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Optimizing Green Infrastructure for Urban Thermal Comfort: A Case Study of Bondowoso Regency

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ABSTRACT

The Urban Heat Island (UHI) is a serious environmental issue in tropical regions because it increases surface temperatures, reduces thermal comfort, and exacerbates health risks. Bondowoso Regency shows the potential for an increase in UHI as green open space decreases. This study aims to identify the distribution of UHI, analyze the effectiveness of green open spaces, and formulate strategies for optimizing green open spaces for mitigation. Secondary data from Landsat 8 TIRS/OLI imagery were analyzed using spatial and descriptive evaluative approaches. The results show that the distribution of UHI in Bondowoso fluctuated between 2013 and 2024, with peak intensity in 2017 and a significant decline in 2022. However, extreme temperatures reappeared in 2024, marked by an increase in the area with temperatures >30°C by 248.75 Ha. The 53% decline in green open space also accelerated the expansion of hot areas, showing an inverse relationship between vegetation and surface temperature. The scenario strategy indicates the need for an additional 317 green open space units covering 11,507.1 Ha to reduce the temperature by 3°C and 8 green open space units covering 580.8 Ha to reduce it by 6°C. Thus, green open space plays an important role in reducing the intensity of the UHI. Therefore, policies to increase the quantity and connectivity of green open space need to be prioritized so that Bondowoso can maintain thermal comfort and environmental sustainability.

Keywords: Green Infrastructure, Green Open Space, Remote Sensing, Thermal Comfort, Urban Heat Island

ABSTRAK

Urban Heat Island (UHI) adalah isu lingkungan yang serius pada wilayah tropis karena meningkatkan suhu permukaan, menurunkan kenyamanan termal, dan memperburuk risiko kesehatan. Kabupaten Bondowoso menunjukkan potensi peningkatan UHI seiring berkurangnya ruang terbuka hijau. Penelitian ini bertujuan mengidentifikasi distribusi UHI, menganalisis efektivitas ruang terbuka hijau, serta merumuskan strategi optimasi ruang terbuka hijau untuk mitigasi. Data sekunder citra Landsat 8 TIRS/OLI dianalisis menggunakan pendekatan spasial dan deskriptif evaluatif. Hasil menunjukkan distribusi UHI di Bondowoso berfluktuasi pada tahun 2013–2024 dengan puncak intensitas pada tahun 2017 dan penurunan signifikan pada tahun 2022. Namun, tahun 2024 suhu ekstrem kembali muncul yang ditandai dengan peningkatan luas area suhu >30°C sebesar 248,75 Ha. Penurunan ruang terbuka hijau sebesar 53% turut mempercepat ekspansi area panas yang memperlihatkan hubungan terbalik antara vegetasi dan suhu permukaan. Strategi skenario menunjukkan kebutuhan tambahan 317 unit ruang terbuka hijau seluas 11.507,1 Ha untuk menurunkan suhu 3°C dan 8 unit ruang terbuka hijau seluas 580,8 Ha untuk penurunan 6°C. Dengan demikian, ruang terbuka hijau memiliki peranan penting dalam mengurangi intensitas UHI. Oleh sebab itu, kebijakan peningkatan kuantitas dan konektivitas ruang terbuka hijau perlu diprioritaskan agar Bondowoso mampu menjaga kenyamanan termal dan ketahanan lingkungan secara berkelanjutan.

