area"

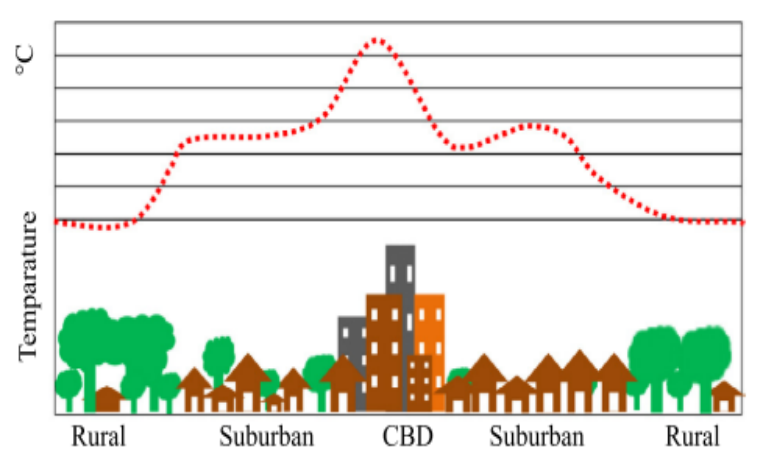
Introduction

01

Urban Heat Island (UHI) is a phenomenon where temperatures in urban areas tend to be higher than those in surrounding rural areas [1].

02

The main causes of UHI are changes in urban structure and land cover, such as an increase in building surfaces, roads, and a reduction in open green areas.



04

There are various causes of UHI, including natural and human factors, with the core cause being land use change [2].

03

UHI has a significant impact on thermal comfort, air quality and energy efficiency in cities.

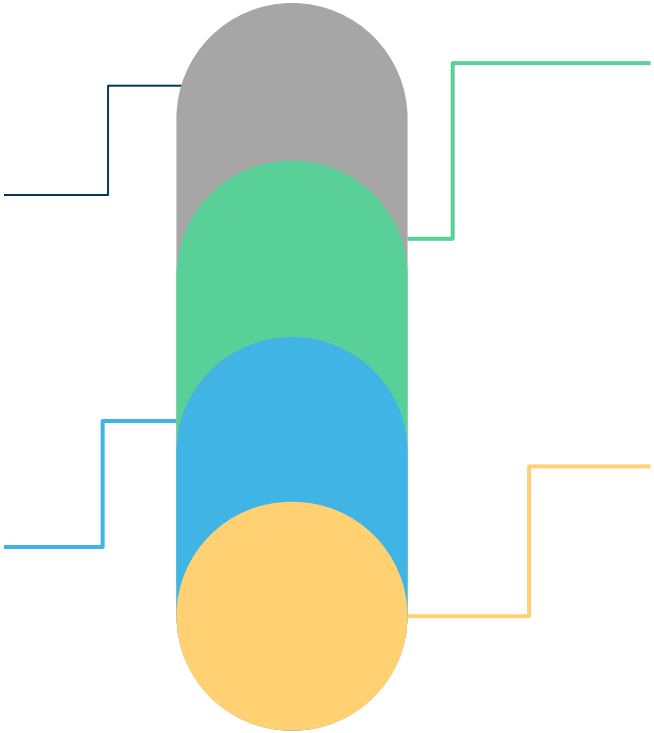
Urban Heat Island

01

UHI can be divided into **two types**, namely Surface Urban Heat Island (SUHI) and Atmospheric Urban Heat Island (AUHI).

02

SUHI reflects the difference **in radiant temperature** between non-absorbing surfaces and natural surfaces.



03

AUHI refers to the **effect on the canopy layer** or air boundary layer, which requires the measurement of air temperature.

04

Surface temperature is **more variable** than air temperature **during daytime** but more consistent after sunset due to the slow release of heat from non-absorbent surfaces.

Research Materials and Methods

Bibliography Data

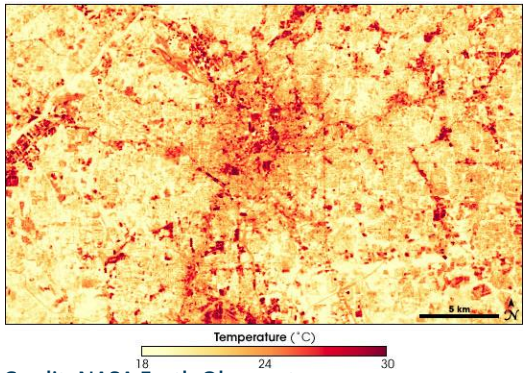
- Google Scholar is a comprehensive bibliographic data source access platform.
- Google Scholar allows searching for scientific publications from various sources.
- The diversity of data sources in Google Scholar makes it a valid source in searching for scientific information [3].

Literature Review

- This research used a literature review approach.
- A literature review involves steps such as selecting relevant references, reading and evaluating, and presenting information.
- A literature search was conducted through Google Scholar with the keywords "Urban Heat Island Study," "Remote Sensing," and "GIS."

