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Analysis of Land Surface Temperature Changes in Sorong City, Indonesia Using Landsat 8 Satellite Image Data Based on Cloud Computing

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Abstract
This study aims to analyze land surface temperature changes in Sorong City, Indonesia using Landsat 8 satellite image data and Google Earth Engine cloud computing platform. With rapid urbanization, understanding the dynamics of surface temperature is important. Through satellite imagery and cloud computing technology, this analysis provides accurate monitoring of temperature change, supports climate change mitigation strategies, and designs more sustainable cities.

Abstrak
Penelitian ini bertujuan menganalisis perubahan suhu permukaan tanah di Kota Sorong, Indonesia menggunakan data citra satelit Landsat 8 dan platform komputasi awan Google Earth Engine. Dengan adanya urbanisasi yang pesat, pemahaman terhadap dinamika suhu permukaan menjadi penting. Melalui teknologi citra satelit dan komputasi awan, analisis ini memberikan pemantauan yang akurat terhadap perubahan suhu, mendukung strategi mitigasi perubahan iklim, dan merancang kota yang lebih berkelanjutan.

Kata Kunci : Google Earth Engine, Suhu Permukaan Daratan, Sorong

INTRODUCTION

Land surface temperature change is an important phenomenon that affects various aspects of the environment and human life (Stoyanova et al., 2022; Rakuasa & Nurul Achmadi, 2024). With rapid urbanization and land use change, understanding the dynamics of surface temperature is crucial (Mohamed & Worku, 2020: Rakuasa et al., 2024). In many cities around the world, including in Indonesia, increases in surface temperature are often associated with human activities that alter the natural structure and function of land ecosystems (Munawar et al., 2023; Rakuasa et al., 2024). Sorong City, located in West Papua, Indonesia, is one of the rapidly urbanizing regions (BPS, 2023). Along with infrastructure development and urban expansion, significant changes in land use have occurred (Rakuasa & Lasaiba, 2024). This affects surface temperature patterns, which in turn affects the quality of life of local communities and ecosystem health (Salakory & Rakuasa, 2022).

To understand surface temperature changes, the use of satellite imagery data is a very effective tool (Rakuasa, 2022). Satellite imagery provides comprehensive and accurate information about the Earth's surface conditions over time (Rakuasa et al., 2023). This technology enables continuous and extensive monitoring of environmental changes, including changes in surface temperature (Rakuasa, 2022). Landsat 8, as one of the earth observation satellites launched by NASA, has become an important data source in environmental studies (Latue et al., 2020). Combined with cloud computing platforms such as Google Earth Engine, data analysis becomes more efficient and accessible. Google Earth Engine enables rapid processing of large-scale data, thus supporting surface temperature change research with extensive and temporal data.

The Urban Heat Island (UHI) phenomenon is one of the major environmental problems faced by cities around the world, including Sorong (Gadekar et al., 2023). UHI occurs when urban areas become hotter than their more rural surroundings, mainly due to human activities and land use change (Hakim et al., 2018). Understanding and analyzing UHI is important for sustainable urban planning. Changes in surface temperature have direct impacts on public health, local ecosystems and microclimates (Mughal et al., 2020). Higher temperatures can worsen air quality, increase energy requirements for cooling, and exacerbate health conditions such as respiratory and cardiovascular diseases. Therefore, a deep

understanding of surface temperature changes can help in mitigation and adaptation to these negative impacts (Wulandari et al., 2023).

The analysis of surface temperature changes using Landsat 8 satellite image data and Google Earth Engine involves several stages, from data collection, processing, to interpretation of results. The methodology used must be able to capture temperature dynamics with sufficient spatial and temporal resolution, resulting in reliable information for decision-making. Cloud computing, such as that offered by Google Earth Engine, plays an important role in facilitating big data analysis. This technology allows researchers to access and process large amounts of data without the need for expensive computer infrastructure (Rakuasa et al., 2023). This opens up new opportunities for more detailed and in-depth environmental research.

Based on the above background, this research is an important step in understanding the dynamics of the urban environment. The results of this research are expected to help the government and other stakeholders in designing mitigation and adaptation strategies to climate change and improve the quality of life of people in Sorong City.

METHOD

This research is conducted in Sorong City, Papua Island, Indonesia. This study will use Landsat 8 satellite image data (Landsat 8 Collection 2 Tier 1 and Real-Time data calibrated top-of-atmosphere (TOA) reflectance) in 2019 and 2024, which is one of the main data sources for geospatial and ecological analysis. Landsat 8 provides high-resolution imagery suitable for land surface temperature change analysis. Google Earth Engine (https://earthengine.google.com/) is a cloud computing platform that allows users to access and analyze geospatial data efficiently. GEE supports programming with JavaScript and Python, and provides data visualization and analysis tools such as time series, image segmentation, and spatial analysis. This research uses the script used previously by (Rakuasa, 2024).

