The effect of building density on land surface temperature, 
(Case Study: Turikale District, Maros Regency)

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Abstract. The amount of land built has increased over the years as the population increases. This results in a higher building density, such as in Turikale District, Maros Regency. Each object on the earth’s surface has its distinctive temperature, such as the buildings. The heat of the earth's surface on certain location points will be captured by the image as an area that has a different surface temperature. The purpose of this study is to determine the temporal-spatial pattern of building density and surface temperature in Turikale Subdistrict, Maros Regency in 2013 and 2018 and is expected to be useful for Turikale District spatial planning and urban environment. Building density data and surface temperature are obtained from Landsat 8 Path 114 row 063 in 2018 and 2013. The data is processed using the Normalized Difference Built-up Index (NDBI) algorithm and Land Surface Temperature (LST) using ArcGIS. Furthermore, an analysis of differences in building density patterns with land surface temperature is analyzed spatially and temporally. The results of the study show that the spatial pattern of building density grows to be higher in density each year, especially in densely populated residential areas and near Jalan Daya-Maros, Turikale District. Temporal patterns of land surface temperatures show significant increases between 2013 and 2018.

1. Introduction

Population growth can increase built-up land so that the building rises very rapidly; this growth influences changes in land cover and land use so the temperature changes [1]. This is exacerbated if there are greenhouse gas compounds in the atmosphere which can cause heat to be trapped below it so that the temperature can become hotter Population density and population increase result on the broader land area being built [2]. If the vegetation land and green open land increase, the opportunity for increasing temperatures will increase. The increase in population can be affected by two things, namely urban population growth and expansion in population movements from village to city, and in general, it can be understood that the population is increasing rapidly and easy to adjust to the situation [3]. Surface temperature or LST can be defined as the heat felt when the ground surface is touched by hand or the heat of the ground skin [4]. Also, LST serves to determine the temperature variation from rural areas to urban areas and identify the amount of land cover in the region [5]. Surface temperatures are higher in the areas that have a greater population than rural areas. Correlation shows that the Land Surface Temperature (LST) correlates strongly with the Normalized Difference Vegetation Index Identification of Land Surface Temperature with Digital Conversion Method Using Remote Sensing and GIS Techniques [6]. In 2018, the population was around 41,856 with an area of 29.92 km² [7]. The increase in population in Turikale Subdistrict resulted in increased land area, and another factor was Turikale Subdistrict, which was the District with the most population in Maros Regency.

Previous research in DKI Jakarta Province used the Normalized Difference Built-up Index (NDBI) approach, oil-adjusted Vegetation Index (SAVI), Normalized Difference Water Index (NDWI), and surface temperature using Landsat 8 Landsat Image data, aiming to determine building density [8].
research deals with the analysis of the relationship between temperature changes and regional indices built using Landsat images in Surakarta. The research method used is the Normalized Differential Built-up Index (NDBI) algorithm and the Brightness Temperature Mono-window algorithm by using Landsat image data and regression tests to determine the relationship between surface temperature and the built area index, the results obtained from this study are how much influence the regional change has on the change in temperature [9]. Other research conducted in West Bengal, India used the correlation methodology for calculating the Normalized Difference Built-up Index (NDBI) and Land Surface Temperature.

This research was carried out because in Maros District, most of Turikale Subdistrict, no research discussed this matter, this study used algorithm calculation method from NDBI and Land Surface Temperature (LST) as well as the research conducted in this study. Only the sub-district level and data obtained from Landsat 8 of this study discuss how to measure land temperature and density in Turikale Subdistrict, Maros Regency in 2013 and 2018, and presents the analysis of building density on the land surface in Turikale District.

2. The Methods

2.1. Study Area and Data Collecting
This research is located in Turikale Subdistrict, Maros Regency has a population of more than 40 thousand, has a geographical location at 5°09.18 "South Latitude 119°58'18.98" More broadly than Turikale Subdistrict is 29.93 Km². up Index (NDBI), Land Surface Temperature (LST) and Air Surface Temperature (AST). Data collection uses Landsat 8 Path 114 Row 63 in 2013 and 2018 images to process primary data using NDBI and LST methods made in map form using ArcGIS 10.3 and using the Smart Thermometer application to retrieve secondary data in the field.

