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Identification of Urban Heat Island Potency in Janten Village area due to Aerotropolis Development

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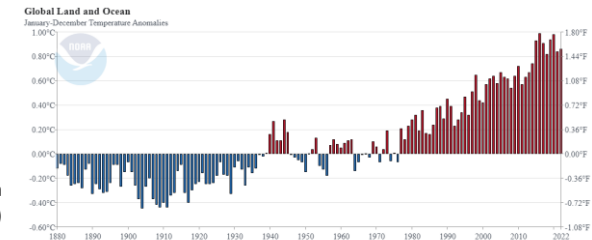
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Introduction

- Decree of the Minister of Transportation Number KP 1164 of 2013 has determined the location of Yogyakarta International Airport (YIA) in Kulon Progo Regency, Special Region of Yogyakarta. Aerotropolis is urban development driven by technological progress by exploiting the advantages of airports and their surroundings as air transportation centers [1]. Increasing global warming is caused by the existence of Urban Heat Islands (UHI). The Urban Heat Island phenomenon is defined as microclimate conditions in urban areas that are warmer than the surrounding villages [2].
- Aspects including land conversion, reduced green open space, built-up area density, roof materials, and high building height ratios have the potential to increase the risk of the Urban Heat Island (UHI) phenomenon. During the 14 years from 1993 to 2007, there was a change in land use covering an area of 1.46 ha in the city center area, including Sleman, Bantul and Yogyakarta [3].
- The Aerotropolis Development Plan has the potential to take over the function of green open land such as rice fields and trees as a residential, industrial, and public area. Land Use-Land Change (LULC) activities have the potential to increase the Urban Heat Island which always increases every year in the Special Region of Yogyakarta.
- This research aims to identify the level of Urban Heat Island resulting from the development of the Core Residential Area of the Yogyakarta International Airport Aerotropolis Plan.



Earth's Surface Temperature Graph
Source: (www.ncei.noaa.gov)



Method



Existing Envi-met Model



Aerotropolis Envi-met
Model

- Existing and Aerotropolis Plan Simulation

The method used in data processing is the experimental method. This method allows existing variables to be changed according to the desired concept. One experimental method based on variable manipulation using computer media is the simulation method. Simulation is a controlled research method in a real context with the aim of studying the dynamic interactions of a setting [4]. The data used was taken from weather station climate data accessed on December 14 2023 via the website www.accuweather.com.

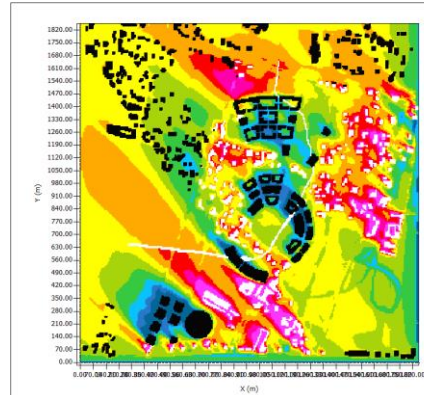
- Comparison of Simulation Results of Existing and Aerotropolis Plans

The aim of this method is to see the increase in area heat based on changes in the values of predetermined variables. The results comparison section can also be used to identify variables that require further improvement so that the preparation of mitigation strategy plans can be more accurate according to existing conditions. The indicators used in the comparison are the surface temperature difference value ($\Delta T_{\text{surface}}$) and the air temperature difference value (ΔT_{air}).

