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Utilization of Landsat 8 Imagery for Analyzing Land Surface Temperature in Sumbawa Regency from 2018 to 2022 Using Google Earth Engine

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ABSTRACT

This study aims to analyze the land surface temperature in Sumbawa Regency from 2018 to 2022 using Landsat 8 imagery and the Google Earth Engine (GEE) platform. The surface temperature data was obtained from the Landsat 8 image collection with a spatial resolution of 1 km and a temporal resolution of 8 days. The Split Window Algorithm was used to calculate the land surface temperature based on thermal infrared data. The analysis process included image acquisition, selection of daytime temperature bands, and conversion of temperature from Kelvin to Celsius. The results showed variations in the average land surface temperature in Sumbawa Regency over the five-year period, with a decreasing temperature trend in certain years, possibly related to climatic factors and the increase in green open spaces. These data can be used to support natural resource management and mitigate the impacts of climate change in the region. This study also emphasizes the importance of utilizing remote sensing technology and cloud computing platforms for efficient and integrated geospatial analysis.

Keywords: land surface temperature; Landsat 8; Google Earth Engine; Split Window Algorithm; Sumbawa Regency

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1. Introduction

Sumbawa is one of the regencies located in the Province of West Nusa Tenggara, Indonesia. The region covers an area of 6,643.98 square kilometers and is bordered by the Alas Strait and West Sumbawa Regency to the west, Dompu Regency to the east, the Indian Ocean to the south, and the Flores Sea and Saleh Bay to the north. As of 2023, the population of Sumbawa reached 529,487 inhabitants. The increase in population in a region often triggers development across various sectors. This population increase can lead to a reduction in green open spaces (GOS), which can trigger various other environmental challenges [1].

Development in Sumbawa Regency often presents a paradox, such as land conversion, infrastructure expansion, and industrial growth that are not accompanied by adequate environmental analysis, which threatens the carrying capacity of the region. One of the primary issues is the lack of a clear development masterplan, which leads to the conversion of productive land into non-agricultural areas, potentially reducing community welfare due to food supply imbalances [2]. According to the survey by [2], environmental damage in Sumbawa is triggered by illegal logging, forest encroachment, and illegal corn cultivation, which spark forest fires and contribute to rising surface temperatures. Land use changes can cause microclimate alterations, including the *Urban Heat Island* (UHI) phenomenon, where temperatures in urban areas are typically higher compared to surrounding regions. This is influenced by human activities, such as

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infrastructure development and other actions that contribute to surface temperature increases [3].

The temperature of an area is influenced by various factors, such as solar radiation intensity, elevation, and land surface temperature (LST). LST is a representation of the average surface temperature of the ground, reflecting a combination of soil and vegetation temperatures [4]. The LST value is highly dependent on wavelength, particularly thermal infrared, which is used to analyze surface temperature using satellite imagery. Global weather and climate patterns are influenced by surface temperature changes [5]. According to [6] in [7], remote sensing is fundamentally a science and technology that utilizes sensors and other devices to collect data and information without direct contact with the observed object or area. Data collected through remote sensing is processed and interpreted to recognize and map the physical characteristics, composition, and changes occurring in an object or region.

MODIS (Moderate Resolution Imaging Spectroradiometer) is a type of satellite imagery used for mapping land surface temperature. This sensor is a key component on the Terra and Aqua satellites, which move in a polar orbit (north-south) at an altitude of 705 kilometers [1]. This sensor is one of the main instruments in the Earth Observing System (EOS) Terra Satellite, which is part of the space program of the National Aeronautics and Space Administration (NASA) of the United States [4]. The use of MODIS satellite imagery with remote sensing technology enables observation of land surface temperature, contributing to the Urban Heat Island (UHI) phenomenon and land surface temperature increase [1]. One algorithm that can be used to help LST observe land surface temperature is the Split Window Algorithm (SWA). The application of the SWA algorithm covers various fields, such as environmental monitoring, land surface temperature change detection, climate research, and natural resource management. By significantly reducing atmospheric influences, SWA is able to provide land surface temperature processing results that are closer to actual conditions, making it very useful for spatial analysis on a large scale [8].

