Assessment of the relationship between building density and urban heat island using Landsat images in Makassar City

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Abstract. Increasing temperatures in urban areas provide many adverse effects, and such is the potential for fires, air pollution up to the comfort of life in the state capital, and the other problems, with the global warming which occurred in the world, such as the melting of ice on most of the north pole, unpredictable Global warming and the number of flora and fauna habitat damaged. The need for facilities and infrastructure is the main factor that triggers settlements' development; in general, urban areas often experience densely populated settlements. Therefore, researchers feel the need to monitor the relationship between Urban Heat Island (UHI) in Makassar City. Monitoring of Urban Heat Island needed surface temperature data from Landsat 8 OLI/TIRS with a thermal band resolution of 100m, building density needed NDBI models for data building density. This study analyses the relationship between building density and urban Heat Island using Landsat Imagery Data in Makassar city. The Landsat 8 OLI/TIRS imagery provides to be used to show the Urban Heat Island (UHI) phenomenon in Makassar City. In addition to UHI analysis, Landsat 8, Oil/TIRS imagery provides building density information using the NDBI spectral transformation. The results of the two result models' determination tests show that Urban Heat Island and Building Density have a very high relationship.

1. Introduction

The rapid growth in Makassar City has an impact on the total need for land use for living. The development of Makassar City has also resulted in the rapid conversion of undeveloped land into built-up land where new activity centers' growth will be the main attraction for land-use changes [1–3]. Land use results from any form of human intervention of land on the earth's surface, which is dynamic and functions to meet life's needs, both material and spiritual [2,4,5]. The more the population, the greater the probability level of land change.

The increase in the earth's surface temperature generally occurs due to changes in land cover changes. The land cover that can control heat is vegetated land with a high density, but this land cover

tends to change its function to support human activities [6,7]. The development of infrastructure, facilities, and infrastructure, clearing forest land into agricultural land is also one of the causes of increasing surface temperature from the surface temperature from receiving solar radiation and air temperature influenced by surface temperature from land cover and climatic conditions. The temperature is also a part or component of nature that is highly influenced by and influences living things and environmental conditions [8].

This occurs in Makassar city, where the dense development seen from building density indicates the city's high development. The building's density is considered because of the need for facilities and infrastructure to support the economy and accommodate the resident population. High-density results in land changes not being developed to become developed, the risk of increasing climate and becoming an urban heat island (UHI) phenomenon [9].

The Changes in surface temperature and building density were observed with multispectral and multitemporal data by taking data extensively. one of the available data is remote sensing data in the form of satellite image data. The remote sensing data are Landsat TM images with a thermal band resolution of 120 m, Landsat UTM + of 60, and Landsat OLI of 100 m [10–12]. This research about the relationship between UHI and build density requires a spectral transformation model that correlates between building density data and the UHI. The spectral transformation used in this study is Normalize Difference Built-up Index (NDBI).

2. Methodology

2.1. Study Area

This research's location is in Makassar City, South Sulawesi Province, Indonesia (figure 1). Geographically, the city of Makassar located between 199 ° 24'17'38 "East Longitude and 5 ° 8'6'19" South Latitude, with an area of Makassar City covering an area of 175.77 km² which includes 15 congestion and a population of 1,526,677 souls in 2019.

The use of land in Makassar City (figure 1) consists of residential areas with an area of 6,674.44 ha or 37.69% of the total area of the city of Makassar, then Sawah with 4732.42 ha (26.93%), Wetlands 2,352.32 ha (13.39%), vacant land 1,186.52 ha (6.75%), Industry 635.35 ha (3.61%), Commercial 590.15 (3.36%), River 550.86 ha (3, 13%), Mangroves 471.68 ha (2.68%), City Forests 293.17 ha (1.67%) and, Lake 88.02 ha (0.50%).

2.2. Materials

Thermal imagery displays radiant temperature data on the earth's surface. Landsat OLI has a TIRS (thermal infrared system) sensor designed to show the thermal infrared channel and obtain temperature data on the earth's surface in the multispectral image. The thermal channel on the Landsat OLI/TIRS imagery has a spatial resolution of 100 cm with flight missions from 2013- to now, where it can be accessed and used via the U.S. Geological Survey (USGS).

This study aims to find the relationship between the urban heat island and buildings' density previously using the Landsat 8 OLI/TIRS thermal channel data. In spatial image modeling, building density can analyze using the urban index spectral transformation method. Several urban indices can use; Urban Index (UI) [13], Visible green-based built-up index (VgNIR-BI) [14], Normalize Difference Built-up Index (NDBI) and Built-up Area [15]. In this study, researchers used the NDBI spectral transformation by utilizing the middle infrared channel one and near-infrared on the Landsat 8 OLI/TIRS satellite imagery, considering that all data was available Landsat 8 OLI/TIRS satellite imagery, so in this study using Landsat data. 8 OLI/TIRS recording date 20th August 2020 path/row; 114/064.