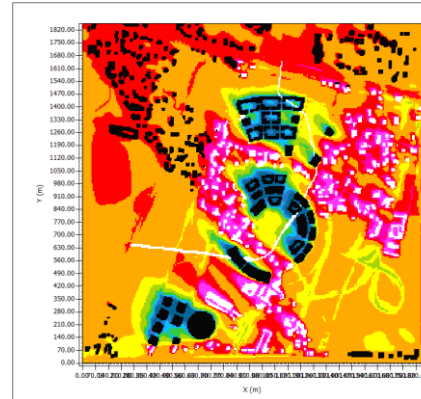
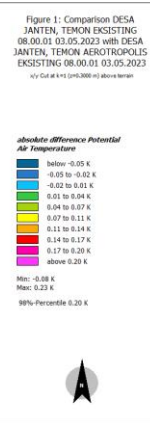
- Validation by measurement of surface and air temperature using measuring instruments (Flir Camera and Micro Weather Station)

When measuring surface temperature, the Flir i5 infrared camera is usually used that captured heat radiation through an infrared system. The tool used to measure outdoor air temperature conditions is a Micro Weather Station. This tool is used to monitor microclimate conditions in large areas, such as air humidity, UV index, wind speed, etc. The Micro Weather Station used is a climate recording tool at the Urban Canopy Layers (UCL) level.

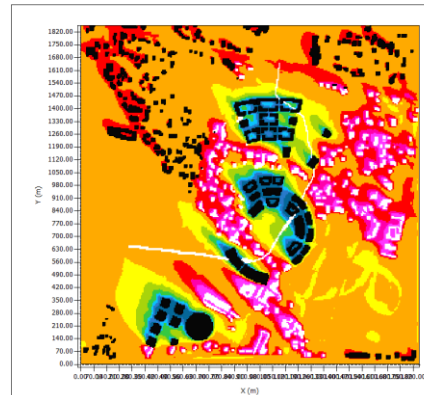
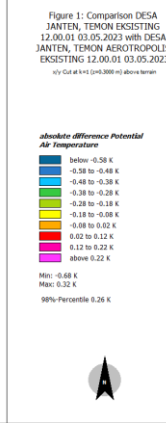
Result and Discussion



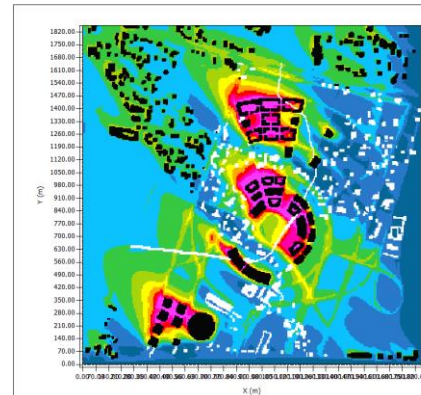
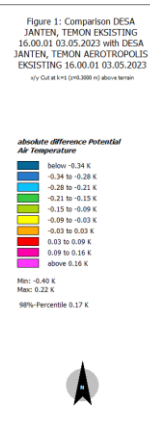
ΔT_{air} at 08.00