Kata kunci: Infrastruktur Hijau, Kenyamanan Termal, Penginderaan Jauh, Ruang Terbuka Hijau, Urban Heat Island

1. INTRODUCTION

Urban microclimate change is closely related to rapid urbanization. This is illustrated by the emergence of the Urban Heat Island (UHI) effect, which is referred to as high urban temperatures compared to surrounding areas (Lukita Sari et al., 2024). The phenomenon causes an imbalance between the temperature of the surrounding environment and human temperature or referred to as thermal discomfort (Puspitasari et al., 2024). UHI has been widely studied in a global context as one of the main threats to thermal comfort that affects environmental sustainability (Santamouris, 2015). Unlike subtropical countries, the negative thermal effects in tropical regions like Indonesia are more alarming because they occur throughout the seasons. Tropical urban heat intensity reaches 3°C-6°C, especially in the dry season during months with low rainfall. (Sari et al., 2022). Anthropogenic activities in urban areas exacerbate the UHI effect by changing the physical characteristics of the surface and affecting the local energy balance (Prasasti et al., 2015). In addition, the UHI effect has a direct impact on health due to the degradation of environmental quality, such as respiratory problems, disruption of vital organs, and even death (KLHK (2020) in Mujahid & YudhaIrawan, 2025).

The Urban Heat Island (UHI) phenomenon resulting in thermal discomfort is a pressing issue in the context of climate change and urban growth (Putro, 2022). This is because it impacts the inconvenience of living, population productivity, and health (Attariq et al., 2025). Therefore, a strategy is needed to overcome these problems. Strategies in supporting thermal comfort can be done by optimizing green infrastructure because it is able to reduce the Urban Heat Island (UHI) phenomenon through increased air capacity.

Green infrastructure was introduced as a solution to urban environmental problems, referring to concepts with different meanings, applications, and scales of application (Cullen (2013) in Faraby et al., 2024). Green infrastructure can refer to trees, green roofs, and vegetation that line surfaces to provide shade, deflect radiation, and release water vapor into the atmosphere through evapotranspiration (Lukita Sari et al., 2024). Green open space can be interpreted as green infrastructure, such as city parks, greenways, and interconnected riverbanks (Austin; Benedict & McMahon; Firehock & Walker; Faradilla; Prastiyo, et al.; Pratiwi et al.; Fitriana et al. in Faraby et al., 2024). Thus, green infrastructure can be summarized as a concept, effort, or approach to maintain a sustainable environment through the arrangement of green open spaces and the preservation of natural processes that occur in nature (Heryana & Firmansyah, 2024). This research focuses on the function of green open space as green infrastructure that can be a mitigation strategy of the Urban Heat Island (UHI) to support thermal comfort. This is because green open space plays an important role in influencing albedo and the value of solar radiation, neutralizing the increase in surface temperature, and providing a cooling effect (Ningrum et al.; Arifah, N., & Susetyo; in Tarigan et al., 2024). Green infrastructure has been proven to reduce urban temperatures through shading and surface energy regulation, which has also been globally recognized as a key strategy for UHI mitigation and urban climate adaptation (Shao & Kim, 2022; Iungman et al., 2023).

Although green infrastructure has the potential to mitigate Urban Heat Island (UHI), studies related to the optimization of this strategy are still minimal spatially and functionally. Spatially, UHI information is only information on the occurrence of increased temperatures in urban areas but is not supported by a comparison of strategy implementation so that its effectiveness cannot be assessed (Hotimah et al., 2025; Ramadhan et al., 2025; Attariq et al., 2025). On the other hand, there is a previous literature review that examines the effectiveness of green open space with UHI but does not explain what percentage of the effectiveness of reducing the temperature of green open space (Khairiyah, 2024; Alfakihuddin et al., 2024). The research gap shows the urgency of the need for a study on the optimization of green infrastructure in reducing Urban Heat Island (UHI) directly.

Bondowoso Regency is one of the regions in East Java that has a tropical climate with temperatures between 21.2°C-33.9°C. As one of the areas with a tropical climate. Bondowoso Regency has the potential to experience an increase in Urban Heat Island (UHI). This is supported by the condition of the surrounding areas, such as Jember Regency, which experienced an increase in temperature of 3.9-4.6°C (Listyawati & Prasetiyo, 2021). This condition is also supported by the percentage of green land change of 458.82% from 2003 to 2016 (Pribadi et al., 2020). This phenomenon highlights the urgency of a more measurable green open space mitigation strategy. Unlike previous studies that only highlighted the distribution of UHI, this study offers a new contribution in the form of a scenario-based green open space optimization model to reduce surface temperatures in tropical regions. Specifically, this study has three main objectives, namely to identify the distribution of UHI in Bondowoso Regency, to analyze the effectiveness of green open spaces as green infrastructure for reducing UHI, and to integrate strategies and scenarios for optimizing green open spaces in reducing temperatures.