The platform used to help observe land surface temperature is Google Earth Engine (GEE). GEE is a cloud computing platform developed by Google to provide access for researchers, scientists, and developers in analyzing satellite imagery data and geospatial information on a large scale[9]. One of GEE's advantages is that users do not need to perform time-consuming image pre-processing or provide data storage space on hardware, as all storage and computation processes are carried out through cloud services. GEE has a comprehensive and continuously updated satellite imagery archive, including data from Landsat 1-8, Sentinel 1-2, MODIS, Vector Data, Terrain, Land Cover, as well as other vector data based on Geographic Information Systems (GIS), such as social data, demographics, weather, digital elevation models, and climate data layers [4].

This study aims to analyze land surface temperature in Sumbawa Regency using the Google Earth Engine (GEE) Platform. The data used is the Modis Land Surface Temperature and Emissivity satellite imagery. The results of this research will show the average temperature in the Sumbawa region over a five-year period, from 2018 to 2022.

2. Research Methodology

2.1 Research Location

This research was conducted in the Sumbawa region, West Nusa Tenggara, Indonesia, with a specific focus on the Sumbawa area covering an area of 6,643.98 km^2.

2.2 Tools and Materials

This research used Modis Terra Land Surface Temperature and Emissivity 8-Day Global 1km imagery and Sumbawa Regency administrative boundary (shp) data. Equipment used included a computer with internet network access.

2.3 Data Collection

This research utilized land surface temperature data from the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor installed on NASA's Terra and Aqua satellites. Handayani et al. (2014) in Rizki & Kurniadin (2022) stated that this MODIS sensor produces daily Land Surface Temperature (LST) data with a 1 km spatial resolution to map temperature variations on a large scale in Sumbawa Regency. Data collection was performed by accessing daily imagery from January 1, 2018, to December 31, 2023, through Google Earth Engine (GEE). The image data was then filtered based on annual date ranges for each year. To provide a clearer picture of land surface temperature, monthly and annual averages were calculated from LST data converted from Kelvin to Celsius. Data was obtained through the GEE platform, which enables cloud-based data downloading and processing without requiring local storage, thus supporting sustainable data processing (Pratama & Sudrajat, 2020).

2.4 Pengolahan Suhu Permukaan

2.4.1 *Brightness Temperature* (T_b)

Converting radiance values to Kelvin by calculating Brightness Temperature (T_b) using the formula (Mukmin, et al. 2016) :

$$T_b = \frac{K_2}{In\left(\frac{K_1}{L_\lambda}+1\right)} \quad (2)$$

Explanation :

T_b : Radiant Temperature in Kelvin
L_λ : Spectral Radiance
K_1 : Spectral Radiance Calibration Constant
K_2 : Absolute Temperature Calibration Constant

2.4.2 Conversion Kelvin to Celsius

Converting Kelvin values to Celsius using the formula (Sunaryo & Iqmi, 2022) :

$$TCelcius = TKelvin - 273 \quad (3)$$

Explanation :
BT : Brightness Temperature
T : Kelvin−273,15 = Konversi Kelvin ke Celcius

2.4.3 ***Emissivity*** (e)

Emissivity is used to analyze the characteristics of the Earth's surface and convert thermal energy into radiant energy (Solihin & Putri, 2020). Surface emissivity is crucial for minimizing errors in surface temperature calculations obtained from satellite imagery. One alternative to obtain surface emissivity is by using Vegetation Index, with the PV value obtained from the equation (Fahwari, et al, 2019) :

$$E = 0.004 * PV + 0.986 \quad (4)$$

Explanation:
0.004 : Average emissivity value of dense vegetation
0.986 : Emissivity Standards for Open Land

2.4.4 *Land Surface Temperature* (LST)

After converting the digital number values to radiance, determining the emissivity, and converting the temperature from Kelvin to Celsius, the Land Surface Temperature (LST) is then calculated using the following equation (humam, et al. 2019) :

$$LST = \frac{T_b}{1+\left(\frac{\lambda T_b}{\rho}\right)\ln e} \quad (5)$$

Explanation:

T_b : Radian Temperature in Kelvin to Celsius
λ : Blotzmann constant
ρ : Planck's constant
e : emissivity

2.5 Pre-Processing Stage with GEE

The MODIS data processing begins with collecting images from the MODIS LST (Land Surface Temperature) dataset. This dataset provides global land surface temperature with an 8-day temporal resolution and 1 km spatial resolution. Secondly, the study area is defined as Sumbawa Regency. Thirdly, the desired time range is set, which is from 2018 to 2022. Fourthly, a date filter function is used to filter the data based on the time range. Fifthly, the band of interest is selected, which is the daytime land surface temperature data with a 1 km resolution. Sixth, the temperature is converted from Kelvin to Celsius. Seventh, a reducer is applied to display only one image using the mean function. Finally, the image is clipped to match the study area using the clip function.

