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# Evaluation of Landscape Design in Urban Parks and Urban Forests on Thermal Comfort

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## *Abstract*

The city of Banda Aceh is experiencing significant land use change due to rapid development, which causes an increase in land surface temperature and encourages climate change. One of the mitigation measures that can be taken is the provision of Green Open Spaces (GOS) such as parks and urban forests that function to maintain microclimate balance. However, current green space designs tend to replace soft elements such as grass with dark-colored hard pavement that has a low albedo, thus exacerbating the Urban Heat Island (UHI) effect. This study evaluates the landscape design of thermal comfort in BNI Tibang Urban Forest and BNI Trembesi Urban Park through a quantitative approach of observation, field measurements and questionnaires. The variables analyzed included landscape elements (grass, trees, soil, water, concrete, paving blocks, and ceramics) and microclimate variables (air temperature, ground surface temperature, average radiant temperature, globe temperature, air velocity and humidity). Vegetation distribution was analyzed with NDVI, while park configuration and material variations were simulated using ENVI-met, with the PET comfort index as an indicator. Results show that vegetated areas have 2-3°C lower temperatures and provide better thermal comfort. Simulation and questionnaire data support these findings, where high vegetation density reduces temperature by 1.8°C and improves thermal comfort. Therefore, landscape design that prioritizes soft elements and reduces the use of hard elements can improve thermal comfort and become a reference in the development of adaptive green spaces in urban areas, especially in Banda Aceh.

***Keywords:*** *Landscape Design; Microclimate; Urban Forest; Urban Park; Outdoor Thermal Comfort*

## *Introduction*

Banda Aceh City, as a city that continues to develop in various sectors, both socially, culturally, and economically, will indirectly cause changes to the city. One of them is the decrease in the availability of Green Open Spaces (GOS). The rapid development of construction occurring in urban areas will have an impact, both positive and negative. One of the negative impacts is on the urban environmental aspect.

The development of infrastructure in Banda Aceh City continues to increase, causing the conversion of land into built-up areas to rise. The increase in built-up areas has led to a decline in

environmental quality, such as rising air temperatures, water pollution, climate change, and reduced biodiversity. One way the Banda Aceh City government addresses environmental issues is by creating Green Open Spaces (GOS). The city government and several related departments continue to strive to improve the quality of Green Open Spaces (GOS) through programs such as the Green City Development Program, building bike lanes, planting mangroves in protected coastal areas to prevent tsunami disasters, and adding urban forests and parks. The Banda Aceh City Spatial Planning Regulation No. 4 of 2009 states that Green Open Spaces (GOS) are part of the city's protected areas.The area of Green Open Spaces (GOS) must reach a minimum of 30% of the total area.

A good city planner should design ideal Green Open Spaces (GOS) for city residents to provide comfort in their activities (Huda dan Pandiangan, 2012). The presence of Green Open Spaces (GOS) is very much needed for urban areas. Green Open Spaces (GOS) has benefits for environmental components, including absorbing heat. Reducing noise levels and air pollution. Green Open Spaces (GOS), through their role as microclimate regulators, can lower surface temperatures, which directly affects air temperature distribution and can enhance the comfort of community life (Ahmad et al.. 2012).

