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Spatial pattern of changes in land surface temperature of seram island based on google earth engine cloud computing

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ABSTRACT

Monitoring land surface temperature in Seram Island using cloud computing-based geospatial technology, Google Earth Engine, could help to understand global climate and weather changes, and provide important information for scientists, governments, and non-governmental organizations to make decisions related to climate change mitigation and natural disaster management. This study aims to analyze the spatial pattern of land surface temperature change on Seram Island based on the cloud computing Google Earth engine. This research uses Moderate Resolution Imaging Spectroradiometer (MODIS) Terra Land Surface Temperature and Emissivity 8-day global satellite image data, which are accessed and analyzed in Google Earth Engine and Arc GIS. The results of this study show that the value of land surface temperature on Seram Island in 2017 is 14.7089°C at the lowest value and 30.1012° C at the highest value and it increased in 2022 where the lowest temperature value is 14.0452°C and the highest temperature is 32.639°C. Built-up land and open land areas on Seram Island have very high surface temperature values compared to forests and plantations which have low land surface temperatures. Analysis of land surface temperature in Seram Island Regency could provide important information for the local government to make policies and plans for sustainable regional development.

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1. INTRODUCTION

Land surface temperature is one of the important parameters in weather and climate and environmental studies [1],[2], It refers to the air temperature measured at a height of about 1.5 meters above the ground or the surface of other objects located on land. Land surface temperature is influenced by various factors, such as air temperature, solar radiation, air humidity, the type of soil or surface object on the land, and geographical location [3]. Changes in land surface temperature have a major impact on the environment and human life. Climate change and increases in land surface temperature caused by human activities, such as deforestation and greenhouse gas emissions, could impact ecosystem balance, human health, and crop and livestock production [4].

Land use changes such as deforestation, conversion of forest land to plantations or agriculture, and urbanization could lead to increased surface temperatures [5]. Deforestation reduces the number of natural heat sinks such as trees and moist soil, while urban land use could increase the concentration of heat-generating materials such as asphalt and concrete. Increased urbanization on Seram Island

could lead to increased surface temperatures because urban areas have a higher concentration of buildings and asphalt than rural areas. Increased residential development activities for transmigrant communities and mining activities could cause an increase in surface temperature due to the heat generated by these activities [6].

Spatial temporal monitoring of land surface temperature in Seram Island using Google Earth Engine cloud computing-based geospatial technology could help in understanding global climate and weather changes, and provide important information for scientists, governments, and non-governmental organizations in making decisions related to climate change mitigation and natural disaster management [7]. Google Earth Engine is a cloud computing platform for geospatial data analysis and mapping that allows users to access and analyze satellite imagery data from various sources, including Landsat, Sentinel, and MODIS [7]. Google Earth Engine offers programming capabilities with JavaScript and Python, as well as data visualization and analysis tools such as time series, image segmentation, and spatial analysis [8]. In addition, the platform provides access to data that has been processed and stored on Google's servers, which allows users to perform complex analyses on very large data [9].

Google Earth Engine is used by scientists, governments, and non-governmental organizations to monitor environmental changes such as deforestation, climate change, and pollution, as well as to map natural resources, plant health, and weather patterns. The platform also helps in natural disaster monitoring and disaster risk mitigation. According to Wang et al [10], Google Earth Engine could be used to analyze land surface temperature by utilizing satellite image data available on the platform. This data could be used to observe changes in land surface temperature over time, as well as identify distinct temperature patterns in specific regions [9]. To perform land surface temperature analysis, users could utilize satellite imagery data such as Landsat, Sentinel, or MODIS available on Google Earth Engine [11], [12].