3. Results and Discussion

The first step in analyzing land surface temperature is to download MODIS Terra image data with 8-Day Global 1km resolution for land surface temperature and emissivity. In this research, multi-temporal MODIS imagery from 2018 to 2022 is used, so that the script is written in Google Earth Engine (GEE) is adjusted to the data period. The next process is to filter using the select function to select the LST_Day_1km band, which contains land surface temperature information. Then, a reducer function is applied to display a single image by calculating the average value with the mean function. Next, the image area is cut according to the research area using the clip function. The surface temperature data obtained is in the form of average values in Kelvin units, so conversion to Celsius units is carried out via GEE. The final results describe the surface temperature in the Sumbawa Regency area. To support visual interpretation, a legend is added that explains the color representation, making it easier to understand the temperature distribution based on color.

Table 1. Land Surface Temperature

Color	Temperature °C
Blue	<20
Lime Green	20-25
Yellow	25-30
Dark Orange	30-35
Red	>35

Based on the results of applying the Google Earth Engine script to process the Landsat 8 Terra Land Surface Temperature and Emissivity 8-Day Global 1km image, data on the distribution of Land Surface Temperature in Sumbawa Regency was obtained. The visual data distribution of Land Surface Temperature in Sumbawa Regency from 2018 to 2022 is presented in Figures 1 to 5, while the presentation in the form of a graph is presented in Figures 6 to 10 for the distribution of Land Surface Temperature in Sumbawa Regency from 2018 to 2022.