2.2. NDBI
Normalized Difference Built-up Index (NDBI) is an algorithm for estimating the level of built-up area [10]. The principle of this algorithm is to see the density of building objects by calculating the ratio between mid-infrared (MIR) and near-infrared (NIR) waves. Based on its characteristics, the default object area reflects the MIR band higher than the NIR band. However, in some cases, dry land and build-up areas have the same characteristics where the MIR reflectance value is much higher than the NIRmend wave [11] NDBI [11]:

\[
NDBI = \frac{(R_{MIR} - R_{NIR})}{(R_{MIR} + R_{NIR})}
\]

(1)

2.3. LST
Land Surface Temperature (LST) is the value of land surface temperature calculated by processing TIRS images, namely, channel 10 and channel 11 [12]. However, to be able to calculate it, the DN value for each channel is first converted into a radiance value using the following equation (2):

\[
L_{\lambda} = ML \times Q_{cal} + AL
\]

(2)

where:
- \(L_{\lambda}\) = Spectral Emission from band 10
- ML = Scale Factor
- AL = Addition Factor

\(Q_{cal}\) = Digital Number (DN)

The obtained spectral radiation values are converted to become the temperature value with the formula (3):

\[
T = \frac{k^2}{ln\left(\frac{k^2}{T^4}\right)+1}
\]

(3)

where:
- \(T\) = Temperature on satellite sensors (Kelvin)
- \(K_1\) = 774.89
The last step is to convert kelvin to Celsius (4):

$$\text{CELCIUS} = T - 272.15$$  \hspace{1cm} (4)

After processing the data using the NDBI algorithm and LST analysis to determine the relationship between NDBI and LST using Simple Linear Regression. By looking for Constants (4) and regression coefficients (5) the formula:

$$a = \frac{\sum Y(\sum X^2) - (\sum X)(\sum XY)}{n(\sum X)^2 - (\sum X)^2}$$  \hspace{1cm} (5)

$$b = \frac{n\sum XY - (\sum X)(\sum Y)}{n(\sum X)^2 - (\sum X)^2}$$  \hspace{1cm} (6)

where:

- \(a\) = Constants
- \(b\) = Regression Coefficient
- \(X\) = Variable Cause
- \(Y\) = Variable Effects

After that compare the \(r\) count with \(r\) table if the correlation coefficient is greater than \(r\) table, then there is a significant relationship, if the reverse is there is no significant relationship, then the results of the classification of the LST and NDBI methods are paired with survey points to survey the areas that have changed. After that, they are correlated with each other using the linear regression method. This simple analysis will provide answers to the effect of NDBI on LST in the Turikale District.

3. Result and Discussion

3.1. (Normalized Difference Built-up Index (NDBI))

![Figure 1. Normalized Difference Built-Up Index Map Turikale District 2013 and 2018.](image)

The Normalized Difference Built-Up Index (NDBI) map in 2013 and 2018 was intended to examine building densities in Turikale Sub-district using data from 2013 and 2018. Divided into four classes,
changes in 2013 and 2018 were quite significant in Turikale District (Figure 1) In 2018 the differences occurred in the northern and central regions of Turikale District in the southern village of Boribellaya Village, Pettuadae Village, and Tarodoa Village, wherein 2013 green was still identified describing non-residential areas. Cloud-covered satellite images and sufficient research areas small affects the classification process so that it becomes less useful. In 2013 Normalized ². Classification for class -1-0, 13.3% as significant as 3.8 km² for the classification 0-0.1 30.8% for an area of 8.9 km² for the classification 0.1-0.2 amounting to 17.7% the area of 5.1 km² for the region 0.2-0.3 is 38.1% of the area of 11 km² of the total area of Turikale District is 29.93 km² in the Changes in the area of Normalized Difference Built-Up Index (NDBI). In 2018 -1-0 classification of 8.5% percent or around 2.4 km² has decreased from the previous year for 0-0.1 classification of 33.8% experienced 8.8 km² for classification 0.1-0.2 for 21.4% or an area of 6.2 km² experienced declines for the classification of 0.2-0.3 by 36% or an area of 10.4 km equaling the reduction from 2013.