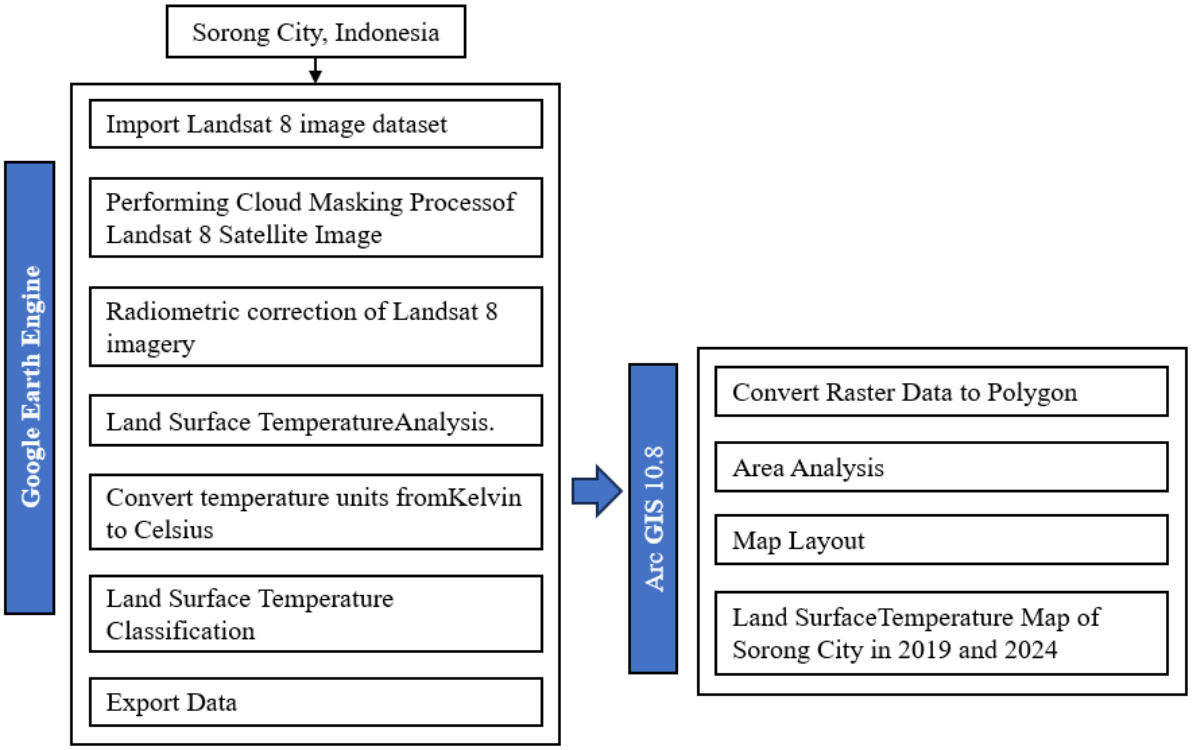

Figure 1. Workflow

This research begins by preparing data for the Sorong City area that is loaded from the Geospatial Information Agency (BIG) website and creating a Google Earth Engine (GEE) account and preparing a

script for processing land surface temperature. The initial step taken is to import the Landsat 8 image, after that cloud masking is a process to detect clouds, cloud masking is done to remove clouds and cloud shadows that interfere with the area to be processed, after that make radiometric correction of the Landsat 8 image which aims to eliminate atmospheric effects on the image, so as to produce more accurate data and can be used for more in-depth analysis. This radiometric correction is done by converting the digital number (DN) value into a surface reflectance value or surface temperature, which allows researchers to understand the physical characteristics of objects seen in the image without distortion caused by the atmosphere (Gorelick et al., 2017). The next step is to analyze the land surface temperature using the "Single Channel Algorithm" or "Split-Window Algorithm". This formula converts the radiance value of the brightness temperature in band 10 into the surface temperature (Onisimo Muntaga, 2019). The results of the LST analysis in Google Earth Engine are then downloaded and converted from raster to polygon format to be able to analyze the area and then the results of the 2019 and 2024 LST analysis of Sorong City are laid out in Arc GIS 10.8 software. The complete workflow can be seen in Figure 1.

RESULT AND DISCUSSION

Land Surface Temperature of Sorong Cirty in 2019

Analysis of the surface temperature of Sorong City in 2019 shows a varied temperature distribution across its area. Surface temperature below 20°C covers the largest area, with a total area of 20,463.81 hectares or about 68.80% of the total area of Sorong City. This area indicates that most of the city has relatively cool temperatures, which may be due to the presence of good vegetation cover, as well as geographical and climatic factors that favor lower temperatures. The area with surface temperature between 20-25°C covers an area of 6,859.22 hectares or about 23.06% of the total area of Sorong City. These areas represent areas with moderate temperatures which could be areas with higher human activities, such as residential or commercial areas. Temperatures in this range are often found in areas that have a mix of vegetation cover and land development.