2. METHODS

2.1. Research Location

Bondowoso Regency is located in the eastern part of East Java Province. The distance from Bondowoso to the capital of East Java Province is approximately 200 km. Astronomically, Bondowoso Regency is located at 7º50'10" north latitude to 7º56'414" south latitude and 113º48'10" to 113º48'10" south latitude. The total area of Bondowoso Regency is 1,560.096 km2 or approximately 3.26% of the total area of East Java Province. Bondowoso Regency is divided into 23 sub-districts, 209 villages, and 10 sub-districts. (BPS, 2025).

2.2. Types of Research

The type of research used in this study is explanatory quantitative with a spatial approach. The explanatory quantitative type was chosen to explain the relationship between green infrastructure optimization and UHI intensity reduction through numerical data, such as LST (Land Surface Temperature) and NDVI (Normalized Difference Vegetation Index). Meanwhile, a spatial approach is used for remote sensing technology and geographic information systems (GIS) in identifying heat distribution patterns and the effectiveness of temperature-reducing elements.

This research began with a literature review to determine the research variables. Next, secondary data collection, pre-processing, UHI distribution mapping, analysis of green open space on UHI, and field checks were carried out. Finally, a simulation of green open space optimization scenarios for temperature reduction was conducted. The stages of this research are illustrated in Figure 1.

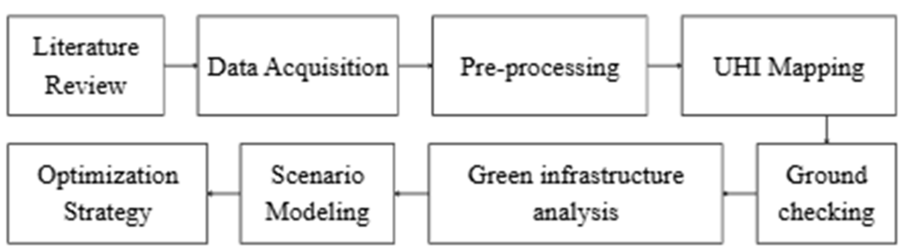


Figure 1. Research Design
Source*: Analysis Result, 2025*

2.3. Data Collection Methods

Data collection in this study used secondary survey techniques. Secondary surveys can be interpreted as research information obtained from third parties (intermediaries) and not through respondents directly. The secondary survey has a role in obtaining some data and information as follows.

1) Satellite images

   Satellite images such as Landsat 8 OLI/TIRS (spatial resolution 30 m) accessed between February and September in 2013, 2017, 2022, 2024 through earthexplorer.usgs.gov were used to extract land surface temperature (LST) and vegetation index (NDVI) data processed through ArcGIS. LST represents surface heat intensity as a key indicator of the urban heat island (UHI) phenomenon. NDVI reflects the presence of vegetation, which acts as a natural cooling element.

2) Green open space land use data

   Land use data serves as an inventory of green infrastructure for supporting data in assessing how much elements contribute to UHI mitigation.

2.4.Research Variables

In this study, the variables used include several important aspects related to the optimization of strategies in reducing UHI intensity. The variables are designed to provide a comprehensive picture, as shown in Table 1.

Table 1. Research Variables and Indicators

Variable	Indicator
Green Infrastructure	Green open space
Urban Heat Island	LST (*Land Surface Temperature*)
	NDVI (*Normalized Difference Vegetation Index*)

Source: *Lukita Sari et al., 2024*

2.5.Data Analysis Techniques

This research uses two data analysis methods, namely spatial analysis and descriptive evaluative analysis. Spatial analysis was used to process Urban Heat Island data. Meanwhile, evaluative descriptive analysis was used for strategies and optimization scenarios of green open spaces. In this way, researchers obtained a more comprehensive picture.