These land surface temperature maps could be used to understand land surface temperature patterns at various locations at any given time. In addition, land surface temperature data obtained from MODIS images could be used to monitor changes in land surface temperature over time and could help in predicting natural disasters such as forest fires and floods. Dutta et al [13], also argue that by utilizing MODIS imagery for land surface temperature analysis, we could understand global climate and weather changes, monitor environmental health, determine appropriate planting zones, improve understanding of human health, and support decision-making in natural resource management [14]. Based on the description above, this research aims to analyze the spatial pattern of changes in the land surface temperature of Seram Island based on the cloud computing google earth engine in 2017 and 2022.

2. RESEARCH METHOD

This research was conducted in Seram Island, Maluku Province which administratively consists of West Seram Regency, Central Maluku Regency, and East Seram Regency. This study used Moderate Resolution Imaging Spectroradiometer (MODIS) Terra Land Surface Temperature and Emissivity 8-Day Global image data accessed and analyzed on Google Earth Engine. (https://earthengine.google.com/). MOD11A2.061 Terra Land Surface Temperature and Emissivity 8-Day Global 1km in Figure 1 is a satellite imagery product developed by NASA. It provides information on land surface temperature and emissivity around the world with a spatial resolution of 1 kilometer. This data is generated by the MODIS (Moderate Resolution Imaging Spectroradiometer) instrument mounted on the Terra satellite [15],[16][17].

MOD11A2.061 Terra Land Surface Temperature and Emissivity 8-Day Global 1km is very useful in various applications such as surface temperature monitoring, forest fire detection, water resource management, and weather modeling. Analysis of land surface temperature on Seram Island was carried out in 2017 and 2022. The surface temperature analysis in this study was carried out on the Google Earth Engine (GEE) cloud computing platform by modifying the script previously used by Rakuasa [4]. Google Earth Engine display could be seen in Figure 2.

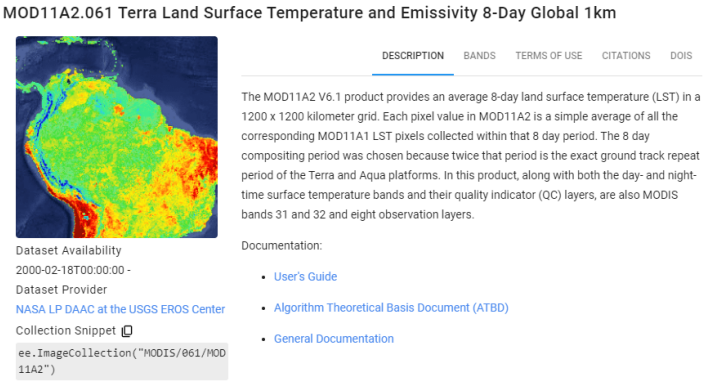

Figure 1. MODIS Image Dataset View

MOD11A2.061 Terra Land Surface Temperature and Emissivity 8-Day Global 1km available on Google Earth Engine (GEE) in Figure 1, is a collection of images acquired from the NASA Terra satellite using the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument [9]. This data includes estimates of land surface temperature and global emissivity at a spatial resolution of 1 kilometer. The MOD11A2.061 image collection in GEE spans 8 days and provides information on land surface temperature at each image pixel as well as emissivity estimates [8]. Land surface temperature estimates are obtained by analyzing the intensity of infrared radiation emitted by the Earth's surface, while emissivity estimates describe the surface's ability to emit thermal radiation [18].