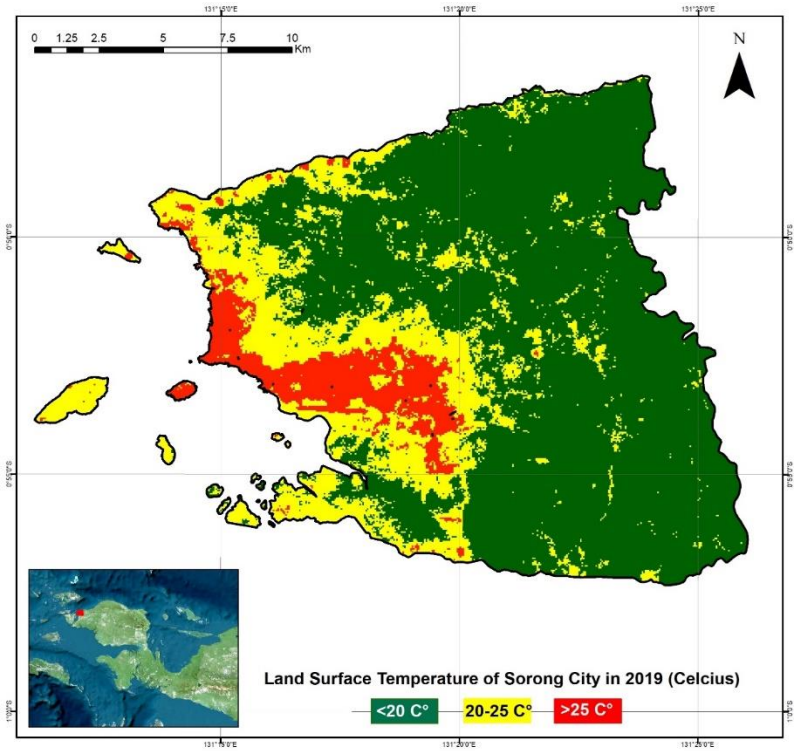

Figure 2. Surface Temperature Map of Sorong City in 2019

Higher surface temperatures, i.e. < 25°C, cover the smallest area of 2,422.45 hectares or about 8.14% of the total area of Sorong City. These areas are most likely to be dense urban areas or industrial areas, where intensive human activities and infrastructure development can lead to increased surface temperatures. Factors such as the urban heat island effect may contribute to higher temperatures in this area. This temperature distribution provides important insights into the environmental characteristics of Sorong City. Cooler temperatures in most areas of the city indicate good potential for environmental conservation and resident well-being. Meanwhile, areas with moderate to high temperatures need special attention in spatial planning and environmental management to reduce the negative impacts of intensive human activities (Gadekar et al., 2023).

Overall, this analysis illustrates the importance of understanding surface temperature distribution to support sustainable urban planning and management. By knowing which areas have higher temperatures, the government and stakeholders can take appropriate measures to mitigate the negative impacts of climate change, such as increasing vegetation cover, developing green open spaces, and managing urban development more sustainably. Spatially, the surface temperature of Sorong City in 2019 can be seen in Figure 2 where red color shows LST >25°C, yellow color shows LST 20-25°C and green color shows temperature <20°C.

Land Surface Temperature of Sorong Cirty in 2024

Analysis of the surface temperature of Sorong City in 2024 shows significant changes in temperature distribution compared to 2019 data. In 2024, areas with temperatures below 20°C are drastically reduced, covering only 9,754.84 hectares or 32.80% of the total area. Sorong City. This decline indicates that cooler areas are shrinking, perhaps due to deforestation, increased human activity, or global climate change. Surface temperatures between 20°C and 25°C experienced a significant increase, covering 15,386.84 hectares or 51.73% of the total area of Sorong City. This means that more than half of the city now has warmer temperatures than in previous years. This increase could be due to increased urbanization, infrastructure development, or a decrease in vegetation that previously helped keep temperatures lower.

Areas with temperatures above 25°C also showed an increase, covering 4,600.55 hectares or 15.47% of the city's total area. An increase in temperature in this area can be an indicator of increased industrial activity, population density, and lack of management of green areas. This could contribute to the urban heat island phenomenon, where urban areas become hotter than surrounding areas. These changes in surface temperature distribution are important to consider in the context of urban and environmental planning. A decrease in areas with cooler temperatures and an increase in areas with warmer temperatures can affect the quality of life of residents, health and local ecosystems. Measures such as increasing green space, sustainable land use management, and initiatives to reduce carbon emissions can help counter this trend.