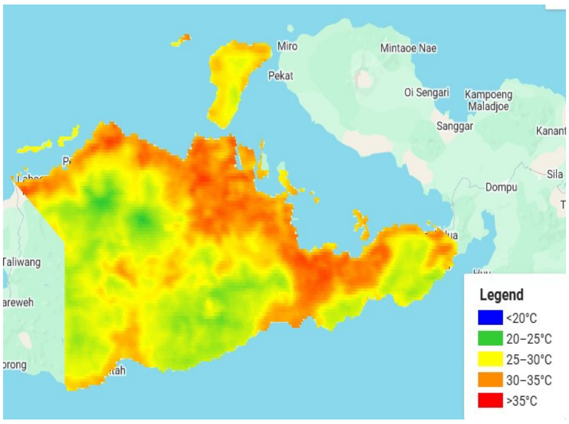

Figure 1. Average land surface temperature of Sumbawa Regency in 2018

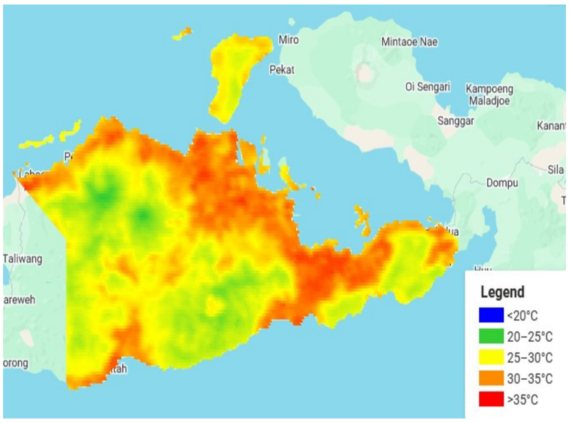

Figure 2. Average land surface temperature of Sumbawa Regency in 2019

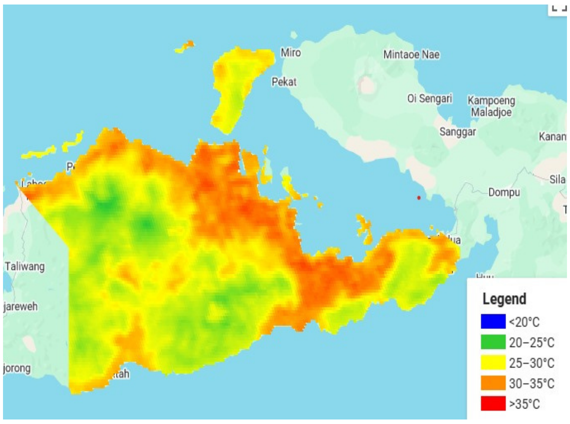

Figure 3. Average land surface temperature of Sumbawa Regency in 2020

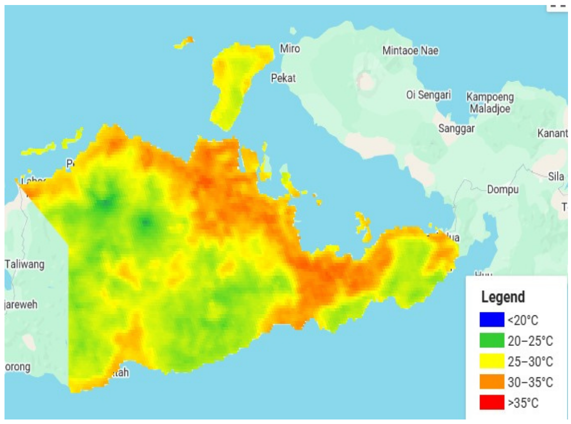

Figure 4. Average land surface temperature of Sumbawa Regency in 2021

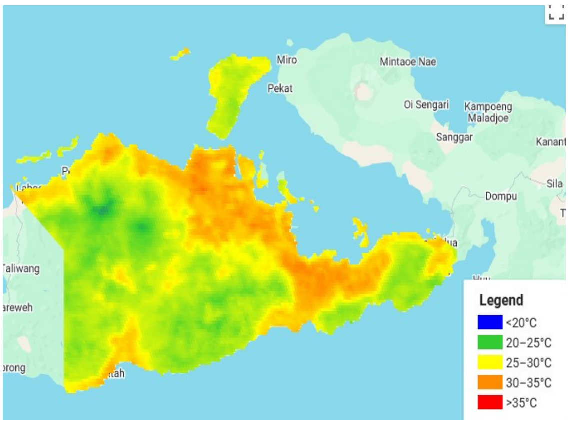

Figure 5. Average land surface temperature of Sumbawa Regency in 2022

The image above presents the results of land surface temperature (LST) analysis using Landsat 8 satellite data. This image illustrates the variation of surface temperature in Sumbawa Regency based on a color scale representing average temperature. Blue colors indicate lower surface temperatures, likely corresponding to areas with dense vegetation, mountainous regions, or areas with high humidity. Green and yellow colors indicate moderate temperatures, generally reflecting areas with agricultural activities, grasslands, or areas with less dense vegetation.

Orange and red colors indicate higher temperatures, typically reflecting areas with less land cover (such as bare land or urban areas) or areas directly exposed to sunlight without natural cover.

During the 2018-2019 period, the image data showed an increase in land surface temperature in Sumbawa Regency. However, during the 2019-2021 period, the image data indicated a decrease in land surface temperature in Sumbawa Regency. Examining the history of floods on https://ntb.bps.go.id/id/statistics-table, there were 2 flood disasters in 2019, 5 in 2020, and 12 in 2021. This phenomenon is believed to be closely related to the increasing frequency and intensity of flood disasters in the region. Widespread flooding causes significant waterlogging, increasing soil and air humidity, which in turn can lower land surface temperature.

The GEE output for analyzing the image above regarding changes in land surface temperature in Sumbawa Regency from 2018 to 2022 can be used as a basis for natural resource planning and management, as well as climate change mitigation. Each period from 2018 to 2022 shows a difference in the surface area of each temperature class. The surface area of each temperature class is shown in the following table.

Table 2. The land surface area in 2018-2022

Year	Area in hectares and ares				
	<20°C	20°C -25°C	25°C -30°C	30°C -35°C	>35°C
2018	-	66900	407441.96	217155.69	35218.82
2019	-	52300	409819.61	214278.04	50318.82
2020	-	85223.92	406398.94	212480.78	22618.82
2021	-	147757.65	386101.96	187756.86	5100
2022	200	221803.53	358376.47	146336.47	-