1. Spatial Analysis

   1) Radiometric Correction

$$L\lambda = MLQcal + AL$$

Description:

Lλ : TOA spectral radiance

ML : Band-specific multiplicative rescaling factor from metadata

AL : Band-specific additive rescaling factor from metadata

Qcal: Quantified and calibrated standard product pixel value (DN)

2) Brightness temperature

$$\mathrm{TB} = \frac{(K2)}{\ln\left(\frac{K1}{\mathrm{L}\lambda}+1\right)}$$

Description:

TB : Brightness temperature (K)

Lλ : TOA spectral radiance

K1 : Band specific thermal conversion constant from metadata

K2 : Band specific thermal conversion constant from metadata

3) NDVI

$$\mathrm{NDVI} = \frac{(NIR-R)}{(NIR+R)}$$

NIR is near infrared and R is red. On Landsat, NIR is band 5 and R is band 4.

4) Vegetation Proportion (Pv)

Pv values are obtained by scaling the NDVI to minimize interference from moist soil conditions and surface energy fluxes.

$$\mathrm{Pv} = \left(\frac{NDVI-NDVIsoil}{NDVIveg-NDVIsoil}\right)^2$$

Description:

Pv = Vegetation Proportion

NDVI = NDVI processing result

NDVIs = NDVI value of bare soil

ND Viv = NDVI value of vegetation fraction 100

5) Emissivity (e)

$$\varepsilon = 0.985 \ + \ 0.960(1 - Pv) \ + \ 0.06Pv(1 - Pv)$$

Description:

e = Emissivity

PV = Vegetation Proportion

0,985 = Vegetation Emissivity

0,960 = Soil Emissivity

0,06 = 4xdε (average value)

6) Land Surface Temperature

$$\mathrm{TS} = \frac{T}{\left(1+\frac{\lambda \mathrm{T}}{\partial}\ln e\right)}$$

Description:

TS = Surface temperature

T = Brightness temperature

λ = Center wavelength of thermal band (Landsat 8 = 10,8 m)

∂ = Constant 1,438 x 10-2mK

e = Emissivity

7) Urban Heat Island

$$T > \mu + 0,5\ \alpha$$

$$0 < T \leq \mu + 0,5\ \alpha$$

Description:

T = Surface temperature (LST)

μ = Mean value of surface temperature

α = Standard deviation of surface temperature

$$UHI = Tmean - (\mu + 0,5\ \alpha)$$

Keterangan:

UHI = Urban Heat Island

Tmean = Land Surface Temperature (°C)

μ = Mean value of LST (°C)

α = Standard deviation value of LST (°C)

The UHI analysis adopts an urban climate framework that links surface temperature variability to vegetation cover density (Rahman et al., 2024). The result is that a positive temperature difference value indicates that the area is experiencing UHI. If it is negative, then the area does not have a UHI phenomenon. The results of UHI processing will then be validated through ground checking based on satellite imagery in 2024 at five observation points representing urban areas, suburbs, and green zones. These points were selected to compare variations in UHI intensity with land cover conditions in the field, particularly in relation to built-up land and vegetation cover. These observations will test whether increased UHI intensity is indeed associated with the dominance of built-up land, while also showing an inverse relationship with vegetation cover, which plays a role in lowering surface temperatures.

2. Descriptive Evaluative

Descriptive evaluative is a type of approach used in research to evaluate the theories and findings of previous studies. Previous studies were searched using search engines, such as google books, google scholar, ScienceDirect, and Sinta web journal (Putra & Indradjati, 2021). Descriptive evaluative in this research is used to examine strategies and optimization scenarios of green open space in reducing Urban Heat Island (UHI). The green open space optimization scenario in this study will refer to the Indonesian Thermal Comfort Standard SNI T-14-1993-03 as the threshold related to temperature reduction or the provision of 27°C as the thermal comfort limit in Indonesia. This standard is still in use because there has been no update to the latest thermal comfort standard in Indonesia, so SNI T-14-1993-03 remains the official reference in force.