Results and Discussion

- Surface Urban Heat Islands (SUHI) represent the radiative temperature difference between impervious and natural surfaces.
- SUHIs are primarily measured by remote sensing in the thermal infrared (TIR) region of the electromagnetic (EM) spectrum.



Credit: NASA Earth Observatory

- Atmospheric Urban Heat Islands (AUHI) refer to effects in the canopy layer or boundary layer [4], [5].
- Measured by in situ sensors mounted on fixed meteorological stations or mobile traverses. Measured by tall towers, radiosondes, and aircraft

Credit: NOAA

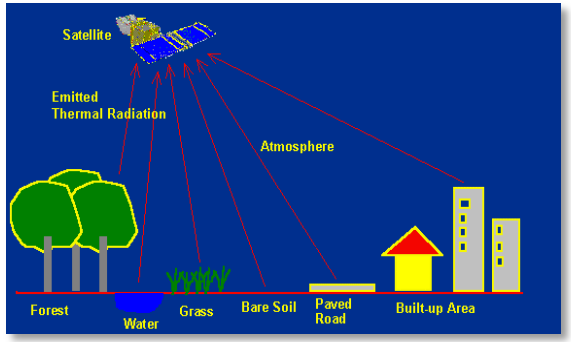
Urbanization changes the natural spatial layout into an artificial spatial layout, which has an impact on changing the radiative, thermal, rough, and moisture properties of the surface and overlying atmosphere, with one of the important impacts being the Urban Heat Island (UHI) phenomenon [6], [7]. Causes of Urban Heat Islands is:

- Albedo & Infrastructure
- Reduced vegetation in urban areas
- Anthropogenic heat
- Urban geometry
- Weather
- Geography

Urban Heat Islands – SUHI

Remote Sensing in UHI Analysis

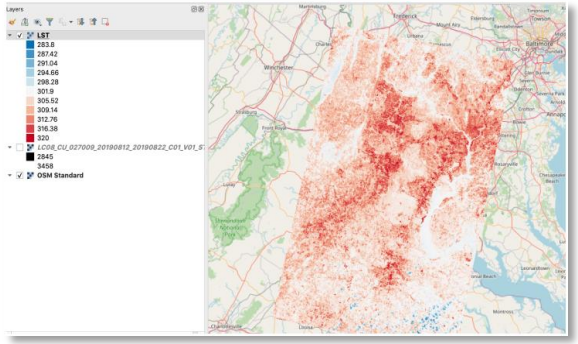
- Satellite thermal remote sensing measures SUHI and provides consistent and repeatable observations of the Earth's surface [6].
- Satellite TIR sensors measure top of the atmosphere (TOA) radiance emitted by the Earth's surface and atmosphere.



Credit: (nus.edu.sg)

GIS in UHI Analysis

- In the context of UHI, GIS can integrate various spatial data such as surface temperature, land cover, elevation and other data, and perform in-depth spatial analyses to better understand the UHI phenomenon.



Credit: nasa.gov

Extraction of surface temperature information

- Thermal Infrared (TIR) wavelengths between 8 to 15 micrometers (μm) are commonly used for LST estimation.
- Here are some examples of Spectral Bands that can be used for LST analysis.

Sensor	Spectral Bands (μm)	Spatial Resolution	Temporal Resolution
TM ETM TIRS	10.40 - 12.50 10.40 - 12.50 10.6 - 11.19 11.50 - 12.51	120 m (30 m resampled) 60 m (30 m) 100 m 100 m	16 days
MODIS	10.78 - 11.28 11.77 - 12.27	1 km	12 hours
ASTER	10.25 - 10.95 10.95 - 11.65	90 m	12 hours
PHyTIR	8.28, 8.79, 9.06, 10.5, 12.05	60 m CONUS only	varies/every few days

Identification of Urban Heat Island Phenomenon

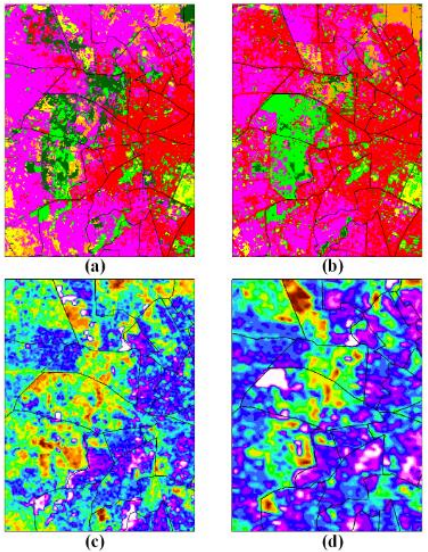
1. **Land Cover Processing**. Land cover classification methods can be performed using several methods considered to be the most accurate
2. **Surface Temperature Processing**. LST processing involves several stages, such as converting pixel values to radiance, calculating brightness temperature, determining the NDVI value, establishing the Proportion Of Vegetation value, determining the emissivity value (e), and calculating the surface temperature value.
3. **Identification of the Urban Heat Island Phenomenon.** From the surface temperature data extracted through remote sensing, identify the UHI phenomenon by subtracting the mean LST value from the UHI threshold value

Relationship between Land Cover and Surface Temperature

- In some studies, high surface temperatures tend to be positively correlated with more built-up land, meaning that there is a significant correlation between an increase in built-up land area and an increase in surface temperature [8]-[10].