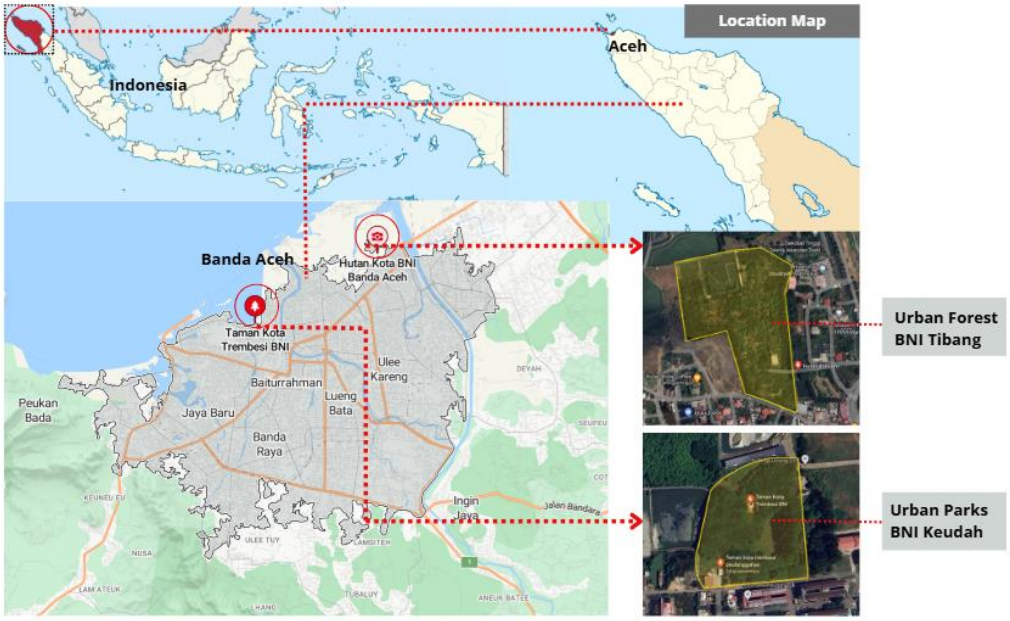
According to Joga and Ismaun (2011), Green Open Spaces (GOS) has several benefits, including the ability to lower air temperature, thereby creating a comfortable urban living environment as an urban environmental facility, creating harmony between the natural environment and the built environment that is beneficial for the community, and creating a healthy, livable, and sustainable city. Forms of green spaces can include urban parks, green roadways, urban forests, cemeteries, fields, and bodies of water. An important aspect that must be considered in green spaces is comfort. Comfort can be defined as a condition where humans can feel and express agreement with the environmental conditions they are in (Saroinsong dkk.. 2017). The condition of human discomfort, especially towards a Green Open Spaces (GOS), can be caused by many factors. Both originating from internal factors such as air temperature, humidity, and light intensity, noise, or those originating from external sources such as the surrounding environmental conditions that can disturb a person's state either directly or indirectly (Sugiasih, 2013). In addition, the comfort of a Green Open Spaces (GOS) can be determined through the facilities it provides. Usually, the facilities available in green spaces can include trees, pedestrian areas, trash bins, seating areas, lighting, prayer rooms, and toilets, which are provided according to the needs of Green Open Spaces (GOS) (Yanti, 2016).

Urban forests are Green Open Spaces (GOS) in the city whose utilization is not only as environmental regulators but also as venues for city residents' recreation. The city of Banda Aceh has an urban forest that attracts very few visitors compared to other recreational places such as beaches, the old town, the grand mosque, and the tsunami memorial sites. Of the many Green Open Spaces (GOS) in Banda Aceh, the BNI Tibang urban forest and the BNI Trembesi urban parks in Keudah were chosen because they are located in urban areas close to residential neighborhoods and are bustling with activity.

According to the Banda Aceh City Spatial Planning Local (Qanun) Law No. 4, Banda Aceh currently has public green spaces with a total area of 668.9 hectares or 12% of its total area.With an urban forest area of 28.60 Ha. The utilization of public Green Open Spaces (GOS) in Banda Aceh is still very minimal, both by the local community and tourists. Public green spaces should be able to provide comfort and well-being for visitors, both aesthetically and health-wise. Therefore, urban parks as public Green Open Spaces (GOS) must be able to address urban environmental issues, enhance the city's beauty, and attract visitors to enjoy the urban parks in Banda Aceh. This underscores the urgency of conducting research titled "Evaluation of Landscape Design in Urban Forests on Thermal Comfort."The evaluation conducted used thermal comfort levels and landscape design assessments on urban parks and forests in Banda Aceh. The results of the evaluation, which include recommendations, are expected to serve as a reference for improving urban parks to create thermal comfort for visitors and to develop a healthy and sustainable city in the future.

## *Research Method*

This research was conducted in the Public green spaces located in Banda Aceh. The chosen locations are two, namely Urban Forest BNI in Tibang and Urban Parks BNI Trembesi in Keudah. The map of the research location can be seen in the following image:




Picture 1. Research location map

Location and scope of research object can be seen in the below table:

Table 1. Location and Wide of Object

| No. | Location | Geographic Location | Wide (Ha) |
|---|---|---|---|
| 1. | Urban Forest of BNI Tibang | 5°35'7.52" East Lotitude and E95°21'0.55" East Longitude | 6.75 Ha |
| 2. | Urban Park of BNI Trembesi | 5° 33' 45,902" East Lotitude E95° 18' 38,718" East Longitude | 2.30 Ha |

This research uses a quantitative research method with a case study approach. Quantitative research is a type of research that heavily utilizes numbers throughout its process, starting from the inventory stage. Analysis and interpretation of data (Arikunto. 2019). Next. The case study approach can be defined as a research strategy that investigates a specific situation and setting holistically by collecting and analyzing various data (Groat & Wang. 2013). Quantitative data were obtained from microclimate measurements at predetermined measurement points and from the results of thermal comfort level questionnaires for visitors near the measurement points.