Overall, the results of the analysis of the surface temperature of Sorong City in 2024 show a significant warming trend compared to 2019. This change requires serious attention from the authorities to manage its impact and maintain environmental balance. Climate change adaptation and mitigation strategies need to be implemented to ensure that Sorong City remains a comfortable and sustainable place to live. Spatially, the surface temperature of Sorong City in 2024 can be seen in Figure 3 where red indicates LST >25°C, yellow indicates LST 20-25°C and green indicates temperature <20°C.

Analysis of land surface temperature changes in Sorong City, Indonesia using cloud computing-based Landsat 8 satellite image data has various important benefits for city planning and environmental management. First, this analysis allows accurate and continuous monitoring of land surface temperature changes over time. Using data from Landsat 8, which has high temporal resolution, authorities can identify long-term trends in temperature changes, isolate areas experiencing significant warming, and understand the causal factors (DeVries et al., 2020). This is critical for detecting the impacts of climate change and developing effective mitigation strategies

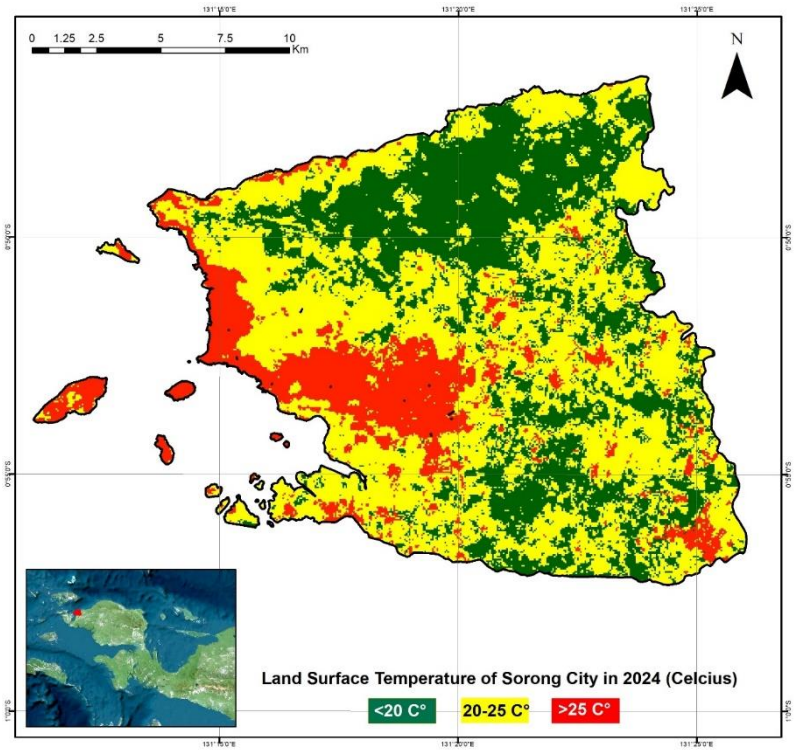

Figure 4. Sorong City Surface Temperature Map in 2024

Second, the use of cloud computing in this analysis provides tremendous efficiency and scalability. Cloud computing enables fast and accurate processing of large amounts of data without the need for expensive and complex computer infrastructure at the local level (Ermida et al., 2020). This facilitates the access and analysis of satellite data for a wide range of stakeholders, including governments, academia, and environmental organizations. Thus, data-driven decisions can be made faster and more targeted, aiding better urban planning, more efficient natural resource management, and more effective environmental protection (Wulandari et al., 2023). Finally, satellite imagery-based land surface temperature analysis and cloud computing also support sustainability initiatives and adaptation to climate change. The information obtained from these analyses can be used to design policies that reduce the negative impacts of urbanization, such as increased temperatures in urban areas known as the urban heat island phenomenon. In addition, the data can also be used to identify areas in need of interventions, such as increased green spaces or reforestation projects, that can help lower surface temperatures and improve people's quality of life (Abunnasr & Mhawej, 2022). As such, this analysis not only provides valuable scientific insights but also practical tools for building more sustainable and resilient cities to climate change.

CONCLUSION

It can be concluded that the analysis of land surface temperature changes in Sorong City has a significant impact in the context of sustainable urban planning and adaptation to climate change. By utilizing satellite imagery and cloud computing technologies, this research provides an in-depth understanding of the Urban Heat Island (UHI) phenomenon and surface temperature changes that occur in urban environments. The results of this analysis provide valuable insights for governments and other stakeholders in designing mitigation and adaptation strategies to the negative impacts of surface temperature change. With accurate and continuous monitoring of surface temperature changes, as well as identification of long-term trends and areas experiencing significant warming, effective measures can be developed to mitigate the impacts of climate change and improve the quality of life of the community.

Thus, this research not only makes a meaningful scientific contribution to the understanding of urban environmental dynamics, but also provides a practical foundation for building a more sustainable, climate resilient city and improving the quality of life of people in Sorong City, Indonesia.

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