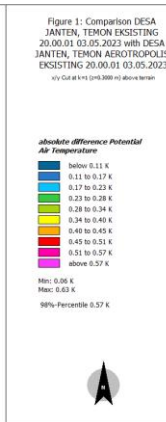
ΔT_{air} at 12.00



ΔT_{air} at 16.00

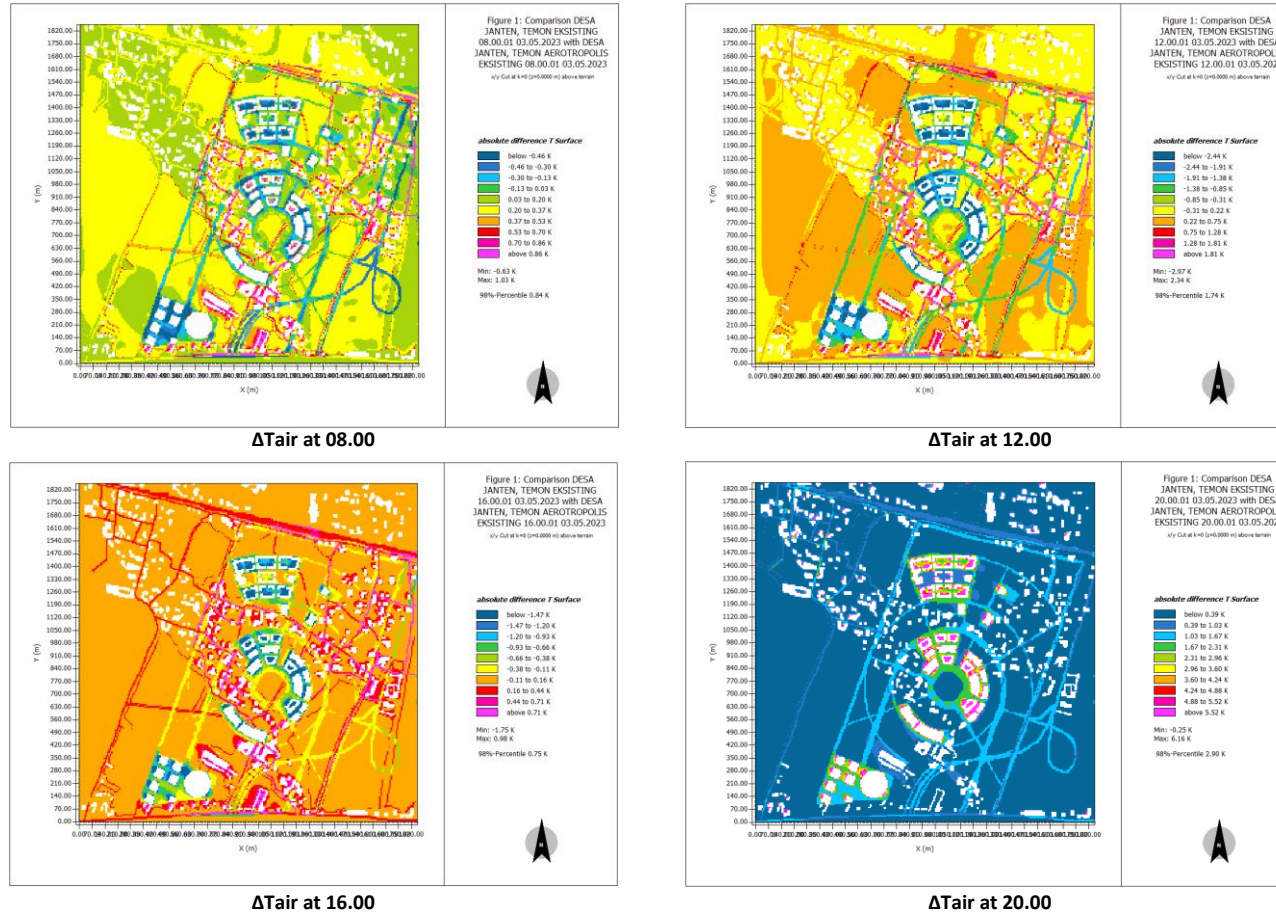


ΔT_{air} at 20.00



- Comparison results through analysis of distribution maps and the 98th percentile system show that mapping with differences in temperature after land conversion.
- Air temperature and surface temperature on several points has decreased due to shadows (shading) from buildings in the core area of the Aerotropolis design plan.