The data collection technique used in this research is through observation methods by measuring air temperature. Humidity and noise. This observation method is conducted by directly observing the observation location with the aim of understanding the actual conditions on the ground. Then, the interview method was conducted through questionnaire recaps to each respondent at each observation location. The analysis techniques used in the research include descriptive analysis, evaluation, and simulation analysis.

(a) (b)

Picture 2. Top view of the object to be measured: a). Urban Forest; b). Urban Park

## *Discussions*

1. Description of Research Object

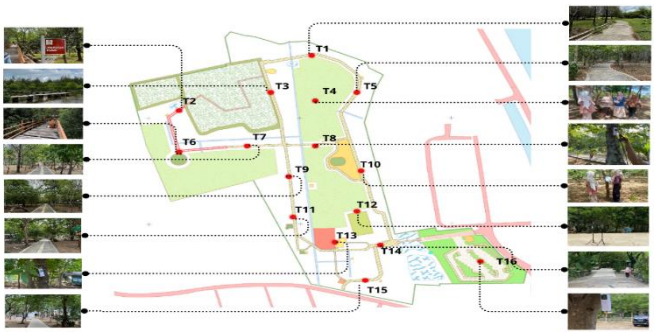
The object of this research is the landscape design of parks and urban forests in Banda Aceh, with a focus on evaluating its impact on the thermal comfort of outdoor spaces. The two locations chosen as research subjects are the BNI Tibang Urban Forest and the BNI Trembesi Urban Park in Keudah, which are situated in an urban area with a relatively high level of community activity.

2. Landscape Characteristics

Urban Forest BNI in Tibang and Urban Park BNI Trembesi in Keudah have different landscape characteristics in their constituent elements as well as their surrounding environmental conditions. Urban Forest BNI in Tibang covers an area of approximately 6.75 hectares and is dominated by dense vegetation with various types of shade trees that function as pollutant absorbers and providers of natural shade. The landscape in this area is also equipped with pedestrian paths, open areas with grass, and bodies of water that contribute to creating a cooler microclimate. Meanwhile, the Urban Park BNI Trembesi in Keudah, which covers an area of approximately 2.30 hectares, is more oriented towards public space with various recreational facilities, such as a children's play area, a prayer room, and pedestrian paths surrounded by shrubs and shade trees. This park also features a combination of hard elements, such as paving blocks and concrete, used for circulation areas and public facilities. The difference in vegetation density as well as the composition of soft and hard elements in these two locations is an important factor in determining the level of thermal comfort in each area, which will be further evaluated in this study.

a. Characteristics of Urban Forest BNI in Tibang Landscape

Urban Forest BNI in Tibang is one of the Green Open Spaces (GOS) in Banda Aceh City, covering an area of approximately 6,75 hectares. The landscape of this area is dominated by soft elements in the form of vegetation, with various types of shade trees that have dense canopies. The presence of this vegetation creates a shaded environment and supports the balance of the ecosystem in the urban area. In addition, there are areas with natural soil cover and grass scattered in several parts of the area.



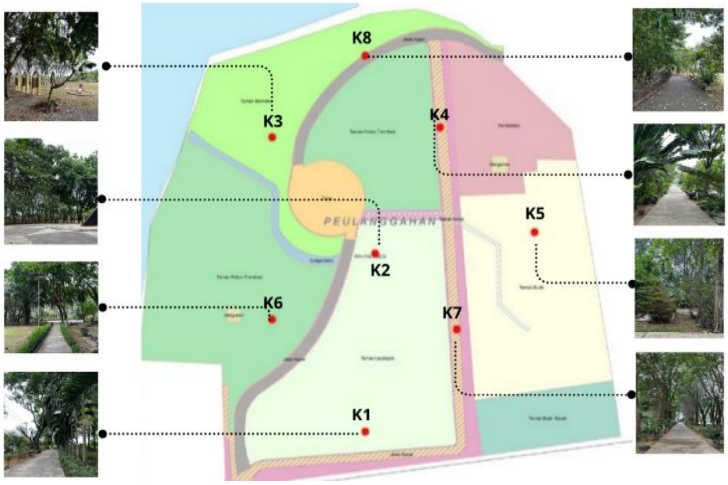

Picture 3. Layout of Urban Forest BNI in Tibang

Urban Forest BNI in Tibang also has a body of water that plays a role in supporting ecosystem diversity and complementing its natural landscape components. From the perspective of hard elements, this area is equipped with pedestrian paths made of paving blocks and concrete that connect various areas within the urban forest. This path serves as the main access for visitors and supports mobility within the area. In addition, there are public facilities such as seating areas and observation points that allow visitors to enjoy the natural atmosphere of this urban forest. With the diversity of landscape elements present, Hutan Kota BNI Tibang serves as one of the Green Open Spaces (GOS) that support ecological and social functions in the city of Banda Aceh.