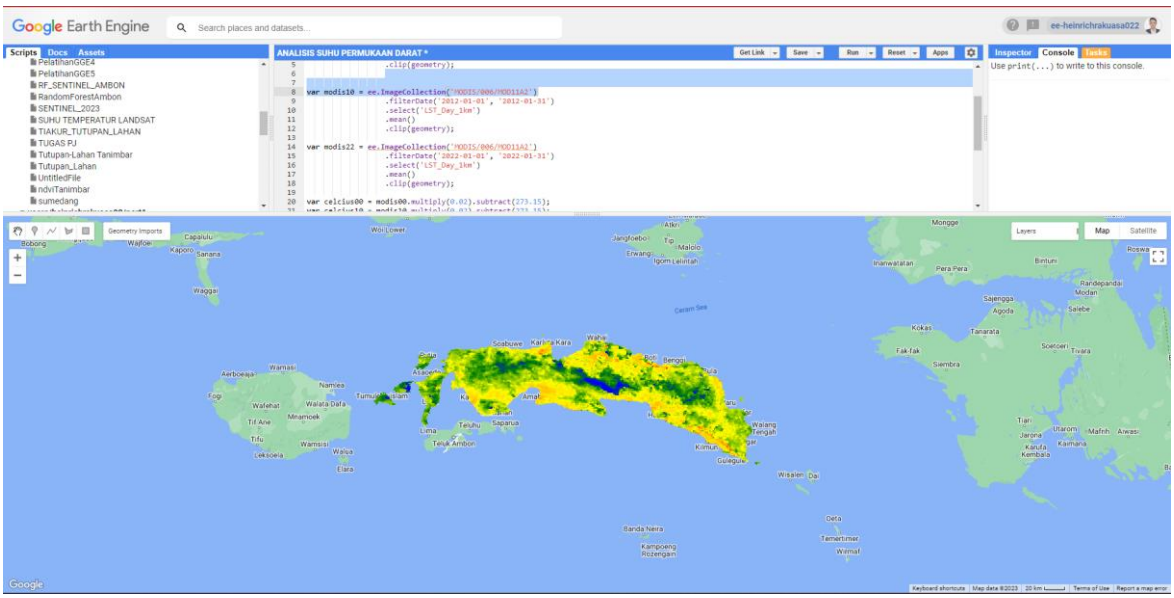

Figure 2. Google Earth Engine View

The MOD11A2.061 Terra Land Surface Temperature and Emissivity 8-Day Global 1km image data on GEE in Figure 2, is useful for a variety of applications, including land surface temperature monitoring, climate modeling, forest fire monitoring, urban temperature analysis, and another related scientific research. Google Earth Engine provides easy access to these data as well as powerful data processing and visualization tools, allowing users to perform efficient data analysis and exploration [7].

The process of processing and analyzing MOD11A2.061 Terra Land Surface Temperature and

8-Day Global 1km image data into Seram Island land surface temperature surface temperature was is fully performed with JavaScript in Google Earth Engine. The stages of data processing and analysis are as follows:

a. Import Image CollectionMODIS, aims to display or call MODIS images from the GEE Catalog.

```
var modis00 = ee.ImageCollection('MODIS/006/MOD11A2')
```

b. Determine the time variable, aiming to determine the period of the study.

```
filterDate('2022-01-01', '2022-12-31')
```

c. Selecting the LST Day 1 Km Band, aims to select the average pixel value of LST Day 1 Km (MOD11A2) from all MOD11A1 pixels in 8 days.

```
select('LST_Day_1km')
```

d. Clip the boundary and display the data on a map, aiming to process the data according to the research location using the Seram Island boundary shapefile and display it on a map.

```
clip(geometry);
```

e. Convert Kelvin to Celsius, which aims to convert LST values from Kelvin to Celsius scale.

```
var celcius00 = modis00.multiply(0.02). subtract(273.15);
```

f. Display surface temperature or radiant emission temperature/netto on a map.

```
var suhuparam = {min: 20, max:
40,palette:['blue','green','yellow','orange','red']};
```

g. Display the result of surface temperature analysis in the GEE Layer.

```
Map.addLayer(celcius00, suhuparam,'SUHU RERATA TAHUN 2022');
```

h. Exported ESG analysis results to Google Drive which could then be downloaded for further analysis in GIS software.

```
Export.image.toDrive({
image:celcius10,
description: 'SUHU_PERMUKAAN_SERAM_2022',
scale: 30,
maxPixels: 600000000,
region: geometry
});
```

After the results of the land surface temperature analysis are downloaded from Google Drive, classification is carried out in Arc GIS software which refers to the research of Sasky et al [19]. Classification of land surface temperature analysis could be seen in Table 1.