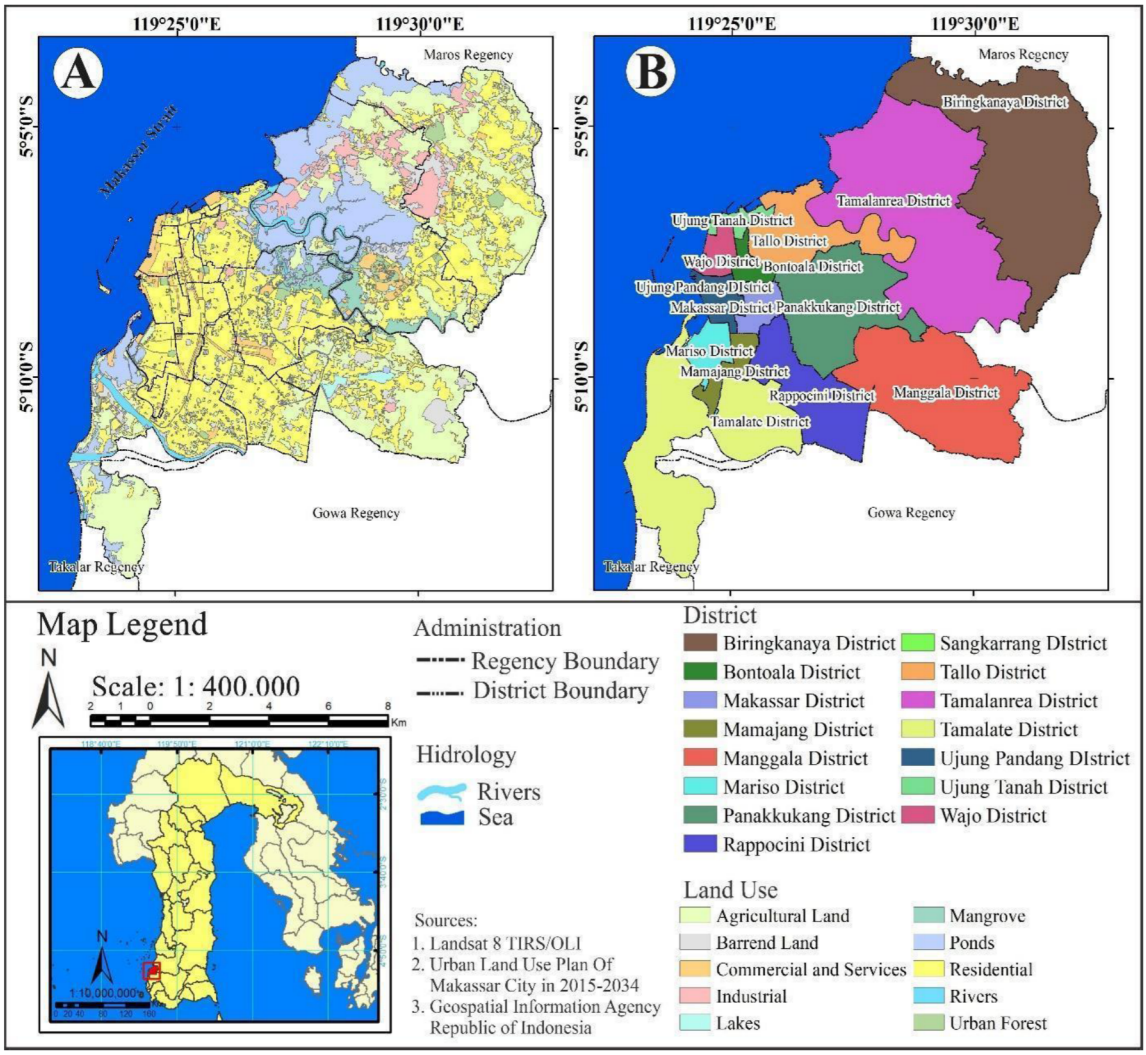

Figure 1. (A) Land use of Makassar City, (B) district in Makassar City.

2.3. Methodology

The TIRS sensor has a spectral waveform error value due to atmospheric interference received by the sensor. This error occurs due to changes in the value of the spectral electromagnetic waves received by the sensor when recording with the emitted spectral value. As with aerial photographs, the influence of the atmosphere significant to the intensity and composition of the energy spectrum recorded by the thermal system, the process used to obtain the temperature/object value of the earth's surface temperature by converting the unit temperature in kelvin to ° C is to change the DN channel into a radiation value. , then change the DN value assessed by radiance to a Kelvin value, and the last process is to convert the brightness temperature value from °Kelvin to °Celsius.