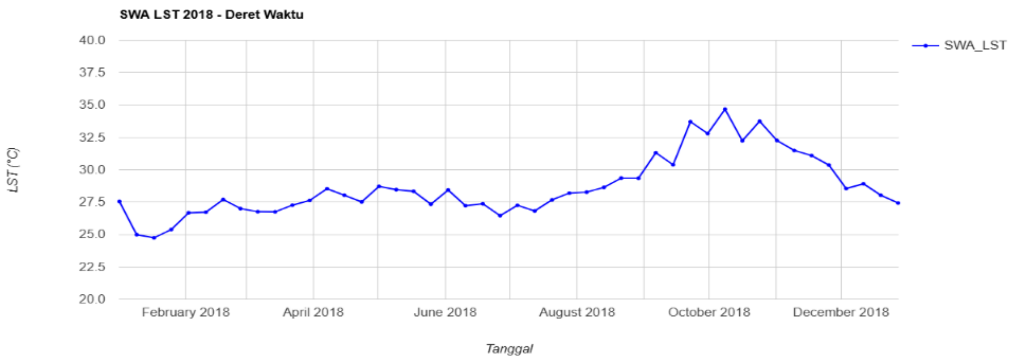

Figure 6. Graph of Mean Ground Surface Temperature for Sumbawa Regency, 2018

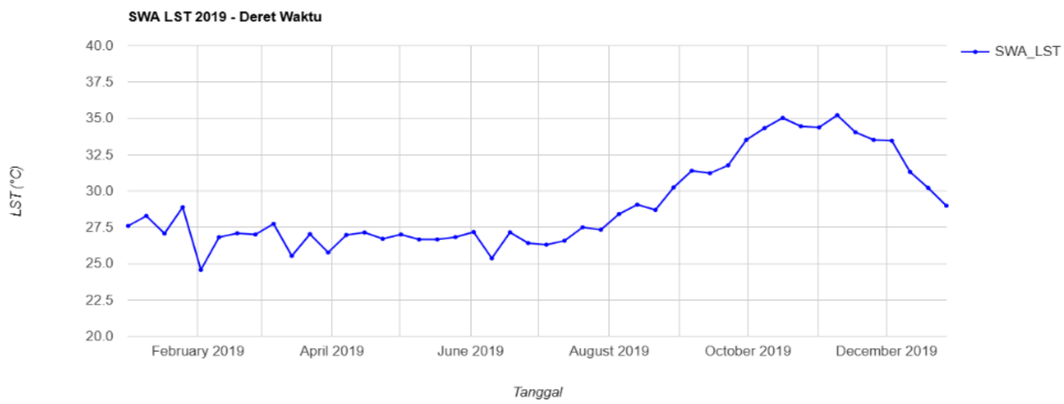

Figure 7. Graph of Mean Ground Surface Temperature for Sumbawa Regency, 2019

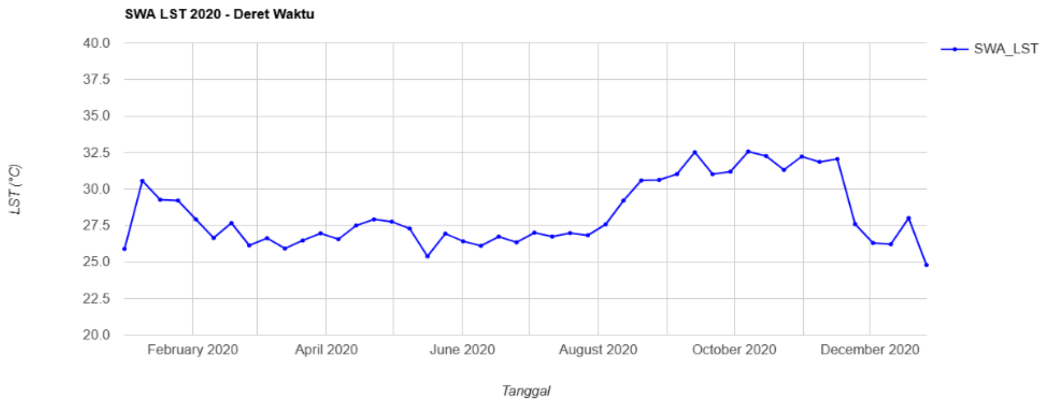

Figure 8. Graph of Mean Ground Surface Temperature for Sumbawa Regency, 2020

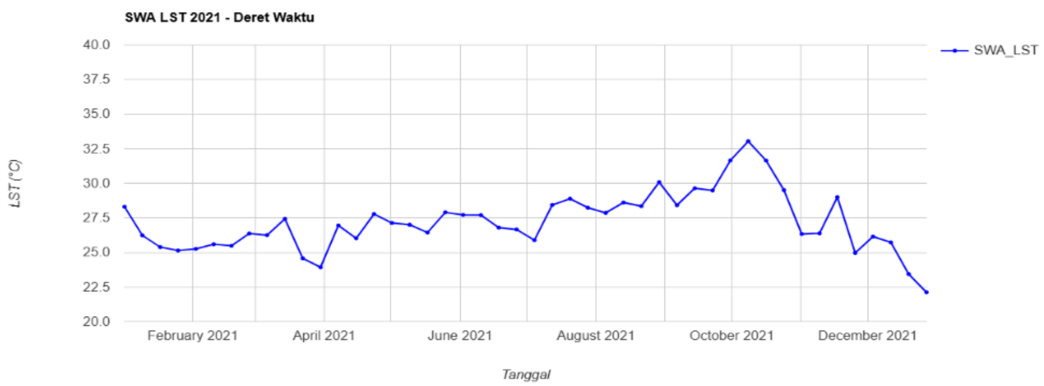

Figure 9. Graph of Mean Ground Surface Temperature for Sumbawa Regency, 2021

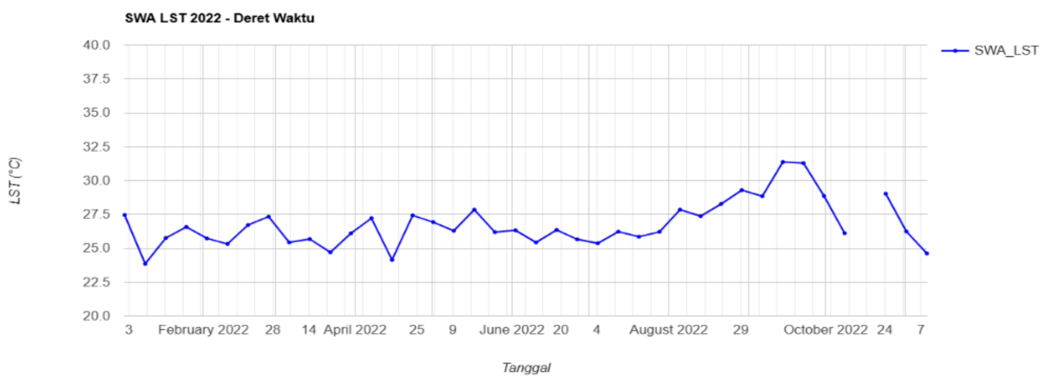

Figure 10. Graph of Mean Ground Surface Temperature for Sumbawa Regency, 2022

Based on the average ground surface temperature graphs of Sumbawa Regency from 2018 to 2022, there is a significant annual fluctuation in temperature. The lowest temperatures typically occur in January or December, while the highest temperatures often occur in October or November. Overall, the highest temperatures have shown a decreasing trend from 2019 to 2022. However, further analysis is needed to determine if this decrease is statistically significant. Extreme temperatures have also been recorded, such as the highest temperature of 35.2°C in 2019. To better understand the pattern of temperature changes, it is recommended to create a line graph showing the monthly temperature fluctuations from year to year.

Table 3. Lowest and highest ground surface temperature

Year	Suhu °C	
	Lowest	Highest
2018	24.7	34,6
2019	24,5	35,2
2020	24,8	32.5
2021	22,1	33.0
2022	23,8	31,3

Table 3 shows the data of the lowest and highest ground surface temperature during the period of 2018 to 2022. Based on the data above, the lowest temperature occurred in December 2021 with a ground surface temperature of 22.1°C, and the highest temperature occurred in November 2019 with a ground surface temperature of 35.2°C. During the period from 2018 to 2019, the ground surface temperature increased. One of the factors causing the increase in ground surface temperature is the development of built-up land. According to Liwan & Latue (2023), to see the impact of built-up land development indicates the urgency of attention to mitigation and adaptation to climate change in urban areas. In 2021, the lowest ground surface temperature was recorded, one of the factors causing this was the high rainfall in December.