Table 1. Land Surface Temperature Classification

No	Land Surface Temperature Classes	Temperature range
1	Very Low	<20° C

2	Low	20° C – 25° C
3	Medium	25° C – 30° C
4	High	30° C - 35° C
5	Very High	>35° C

Source: [19]

In Table 1, the Land Surface Temperature Classification is divided into 5 classes based on the research of Sasky et al [16], including a very low class with a land surface temperature (LST) < 20° C, a low class with a land surface temperature (LST) of 20° C - 25° C, a medium class of 25° C - 30° C, a high class of 30° C - 35° C and a very high LST class of >35° C. The results of the analysis of the land surface temperature of Seram Island in 2017 and 2022 than calculated the area of change and map layout in Arc software. GIS software and Microsoft Excel.

3. RESULTS AND DISCUSSIONS

Based on the results of the application of the Google Earth Engine Script to process the MODIS MOD11A2.006 Terra Land Surface Temperature and Emissivity 8-Day Globalıkm Image, data on the distribution of the average Land Surface Temperature of Seram Island in 2017 and 2022 were obtained. Visual data of the average Land Surface Temperature distribution of Seram Island in 2017 could be seen in Figure 3 and in 2022 could be seen in Figure 4.

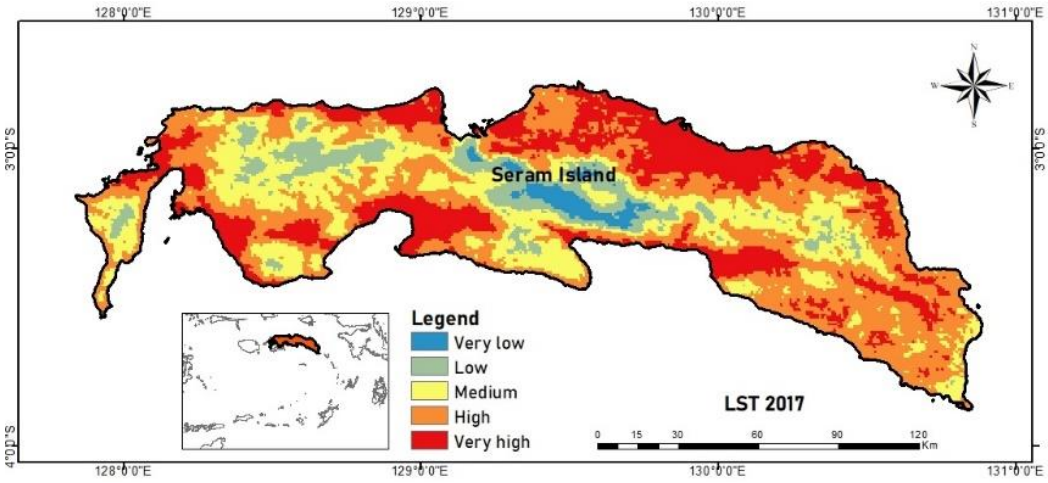

Figure 3. Land Surface Temperature in 2017

The land surface temperature of Seram Island in 2017 in Figure 3, the highest temperature is marked with red color and the lowest temperature is marked with blue color. Coastal areas of Seram Island generally have high surface temperatures in contrast to mountainous areas which have low land surface temperatures. Land Surface Temperature class is the division of the range of land surface temperature values into several classes or categories based on certain boundaries. This division aims to facilitate data analysis and interpretation of information related to land surface temperature. In this study, the land surface temperature class is divided into four classes referring to the research of [19] namely very low, low, medium, high, and very high. The surface temperature on Seram Island in 2017 in the very low class (<20° C) is 35,377.41 ha, and low class (20° C - 25° C) is 158. 628.65 ha, medium class (25° C - 30° C) covering 424,898.18 ha, high class (30° C - 35° C) covering 681,855.42 ha and in the extremely high class (>35° C) covering 434,980.92 ha/