Furthermore, to analyze the urban heat island, the temperature data of Makassar city will be analyzed using data land cover and temperature distribution for each district in Makassar City. Data between land cover with temperature values and land cover with sub-district topology and then overlay to obtain an urban heat island analysis. The specific transformations are used for various studies, starting from observing vegetation growth stages (phenology) and their development. Specific transformations can also use for various urban studies with the character of building land cover objects. Spectrally, the roofs of buildings in Indonesia's cities are dominated by roof tiles, clay, and

concrete. So middle infrared spectral reflection is sensitive to these objects and has differences in natural objects such as vegetation and water bodies.

This research uses the Normalized Difference Built-up Index (NDBI) spectral transformation, an image transformation, to provide built-up area information. Zha, et al. (2003) carried out the NDBI transformation to map China's Nanjing city's built-up [15].

3. Results and discussion

3.1. Urban heat island Makassar City

The temperature analysis results of the city of Makassar using the Landsat 8 OLI/TIRS thermal channels recording on 20th August 2020 path/row; 114/064. This indicates the lowest temperature has a surface heat as high as 16.09 ° C, and the warmest surface shows a temperature of 28.87 ° C (figure 2). The Sub-districts of Makassar city with the highest average temperature and the tallest land cover showing in table 1.

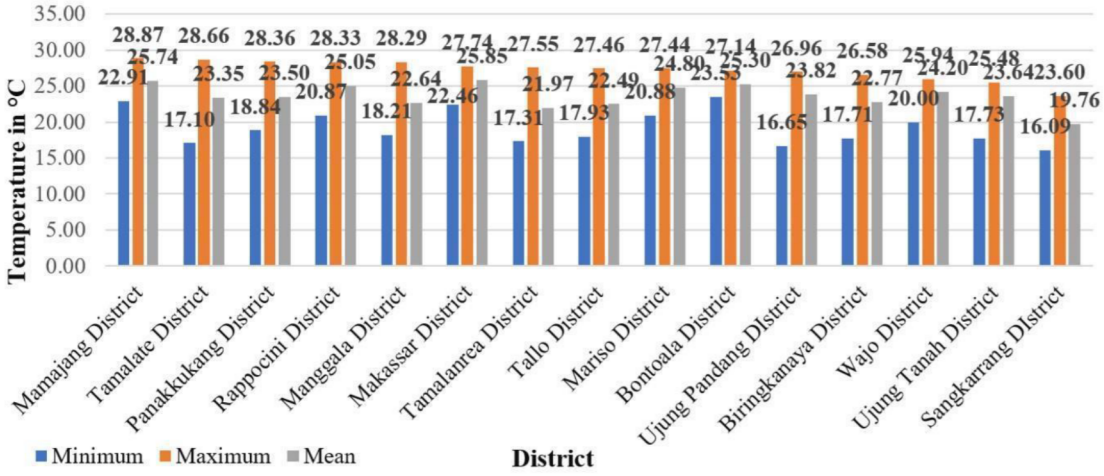

Figure 2. The temperature in °C of district in Makassar City.

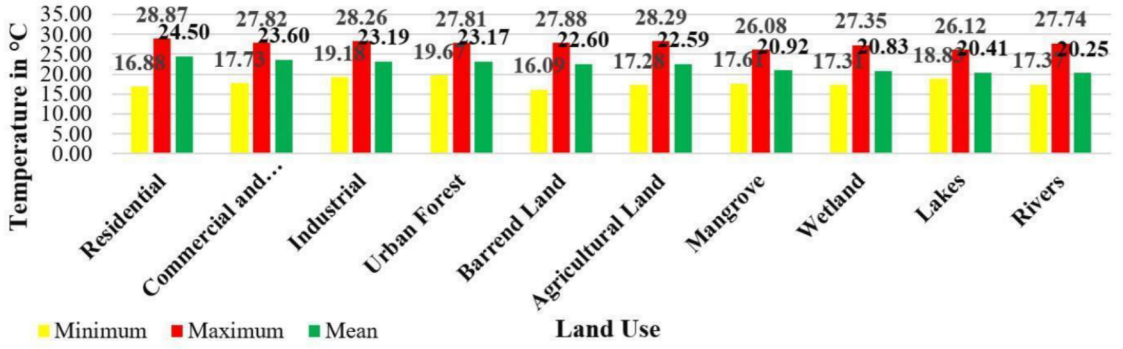

Figure 3. The Land use temperature in °C of Makassar City.