The Effect of Land Surface Temperature and Land Use on Energy System Development in Gorontalo City

N Arif1*, A N Khasanah2, R Jaya1, M Gozan3, B Hendrawan4

1Geography Department, Faculty of Science and Technology, Universitas Muhammadiyah Gorontalo, Pentadio Timur, Gorontalo, 96181
2Remote Sensing and Geographical Information System, Vocational School, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia
3Chemical Engineering Department, Faculty of Engineering, Universitas Indonesia, Kampus UI Depok 16424, West Java, Indonesia
4Department of Education of Elementary School Teachers, Faculty of Teacher Training and Education, Universitas Muhammadiyah Tasikmalaya

*nursida.arif@um-gorontalo.ac.id

Abstract. Land use change is one of the factors affecting urban development including urban energy needs. This study analysis the effect of land use and surface temperature on energy system development of Gorontalo city. Gorontalo has a very high solar energy potential but has not been utilized optimally. Land Surface Temperature (LST) mapping is the first step to identify the potential of solar energy for energy system development in Gorontalo City. Remote sensing technology and geographic information systems are helpful in mapping the spatial distribution of each parameter used. In this research the data used is Landsat 8 for mapping land cover/land use, green area and LST. The results showed that in the dry season the highest surface temperature was in the building area, and the lowest temperature was in the vegetation area. Land use in city of Gorontalo is dominated by high density vegetation (VKT) of 36% of the total area, while built-up area has 26% of the total area. LST was dominant in the wet season of 30-40 °C i.e 50.51% of the area while in dry season wasdominant at 40-50 °C covering 42%. The highest temperature in the city of Gorontalo in both dry and wet season is distributed in Pulubala, Limba U1, and Biawao. These three regions can be a recommendation for the development and utilization of solar energy as an alternative energy source. This research provides insight into land surface temperature and become a recommendation in urban planning and energy policy.

1. Introduction
Dynamic urban developments have had a significant effect on the increase in urbanization, urban physical development and land use change. One of the main reasons for the complexity of a city's problems is the population growth, economic attractiveness and academic facilities found in the city. This has an impact on urban energy needs where the largest energy users are in urban areas [1-2]. Land surface temperature (LST) is one of the main parameters in environmental studies and urban dynamics that affect the balance of surface energy and energy exchange impacting the comfort of urban population [3-5]. The LST study is conducted to determine the surface temperature of Gorontalo
city as part of the analysis of solar energy potential as an alternative energy in Gorontalo city. The amount of solar energy varies on every surface of the earth, depending on location and weather. Dense settlements in the city will affect the surface temperature because land cover is correlated with climate and surface temperature.

Indonesia, particularly Gorontalo, has a very high solar energy potential where the average intensity of 4-5 Wh/m² is valid throughout the year. In 2010, Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) mentioned that the intensity of solar radiation is 4.911 Wh/m². The potential to be a source of electrical energy for the community is huge. But the results of initial observation show that the utilization of solar power as a source of electrical energy has not been maximized. On the other hand, the problem of urban energy becomes important because environmental problems are caused by energy consumption that is basically to meet human needs and sustain economic growth.

Heat analysis of a region can be done using a remote sensing approach. Remote sensing is one of the most comprehensive technologies used for earth observation for military, geological, surveys and resource inventory, mapping, urban planning and others [6]. Remote sensing has been used extensively for city environmental studies, identification of surface temperatures and urban heat islands [4,7-8]. One of the remote sensing systems utilizes thermal energy recording, which is recording the energy information emitted by an object. The red and infrared channels in the image are used to calculate the values of vegetation index and emissions from the land cover, whereas thermal is used to calculate the surface temperatures. LST study is very important to be done in relation to the balance of energy and climate change as well as a recommendation in the analysis of energy planning for decision makers on energy policy such as adding alternative energy, energy optimization or reducing carbon emissions.

2. Methods and Materials

2.1. The Study Area

The city of Gorontalo is the capital of Gorontalo Province which has a total area of 79.03 square kilometers. Geographically located at 00°28'17" - 00°35'56" N and 122°59'44"- 123°05'59" E. Gorontalo is one of the regions in Indonesia that has high solar radiation compared to other regions [9].

2.2. Image Processing

Landsat image classification is performed to produce land cover information. The classification method, which is supervised classification, is the maximum likelihood classifier (MLC) by grouping pixels into appropriate land cover classes or most closely resembling the sample pixel value of the ROI (region of interest). ROI is recognized based on the visual appearance of objects in the image using interpretation keys in the form of colors, hues, shapes, sizes, associations. For example, the vegetated area is characterized by a thick green color while the built-up area has a color tends to light brown and coarse textured.

In [10] stated that vegetation index is a transformation designed and applied to multichannel remote sensing images to sharpen or highlight the aspects of vegetation density. The lower pixel image value at a location indicates that the vegetation intensity at the location is lower and if the pixel value is high then the location has high vegetation density. Red and infrared channels are used to calculate Normalized Difference Vegetation Index (NDVI) values and emissions of land cover.

Land Surface Temperature (LST) derived from the processing of two landsat imagery of August 2017 and February 2018. Both images are used to distinguish the surface temperatures during wet and dry seasons. Landsat 8 has 11 channels consisting of nine (9) multispectral channels and two (2) thermal channels. LST calculations use 3 bands in Landsat image: red, infrared, and thermal bands 1, while thermal channels are used to calculate surface temperatures.