3.2. Land Surface temperature (LST)

Research on land Surface Temperature to determine changes in surface temperature within five years from 2013 and 2018 in Turikale District using the LST algorithm method. Classification of surface temperature in Turikale District is divided into four temperature classes as in (Figure 2). The year 2018 looks significantly different from 2013, wherein 2013, the temperature in Turikale Subdistrict was dominated by the green color, but the target was less than 28 to 30 degrees Celsius. If seen from the classification in 2018 the temperature changed significantly where the green color had turned orange categorized as more than 33 degrees Celsius in the central area in Pettuadae and northern villages or Boribellaya Village. From the total Turikale Subdistrict as 29.9 km² in 2013, the identified classification was only a temperature of fewer than 28 degrees and 29-30 degrees of area in 2013 for a classification below 28 degrees at 5.6 km² or 19.4% for the classification of 29-30 degrees is 23.8 km² or 80.3% of all.
regions in Turikale District. For 2018 Land Surface Temperature (LST) has a more diverse ranking and increased in 2013. Classification below 28 degrees is 5 km² or 17.2% for the 29-30 classification of 10.2 km² or 35.1% in 2018 there is a total of 31-32 degrees with an area of 11.8 km² or 40.8% and a grouping of more than 33 degrees has a density of 1.8 km² or 6.8% of the total population in Turikale District.

3.3. Analysis of Relation NDBI and LST
The results of the correlation calculation test using simple linear regression resulted in the relationship between building density and surface temperature in 2013 yielding the equation $Y = 1.322 + 0.9495X_1$ with the effect of the relationship of 26.6% and in 2018 resulting in an equation $Y = 2.733 + 0.2X_1$ with a correlation of 3.2 %. So that it can be concluded that the absence or lack of a strong relationship between the index of building density and surface temperatures in 2013 and 2018 is definite. This is because Land Surface Temperature (LST) is the surface temperature associated with the geothermal potential inside Earth's surface [13]. While the Normalized Difference Built-Up Index (NDBI) takes into account building density such as settlements and other built-up lands were above the surface of the earth [14].

![Comparison of LST with Field Temperature](image)

**Figure 3.** Graph Comparison of LST with Field Temperature.

Comparison of the temperature of the Land Surface Temperature (LST) with temperatures in different fields 1-2 degrees of factors that affect the difference in the timing of secondary data collection and primary data for temperature comparison, another factor is a tool that is used to take the field temperature is inadequate. almost resembles the LST temperature at the survey point 1, 3, 5, 8, 9, 10 and 11 comparisons 50% when compared to LST temperature data and field temperature.

4. Conclusion
Changes in NDBI in 2013 in 2018 significant changes occurred in the 0-0.1 classification. Surface temperatures in Turikale Subdistrict were seen as very substantial changes seen in 2013 is dominated by green classes in 2018 temperatures have increased and are more varied compared to 2013. The comparison of ESG temperature with the field temperature surveyed is only 50% other things that increase NDBI and LST results in Turikale Subdistrict which is not large enough Landsat 8 imagery for the small sub-district of Turikale.

The results of testing the calculations using linear regression resulted in the relationship between building density and surface temperature in 2013 yielding the equation $Y = 1.373 + 0.675X_1$ with a correlation of 18.9% and in 2018 generating an equation $Y = 1.364 + 0.636X_1$ with a relationship of 10.9%. 2013, 2013-2015. In 2018. To be improved in the future to use Landsat Imagery that has a higher sharpness.
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