3. RESULT AND DISCUSSIONS

3.1. UHI Distribution and Urban Surface Pattern

Based on the calculation results, the resulting LST (Land Surface Temperature) is quite varied. In the statistical data for 2013-2024, the LST trend in Bondowoso Regency was dynamic, peaking in 2017, which was marked by an increase in the area of land with temperatures of 26-30°C by 41,306.09 Ha and 30-33 °C by 18,406.66 Ha. However, there was a recovery in 2022 with a decrease in the area of land with temperatures of 26-30°C by 56,859.92 Ha and 30-33 °C by 22,487.45 Ha and a resurgence in UHI intensity in 2024 with an increase in the area of land with temperatures of 26-30°C by 8,980.23 Ha and 30-33 °C by 248.75 Ha. The distribution of temperatures in this non-static area is caused by changes over time. It is also influenced by natural factors, such as climate, weather and hydrology. The spatial distribution of LST in Bondowoso shows a shift from dispersed and concentrated to a localized pattern that appears in built-up areas. This phenomenon reflects the spatial polarity of urban heat as only certain areas experience extreme heat stress. (Table 2).

Table 2. Area of LST Result

Year	Area (Ha)				
	>17°C	17-22 °C	22-26 °C	26-30 °C	30-33 °C
2013	24.657,65	37.635,22	72.427,22	17.019,36	4.117,52
2017	3.404,64	16.120,65	55.203,48	58.325,45	22.524,18
2022	64.499,92	41.742,69	48.082,56	1.465,53	36,73
2024	33.515,64	68.909,67	42.700,41	10.445,76	285,48