3. Results and Discussion
The change of land use in 2017-2018 is not very specific, considering the data used is only 6 months difference. Therefore, only one Landsat data is used as data of 2017 and geographical condition of the city of Gorontalo is also seen from the climatic conditions. [12] explains that urban land use patterns have a significant correlation to energy consumption. Land use change and LST are major factors in the study of urban heat island [13-15].

![Figure 1. Land Cover Distribution Derived from Landsat August 2017](image)

Based on the classification results (Figure 5), it is known that the land cover in the city of Gorontalo is dominated by high density vegetation (VKT) of 36% of the total area, while built-up area has an area of 2.074 ha or 26% of the total area of Gorontalo city. Land covers (LC) in the form of vegetation scattered in mountainous areas near the coast, while the agricultural and urban areas scattered in the flat area in the centre to the north of Gorontalo city. The percentage of land cover area is shown in Figure 6 and Table1 (You Can Check Figure, Figure 5 is wrong)

![Figure 2. Percentage Area of land cover](image)

In contrast to research conducted by [5] which links LST with elevation, this study only looks at the relationship between land cover/land use and surface temperature. The changes of land use have an
effect on the amount of thermal energy reflected by the earth's surface. If the vegetation density decreases, the open area will appear brighter and reflect more solar energy. In the absence of adequate vegetation, the absorption of carbon dioxide in the air will not be maximized as well. The value of solar radiation is different in various types of land use as shown in Table 1

Table 1. The value of solar radiation in various types of land use

| Land use type            | Solar irradiance (kWh/m²) |
|--------------------------|---------------------------|
| Built up area (bu)       | bu_1 4.40                 |
|                          | bu_2 4.43                 |
|                          | bu_3 4.43                 |
| Vegetation high density (vkt) | vkt_1 4.1           |
|                          | vkt_2 4.1                 |
|                          | vkt_3 4.0                 |
| Vegetation low density (vkr) | vkr_1 4.3          |

Source: Analysis of Land use, 2018; http://globalsolaratlas.info

Table 1 shows higher radiation values in the built up area and low density vegetation compared to high density vegetation. This shows there is a correlation between land use, land surface temperature and the value of solar radiation. Figure 3 shows the result of land surface temperature processing from Landsat 8 thermal data. The highest temperature in Gorontalo city, in both dry and wet season, is distributed in Pulubala, Limba U1, and Biawao areas. High land surface temperature (>60°C) in dry season (Figure 3, left). The results of the LST spatial distribution can be used as a reference for the operation of the photovoltaic module system. [16] stated that surface temperature has a strong correlation with solar radiation or straight-line.

Figure 3. Land surface temperature distribution in Dry season August 2017 (Picture left) and in Wet Season February 2018 (Picture right)
High temperature values are indicated by the use of land in the form of distributed land in the built-up area. The temperature distribution decreased in the following year. The average temperature differences in wet and dry seasons reach 12°C (Table 2).

Table 2. Area based on surface temperature

| No | Surface temperature | Tahun 2017 (dry season) | Tahun 2018 (wet season) |
|----|---------------------|-------------------------|-------------------------|
| 1  | 20-30               | 595,35                  |                         |
| 2  | 30-40               | 896,13                  | 3969,63                 |
| 3  | 40-50               | 3321,18                 | 2712,06                 |
| 4  | 50-60               | 2092,77                 | 556,29                  |
| 5  | 60-70               | 1446,12                 | 24,3                    |
| 6  | 70-80               | 96,39                   | 0,81                    |
| 7  | 80-90               | 4,23                    |                         |
| 8  | 90-100              | 0,81                    |                         |
| 9  | >100                | 0,81                    |                         |
| Jumlah |             | 7858,44                 | 7858,44                 |

Figure 3 shows that in dry season, the dominant temperature in the built-up area ranges from 40-50°C, and 30-40°C in wet season. The average surface temperature in dry season was 30-100°C, while in wet season is 20-80°C (Table 2). LST values can be a recommendation for spatial analysis of the use of solar energy as an energy source by looking at the spatial distribution of land cover and land surface temperature.

4. Conclusion
The results show that remote sensing images can be utilized for surface temperature analysis. There is a correlation between land cover, land surface temperature and NDVI. In dry season, the dominant surface temperature in the built-up area ranges from 40–50 °C, while in wet season it ranges from 30-40 °C. The results obtained may be different if it was done in different locations and climates. The highest temperature in Gorontalo city in both dry and wet season is distributed in Pulubala, Limba U1, and Biawao areas. Based on the LST value and the geographic conditions of Gorontalo city allows for the development and utilization of solar energy as an alternative energy source. Each type of land cover /land use has a different value for solar radiation. Built land has an average value of solar radiation 4.4 kWh /m², low density vegetation 4.3 kWh /m² and high density vegetation 4.1 kWh /m².

Future research can be continued with an analysis of the effect of environmental parameters and morphology of the city on energy efficiency. It is also necessary to test the correlation between the spatial distribution of LST with the potential of solar panel installation location and to predict how much energy can be saved.

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