- In the study by Jalan and Sharma (2014), the northern part of Jaipur City, India, has undergone a transition from vegetated and vacant land to built-up land and an increase in the density of built-up areas. As a result, this area has shown a significant increase in Land Surface Temperature (LST).

- (a) LULC map of 2000 (b) LULC map of 2011 (c) LST map of 2000 (d) LST map of 2011.



Conclusions

- UHI is a phenomenon in which temperatures in urban areas are higher than in surrounding rural areas, caused by changes in urban structure and land cover such as an increase in buildings and a reduction in green open areas. UHI measurements can be made by analyzing Land Surface Temperature (LST) using remote sensing.

- LST provides information on temporal and spatial variations in the Earth's surface temperature. Remote sensing and Geographic Information Systems (GIS) can be integrated to understand the relationship between land cover and surface temperature in the context of UHI. Some studies suggest that high surface temperatures tend to be positively correlated with more built-up land, meaning that there is a significant correlation between an increase in built-up land area and an increase in surface temperature.

- This review hopes to provide a deeper understanding of the UHI concept and its impact on the urban environment as well as a collection of technical remote sensing and GIS methods that can be applied to map the UHI phenomenon.

References

[1] R. ASmiwyati, “Urban Heat Island ; Sebuah Kajian Pustaka,” Progr. Stud. Arsit. Pertamanan, 2018.

[2] J. Tsou, J. Zhuang, Y. Li, and Y. Zhang, “Urban Heat Island Assessment Using the Landsat 8 Data: A Case Study in Shenzhen and Hong Kong,” Urban Sci., vol. 1, no. 1, p. 10, 2017, doi: 10.3390/urbansci1010010.

[3] G. Halevi, H. Moed, and J. Bar-ilan, “Suitability of Google Scholar as a source of scientific information and as a source of data for scientific evaluation — Review of the Literature,” J. Informetr., vol. 11, no. 3, pp. 823–834, 2017, doi: 10.1016/j.joi.2017.06.005.

[4] N. I. Fawzi, “Measuring Urban Heat Island using Remote Sensing , Case of Yogyakarta City,” Maj. Ilm. Globe, vol. 19, no. 2, pp. 195–206, 2017.

[5] Y. Ma, Y. Kuang, and N. Huang, “Coupling urbanization analyses for studying urban thermal environment and its interplay with biophysical parameters based on TM/ETM+ imagery,” Int. J. Appl. Earth Obs. Geoinf., vol. 12, no. 2, pp. 110–118, 2010, doi: 10.1016/j.jag.2009.12.002.

[6] G. Kaplan, U. Avdan, and Z. Y. Avdan, “Urban Heat Island Analysis Using the Landsat 8 Satellite Data: A Case Study in Skopje, Macedonia,” p. 358, 2018, doi: 10.3390/ecrs-2-05171.

[7] Y. Xu, Z. Qin, and H. Wan, “Spatial and Temporal Dynamics of Urban Heat Island and Their Relationship with Land Cover Changes in Urbanization Process: A Case Study in Suzhou, China,” J. Indian Soc. Remote Sens., vol. 38, no. 4, pp. 654–663, 2010, doi: 10.1007/s12524-011-0073-7.

[8] R. Maru and S. Ahmad, “The relationship between land use changes and the urban heat Island phenomenon in Jakarta, Indonesia,” Adv. Sci. Lett., vol. 21, no. 2, pp. 150–152, 2015, doi: 10.1166/asl.2015.5842.

[9] S. A. Al Mukmin, A. Wijaya, and A. Sukmono, “Analisis Pengaruh Perubahan Tutupan Lahan Terhadap Distribusi Suhu Permukaan Dan Keterkaitannya Dengan Fenomena Urban Heat Island,” J. Geod. Undip, vol. 5, no. 1, pp. 224–233, 2016.

[10] S. P. Darlina, B. Sasmito, and B. D. Yuwono, “Analisis Fenomena Urban Heat Island Serta Mitigasinya (Studi Kasus : Kota Semarang),” J. Geod. Undip, vol. 4, no. April, pp. 86–94, 2015.

[11] S. Jalan and K. Sharma, “Spatio-temporal assessment of land use/ land cover dynamics and urban heat island of Jaipur city using satellite data,” Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch., vol. XL–8, no. 1, pp. 767–772, 2014, doi: 10.5194/isprsarchives-XL-8-767-2014.

THANK YOU

The 6th International Geography Seminar

"The Contribution of Geography to Improve Human Capacity Facing Natural Multi-Hazard Problem in Tropical Area"