Source: *Analysis Result, 2025*

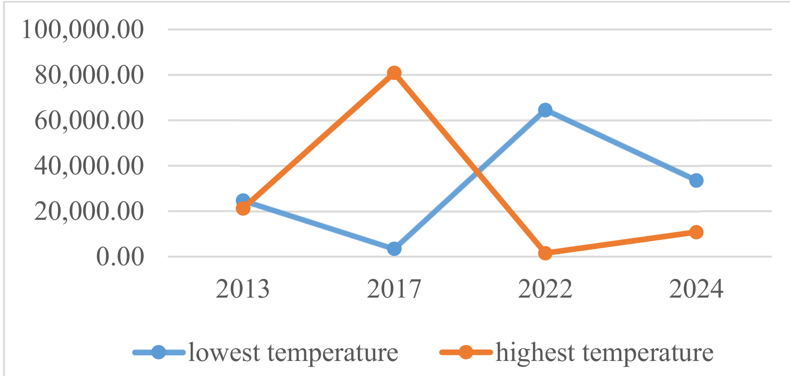
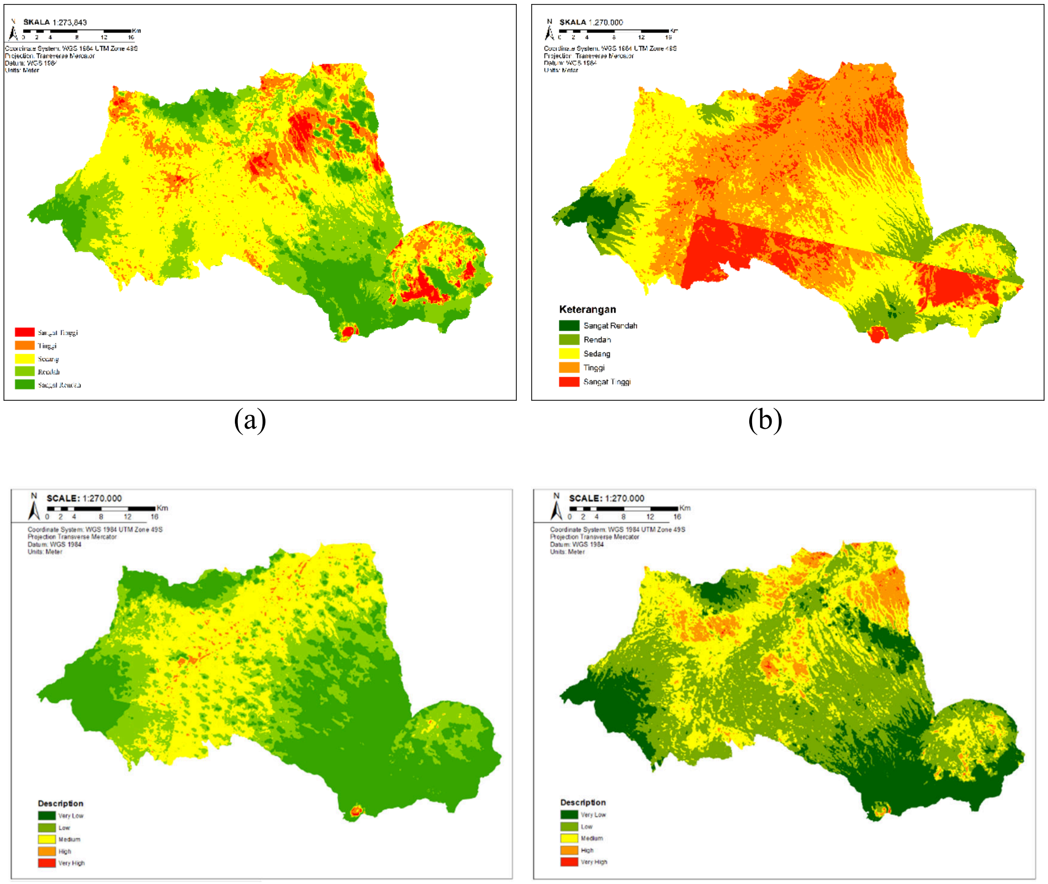


Figure 2. Chart of the LST Result Area
Source: *Analysis Result, 2025*

Based on SNI T-14-1993-03, thermal comfort is at a temperature threshold below 27 ºC. Figure 2 shows that the trend of the highest and lowest temperature areas of LST has changed significantly. In 2017 there was a very significant change in the increase in surface temperature and in 2022 there was a decrease in surface temperature. However, in 2024 the UHI trend began to increase, characterized by an increase in the highest temperature and a decrease in the lowest temperature.

Figure 3 shows the spatial distribution of UHI (Urban Heat Island) from 2013 to 2024 in Bondowoso Regency. UHI values are classified into five classes of temperature difference. This is based on the results of the UHI calculation from each year. The majority of UHIs are located in built-up areas of Bondowoso Regency.

Based on the results of the analysis, Figure 3 (a-d) shows that the distribution of UHI with the highest temperature is in the city center which then spreads spatially to the surrounding areas. Overall, the UHI trend in Bondowoso Regency experienced a sharp increase in 2017 with a widespread pattern, then showed a decrease in the intensity and localization of the UHI phenomenon in subsequent years, especially in 2022 and 2024. This pattern reflects the dynamic interaction between physical development, land cover change, and spatial planning policies that can mitigate the spatial impacts of the Urban Heat Island phenomenon. In addition, Figure 3 shows that the trend of the location of the highest UHI distribution tends to cross diagonally from northeast to southwest. The UHI classification of <17 ºC is mostly in the suburbs of Bondowoso Regency. Meanwhile, the 17-22 ºC and 22-26 ºC classifications have a very spread out area. Meanwhile, the 26-30 ºC and 30-33 ºC classifications tend to be in the city center or activity center with a smaller area.