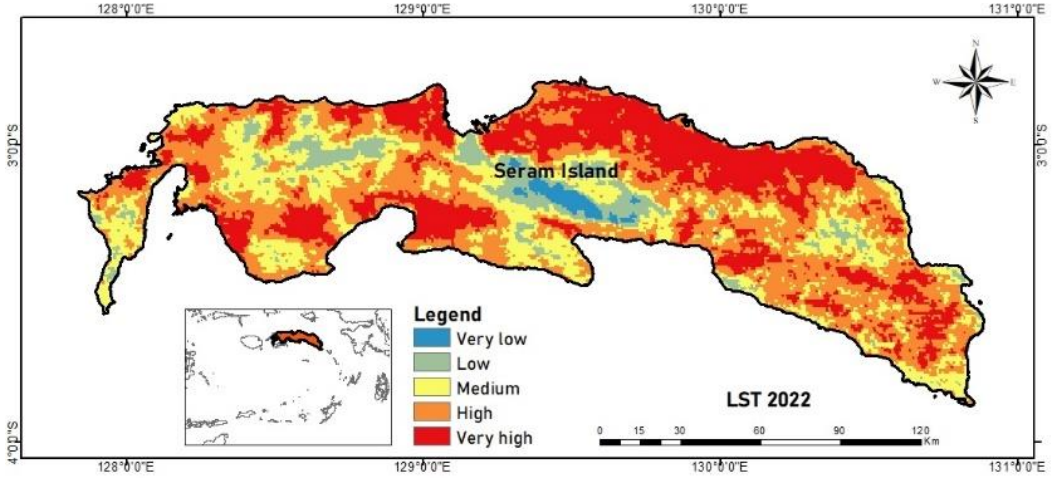

Figure 4. Land Surface Temperature in 2022

Based on Figure 3 and Figure 4, it can be seen that the land surface temperature continues to increase. Land surface temperature values can vary depending on various factors such as location, time of day, weather conditions and land use. Land surface temperature data can be obtained from satellites equipped with thermal sensors such as MODIS or Landsat [20]. Land surface temperature values obtained from satellite data can be expressed in Kelvin, Celsius, or Fahrenheit depending on the analysis preference [19]. The land surface temperature value in Seram Island in 2017 was 14.7089° C at the lowest value and 30.1012° C at the highest value. The value of land surface temperature on Seram Island in 2022 has increased where the lowest temperature value is 14.0452°C and the highest temperature is 32.639° C. The value with the highest surface temperature in Figures 3 and 4 is identified in red and the lowest value in blue.

In 2022, the land surface temperature in Seram Island increased in the area where the very low class (<20° C) was 22,954.75 low class (20° C - 25° C) was 134. 094.82 ha, medium class (25° C - 30° C) covering 419,008.89 ha, high class (30° C - 35° C) covering 692,368.01 ha and very high class (>35° C) covering 478,182.53 ha. The results of the analysis also show that spatially very high surface temperatures are in coastal areas and built-up land areas. in general, areas that have high land surface temperatures are tropical and subtropical regions as I mentioned earlier. Land surface temperature in an area could be influenced by factors such as climate, weather, altitude, and land cover, so it could vary in different regions [21] The correlation of developed land development with increased land surface temperature could be seen in Figure 5.