Picture 4. Layout Existing of the Urban Forest BNI in Tibang

Based on the existing map, the landscape of the BNI Tibang Urban Forest has a diverse land cover composition. The most dominant area is the vegetation cover with trees spanning 33,063 m², which are evenly distributed throughout the area and serve as the main element of the urban forest. Additionally, there is a water body covering 11,993 m² that plays a role in maintaining the humidity and coolness of the environment. The paved area covers 9,572 m², indicating the presence of access paths and facilities supporting visitor activities. The grass area with an area of 6,024 m² serves as an open space for recreation and has an open land area of 10,872 m². These characteristics reflect a combination of ecological, social functions, and potential further development in the urban forest area.

b.Characteristics of the Urban Parks BNI Trembesi in Keudah Landscape




Picture 5. Layout Existing of the Urban Parks BNI Trembesi in Keudah

Urban Parks BNI Trembesi in Keudah has a relatively small area but is well-organized in its landscape composition. Urban Parks in Keudah is a Green Open Spaces (GOS) with a well-organized landscape arrangement. This area consists of vegetation elements such as trees and grass that create a cool and comfortable atmosphere for visitors. The presence of paved paths facilitates access and circulation within the park. In general, this park harmoniously combines natural and artificial elements, thereby supporting ecological, recreational, and social functions as part of the Green Open Spaces (GOS) in urban areas.


Picture 6. Layout of the Existing Urban Parks BNI Trembesi in Keudah

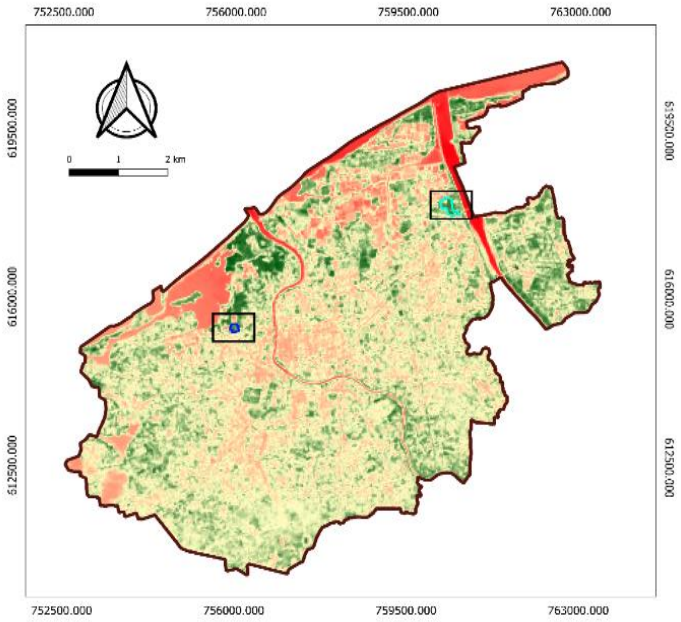
Based on the existing map, the largest area is dominated by tree cover of 11,097 m², which plays an important role in creating shade and thermal comfort within the park. In addition, there is a grass area of 5,203 m² that serves as an open space for social and recreational activities. The paved area of 3,862 m²

is used as visitor circulation paths and park accessibility. There is also a water body measuring 258 m² that serves as a natural cooler for the park's environment. Meanwhile, the open land covering 2,941 m² indicates an area that is not yet fully covered by vegetation and has the potential for further development. Overall, the landscape of this park reflects a balance between natural and artificial elements and supports the ecological and social functions of Green Open Spaces (GOS) in urban areas.

3. Availability and Distribution of Green Open Spaces (GOS) in Banda Aceh City

Vegetation plays an important role in maintaining environmental sustainability, especially in the Green Open Spaces (GOS) areas of Banda Aceh City, which have a high level of activity. In addition to serving as natural shade, vegetation also contributes to reducing air pollution, improving air quality, and creating thermal comfort for visitors. Below is presented the distribution map of green spaces in Banda Aceh City for the year 2024.