(a) (b)

(c) (d)

Figure 3. Urban Heat Island Map (a) 2013; (b) 2017; (c) 2022; (d) 2024
Source: *Analysis Result, 2025*

Furthermore, validation was carried out with ground check techniques to determine the condition of land cover at the research location. In the ground check technique, it was found that the surface temperature of the built-up area was higher than other locations in the vicinity. The following are the results of the ground check in Bondowoso Regency.

Figure 4. Ground Check of Land Cover Based on Cloud Cover Anomalies with 2024 Imagery
Source: *Analysis Result, 2025*

Based on Figure 4, observations were made at the hottest and coldest points in the research location. The hottest location points are on built-up land in the form of trade and service areas, as well as residential areas with a fairly dense density. Meanwhile, the coldest location points are in green open land, such as agricultural and plantation areas. Based on the results of the analysis, high surface temperature conditions are influenced by human activities such as trade and service activities. Conversely, low surface temperature conditions tend not to have much activity intensity. The results show that the dominance of built-up land is strongly correlated with an increase in LST, while the presence of vegetation cover plays an important role in reducing heat.

3.2.Green Infrastructure Effectiveness

UHI impacts that interfere with thermal comfort can be minimized through green infrastructure (Lukita Sari et al., 2024). Green open space can be interpreted as green infrastructure, such as city parks, greenways, and interconnected riverbanks (Austin; Benedict & McMahon; Firehock & Walker; Faradilla; Prastiyo, et al.; Pratiwi et al.; Fitriana et al. in Faraby et al., 2024). Based on the calculation results, the presence of green open space in Bondowoso Regency has an inverse relationship with surface temperature. These green open spaces include forests, moorlands, rice fields, parks, and nature reserves (RTRW Kabupaten

Bondowoso Tahun 2024-2044, 2024; Dinas Komunikasi dan Informatika, 2024). Table 3 shows that a reduction in green open space in Bondowoso results in an increase in the number of areas with high surface temperatures.

Table 3. Area of LST and Green Open Space

2022				
LST Area (Ha)	>17 ºC	64.499,92	Green Open Space (Ha)	131.329
	17-22 ºC	41.742,69		
	22-26 ºC	48.082,56		
	26-20 ºC	1.465,53		
	30-33 ºC	36,73		
2024				
LST Area (Ha)	>17 ºC	33.515,64	Green Open Space (Ha)	61.934,58
	17-22 ºC	68.909,67		
	22-26 ºC	42.700,41		
	26-20 ºC	10.445,76		
	30-33 ºC	285,48		

Source: *Analysis Result, 2025*

Based on Table 3, there is a downward trend in the capacity of the region to reduce the impact of Urban Heat Island (UHI). This is due to a 52.85% decrease in green open space area in 2024 compared to 2022, resulting in an 86% expansion of land area above the thermal comfort threshold. These findings confirm that reduced green cover exacerbates the intensity of the UHI, while optimally distributed green infrastructure can reduce urban heat stress. These results are in line with the research by Aram et al. (2019), which emphasizes the importance of vegetation in lowering surface temperatures through increased evapotranspiration and the provision of shade. In the context of tropical cities, green infrastructure efforts can reduce surface temperatures, improve thermal comfort, and mitigate the urban heat island (UHI) effect in Singapore through strategic land cover changes (Teo et al., 2022). Theoretically, this study contributes to the UHI–Green Infrastructure (GI) literature by formulating the relationship between urban ecosystem services and spatial resilience, where green open spaces function as thermal buffers that improve the quality of life for communities. The results of this study confirm the hypothesis that optimizing green infrastructure is an important strategy in reducing urban temperatures while maintaining thermal comfort.

However, the limitations of this study should also be noted. The data used came from Landsat images with medium resolution (30 m) and secondary sources, so details of micro conditions, such as the shape of certain buildings, may not be clearly recorded. The analysis also did not include socioeconomic factors or the community's perception of thermal comfort. Therefore, the results of this study are more appropriate for use in providing a general overview of a large area and should be used with caution when applied to a smaller environmental scale.