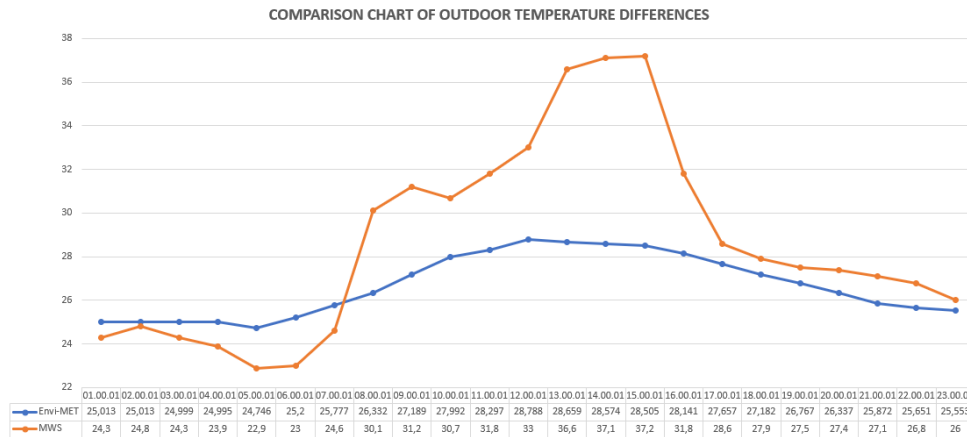
Result and Discussion



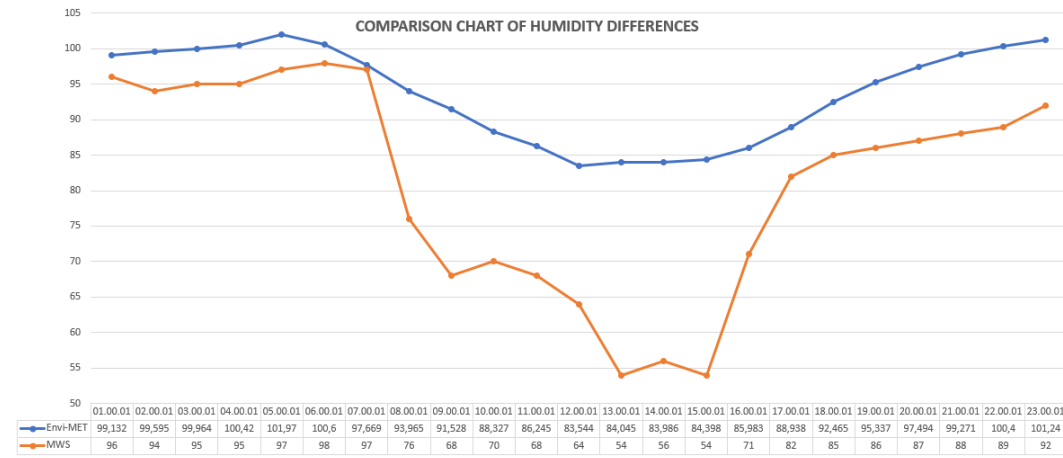
- Replacing pavement materials in access and open areas increases temperatures.
- During night conditions, surface temperatures on materials with high albedo release stored heat.
- Temperature areas that are not shaded by buildings and vegetation canopy has increased when compared to existing conditions before the development plan.



Result and Discussion



Outdoor Temperature Comparison Envi-MET and Micro Weather Station



Relative Humidity Comparison Envi-MET and Micro Weather Station

- Comparison of measurement results in the field becomes a validation value for Envi-MET results against original conditions with air temperature and relative humidity indicators on December 14 2023.
- When taking results from the same point, there are slightly shifted from field measurements using a Micro Weather Station. Significant changes in conditions occur during the day (the presence of the sun).
- The hypothesis obtained is that there is dynamic cloud movement around the area near the airport so that the level of cloud cover changes over time and affects heat reception on measuring instruments in the field.



Conclusion

- In the comparison results, samples shown at 08.00, 12.00, 16.00, and 20.00 in Janten Village show that there are differences in surface temperature and air temperature from existing conditions to the YIA aerotropolis design.
- The results of the comparison of air temperature differences and surface temperature differences from Envi-MET have values with accuracy that are not too far from field conditions.
- Through a graphical display of measurement validation points, simulation results can be adjusted to field conditions by ignoring the dynamics of cloud cover.
- The increase in temperature occurred at several points, giving rise to an Urban Heat Island in the Janten Village area, Temon, Kulon Progo, Special Region of Yogyakarta.



References

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- [2] Arnfield, A.J., (2003). Two decades of urban climate research: a review of turbulence, exchanges of energy and water, and the *Urban Heat Island*. *Int. J. Climatol.* 23 (1), 1e26. <https://doi.org/10.1002/joc.859>.
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- [4] Wang, G. M., Sevick, E. M., Mittag, E., Searles, D. J., & Evans, D. J. (2002). Experimental demonstration of violations of the second law of thermodynamics for small systems and short time scales. *Physical review letters*, 89(5), 050601.