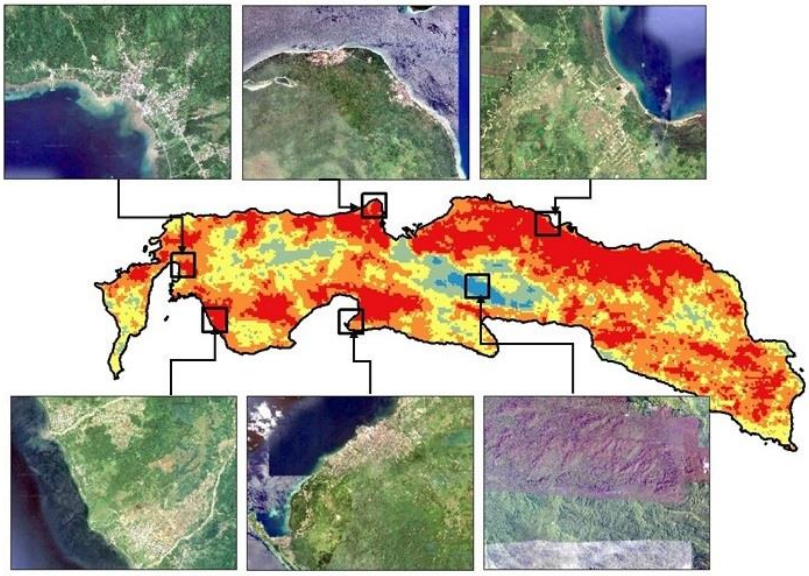

Figure 5. Correlation of Built-Up Land Development with Increased Land Surface Temperature

Figure 5 shows that the area of built-up land and open land on Seram Island has a very high surface temperature value compared to the forest which has a low land surface temperature. The development of built-up land could cause an increase in land surface temperature. Building materials such as concrete, asphalt, and glass in buildings built on built-up land could absorb and reflect solar heat so that the land surface temperature could increase significantly [11].

In addition, built-up land could influence airflow patterns and cloud formation, which could affect the temperature and weather in an area [22]. Therefore, when green lands that can absorb solar heat and produce oxygen are replaced with built-up lands, there will be an increase in land surface temperature. Based on the results of research conducted by previous researchers, there is a positive correlation between the development of built-up land and an increase in land surface temperature in several regions [23]. The results of this research are expected to provide benefits for the community and government, including:

a. Assist in the understanding of changes in land surface temperature: By utilizing Google Earth Engine cloud computing technology, this research was able to produce highly detailed and accurate land surface temperature maps [24]. This helps researchers and the general public to understand the pattern of land surface temperature change and the factors that influence it on Seram Island.
b. Enhance environmental monitoring capabilities: Google Earth Engine's cloud computing technology enables researchers to process and analyze large amounts of data in a short period. In this context, this technology could enhance environmental monitoring capabilities more effectively and efficiently [2].
c. Provides important information for climate change mitigation: Changes in land surface temperature could affect the climate and human environment [25]. The information obtained from this research could provide important insights for governments, organizations, and communities to plan climate change mitigation [26].
d. Improving policy and decision-making effectiveness: With the information obtained from this research, governments, and organizations could make more effective policies and decision-making in efforts to protect the environment and mitigate climate change on Seram Island [27].
e. Could be applied to other regions: The methods and technologies used in this research could be applied to other regions in Indonesia or even around the world [28]. This opens up opportunities for researchers and communities to understand and address environmental challenges more effectively and efficiently.

4. CONCLUSION

The results of this study indicate that the value of land surface temperature on Seram Island in 2017 is 14.7089°C at the lowest value and 30.1012° C at the highest value and in 2022 it increased where the lowest temperature value is 14.0452 ° C and the highest temperature is 32.639° C. Surface temperature on Seram Island in 2017 in the very low class is 35,377.41 ha, low class is 158,628.65 ha, medium class is 424,898.18 ha, high class is 681,855.42 ha and in the very high class is 434,980.92 ha. In 2022, the land surface temperature in Seram Island increased in areas where the very low class was 22,954.75, low class was 134,094.82 ha, the medium class was 419,008.89 ha, the high class was 692,368.01 ha and the very high class was 478,182.53 ha. Built-up land and open land areas on Seram Island have very high surface temperature values compared to forests which have low land surface temperatures. The research results are expected to provide great benefits for the local government in planning and making decisions in various sectors including the development of the agricultural sector, water resource management, and disaster management. Thus, the analysis of land surface temperature in Seram Island could provide important information for the local government in making policies and planning sustainable regional development.

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