3.3. Green Open Space Optimization Scenario Strategy

Green open space can be optimized to reduce heat in Bondowoso Regency with a certain area so that the impact of UHI which results in thermal discomfort can be overcome. Based on previous literature, green open space with an area of 0.5-2 Ha can reduce temperatures by up to 0.3°C with the cooling effect felt up to a distance of 40 meters. Meanwhile, green open space with an area of 3-5 hectares is able to reduce the temperature to 0.7 ° C whose effect can reach 70-120 meters. Meanwhile, green open space with an area of 12.1 hectares is able to reduce the temperature to 1°C with the cooling effect felt up to 180-330 meters around (Vaz Monteiro et al. & Cohen et al. in Aram et al., 2019).

Table 4. Low Thermal Comfort Area in 2024

LST (ºC)	Area (Ha)
26-30 ºC	10.445,76
30-33 ºC	285,48

Source: *Analysis Result, 2025*

Based on the 2024 surface temperature (LST) data in Table 4 and scientific findings, green open space optimization strategies can be developed to measurably reduce Urban Heat Island (UHI). Scientifically, thermal comfort is in the range of values below 27°C (Standar Kenyamanan Termal Indonesia, 1993). Thus, this optimization strategy can be focused on the area with temperatures above 26°C, which is 10,445.76 Ha with a target reduction of 3°C and 285.48 with a target reduction of 6°C. Referring to previous studies, one unit of green space with an area of 12.1 hectares is proven to be able to reduce air temperature by 1°C with a thermal effect range of up to 330 meters. If it is assumed that one unit of green space has a range of about 33 hectares, then areas affected by high temperatures need at least 325 green spaces. Thus, the total estimated green space requirement to reduce the temperature by 1°C is around 3,932.5 hectares. In detail, the optimization strategy carried out is the addition of 317 green spaces for the 3°C reduction target with an area of 11,507.1 Ha and the addition of 8 green spaces for the 6°C reduction target with an area of 580.8 Ha. This amount does not have to be met directly in the form of parks or urban forests, but can be achieved through the integration of green networks.

The optimization scenario strategy is in line with the principles of UHI mitigation-based spatial planning that not only considers the ecological function of green spaces but also considers the spatial distribution, effectiveness of thermal functions, and ease of public access to green spaces. With a structured and integrated strategy, green space optimization in Bondowoso Regency can be an effective solution to reduce ambient temperature and improve the quality of life of the community in a sustainable manner. However, this green space optimization strategy solution can be strengthened to support policy through further research using higher resolution imagery, applying urban climate models, combining thermal comfort surveys, and conducting field trials at the community level to directly observe the effectiveness of planned green spaces.

4. CONCLUCION

The intensity of the Urban Heat Island (UHI) in Bondowoso Regency experienced significant changes throughout 2013–2024, with peak intensity in 2017, a decline in 2022, and an increase again in 2024. In addition, the distribution pattern shows a tendency for built-up areas to be the center of community activities. The analysis also shows an inverse relationship between the presence of green open spaces and surface temperature. A 53% reduction in green open spaces contributed to an increase in the area with temperatures above the thermal comfort threshold (>27°C). An optimization scenario is needed to address this thermal discomfort by adding 317 green open space units (11,507.1 Ha) capable of reducing temperatures by up to 3°C and 8 green open space units (580.8 Ha) capable of reducing temperatures by up to 6°C. This study validates the hypothesis that optimizing green infrastructure can reduce UHI intensity and improve thermal comfort. The results of the study contribute by providing a spatially explicit green infrastructure optimization scenario that bridges remote sensing analysis with urban environmental planning. The implications of this research provide practical insights for urban planners and policymakers to design climate-resilient green infrastructure strategies in tropical cities, the results of which can support the climate change adaptation agenda, the achievement of Sustainable Development Goals (SDGs), and serve as important input in the implementation of spatial planning policies.

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