Tabel 4. Average Ground Surface Temperature

Year	Suhu °C
2018	28.53
2019	29.15
2020	28.52
2021	27.80
2022	26.94

Table 4 presents the average ground surface temperature data for Sumbawa Regency from 2018 to 2022. Based on the table data above, there is a variation in temperature that reflects changes in climatic conditions or other factors affecting the ground surface temperature. In 2018, the average ground surface temperature was recorded at 28.53°C, serving as the starting point for observation. In 2019, the average ground surface temperature increased to 29.15°C, indicating an increase of approximately 0.62°C from the previous year. From 2020 to 2022, the average ground surface temperature decreased. According to Chen et al. (2023) in Latue et al. (2024), to reduce the ground surface temperature, it is possible to increase the quantity and quality of green open spaces in an area. Based on the data above, the decrease in temperature from 2019 to 2024 is due in part to the increase in the amount of green open space.

4. Conclusion

By using GEE, analysis of land surface temperatures in Sumbawa Regency provides quite good information. In 2018 to 2019 surface temperatures increased in urban areas. In 2019-2021 surface temperatures decreased. The average land surface temperature in Sumbawa Regency for the period 2019 to 2022 decreased. One of the factors causing the surface temperature to decrease is the increase in the number and quality of green open space in the area.

Thank-you note

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DAFTAR PUSTAKA

[1] Novianti, T. C., & Gumano, H. N. (2023). Pemanfaatan Google Earth Engine Dan Citra Terra MODIS Untuk Analisis Suhu Permukaan Tanah Di Provinsi Sumatera Selatan. *Jurnal Ilmiah Tekno Global, 12*(1), 18. https://doi.org/10.36982/jtg.v12i01.3139

[2] Hadi, A. P., Lestari, D. P., Rochayati, N., Mas'ad, & Rahman, F. A. (2021). Kajian Daya Dukung Fungsi Lindung Dan Lahan Berbasis Spasial Di Kabupaten Sumbawa. *Bioscientist: Jurnal Ilmiah Biologi, 9*(2), 455-464. https://doi.org/10.33394/bioscientist.v9i2.4248

[3] Darmawan, S., Nurulhakim, N. N., & Hernawati, R. (2024). Kecerdasan Buatan Berbasis Geospasial (Geoai) Menggunakan Google Earth Engine Untuk Monitoring Fenomena Urban Heat Island Di Indonesia. *ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika, 12*(2), 303–320. https://doi.org/10.26760/elkomika.v12i2.303

[4] Rizki, M., & Kurniadin, N. (2022). Pemanfaatan Google Earth Engine Dan Citra Satelit Aqua/Terra MODIS Untuk Pemetaan Suhu Permukaan Tanah Rata-Rata Di Provinsi Kalimantan Timur Tahun 2015-2020. *Journal Of Geomatics Engineering, Technology, And Sciences (JGETS), 1*(1), 11–18. https://doi.org/10.51967/gets.v1i1.3

[5] Ningrum, W. & Ida. N. (2018). Deteksi Perubahan Permukaan Menggunakan Data Satelit Landsat Multi-Waktu Studi Kasus Cekungan Bandung. Jurnal Teknoligi Lingkungan, 19(2), 145-153. https://doi.org/10.29122/jtl.v19i2.2250

[6] Latue, P. C., Rakuasa. H., & Sihasale, D. A. (2024). Analisis Spesial Perubahan Suhu Permukaan Daratan Kota Kupang Menggunakan Data Penginderaan Jarak Jauh. *Journal of Computer and Information Technology*, 1(1), 22. https://doi.org/10.56211/buana.v1i1.343

[7] Manakane, S. E., Latue, P. C., & Rakuasa, H. (2023). Pemanfaatan Teknologi Penginderaan Jauh Dan Sistem Informasi Geografis Untuk Identifikasi Perubahan Tutupan Lahan Di DAS Marikurubu, Kota Ternate. *TABELA: Jurnal Pertanian Berkelanjutan*. 1(2), 51-60. https://doi.org/10.56211/tabela.v1i2.301

[8] Nugraha, A. S. A. (2019). Pemanfaatan Metode Split-Windows Algorithm (SWA) Pada Landsat 8 Menggunakan Data Uap Air M ODIS Terra. Geomatika, 25(1), 9-16. http://doi.org/10.24895/JIG.2019.25-1.877

[9] Ermida, L. S., Soares, P., Mantas, V., Gottsche, F., & Trigo, I. F. (2020), Google Earth Engine Open-Source Code For Land Surface Temparature Estimation From the Landsat Series. Remote Sensing 12(9), 1471. http://doi.org/10.3390/rs12091471.