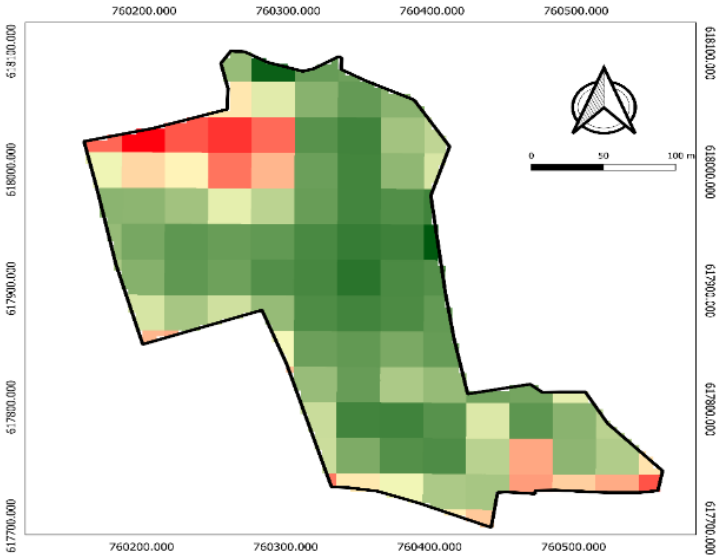
The NDVI (Normalized Difference Vegetation Index) analysis for 2024 in the green spaces of Banda Aceh City provides an overview of vegetation distribution based on density levels, ranging from areas without vegetation to areas with dense vegetation. The results of this analysis serve as an important basis for understanding the ecosystem conditions in that open space and their relevance to thermal comfort, particularly in the areas that are the focus of the research.




Picture 7. Map of NDVI Banda Aceh Municipality Territory

Based on the data analysis that has been conducted, the results show the density values with variations in NDVI in the Green Open Spaces (GOS) of Banda Aceh City in 2024, consisting of Non-Vegetation, Moderate Vegetation, and High Vegetation.

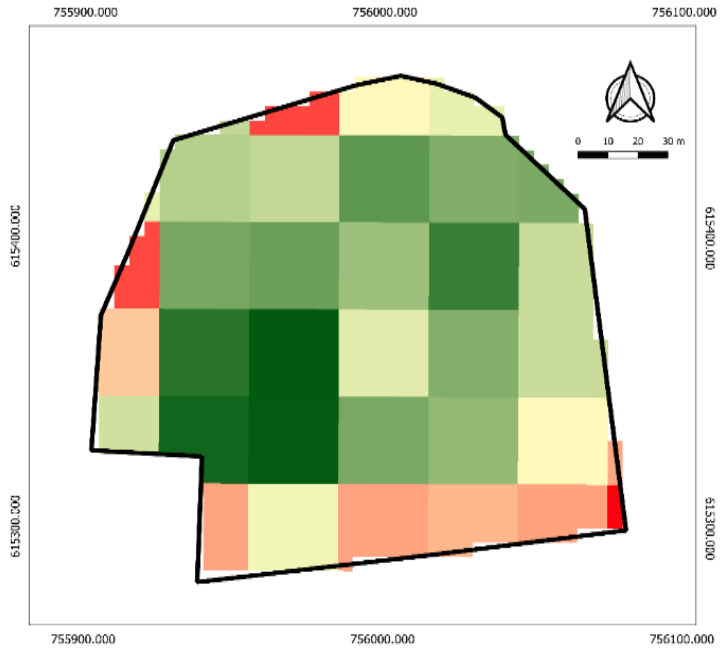
The assessment of the vegetation cover condition in the city's Green Open Spaces (GOS) can be conducted through the analysis of NDVI (Normalized Difference Vegetation Index) values. NDVI is an indicator used to measure the greenness of vegetation based on the reflection of red and near-infrared light from the surface of the vegetation. NDVI values range from -1 to +1, where values approaching +1 indicate healthy and dense vegetation, while values approaching zero or negative indicate little to no vegetation.




Picture 8. Map of NDVI Urban Forest BNI in Tibang

Based on the results of satellite image processing displayed on the NDVI Map of BNI Tibang Urban Forest, Banda Aceh City has an NDVI (Normalized Difference Vegetation Index) value ranging from 0.077336 to 0.417675. This range of values illustrates the varying levels of greenness or vegetation cover within the urban forest area. The dark green color on the map indicates high NDVI values, signifying the presence of dense and healthy vegetation, while the red color represents low NDVI values, meaning the area has little to no vegetation cover, such as open, built-up, or degraded areas.

The spatial distribution of NDVI values shows that the central to northeastern part of the BNI Tibang Urban Forest area is dominated by high NDVI values, which represent relatively good vegetation conditions. Meanwhile, in the northern and southeastern parts of the area, red and yellow colors are dominant, indicating that these areas have low to moderate NDVI values and are likely experiencing pressure from human activities or land-use changes. This variation illustrates the differences in the quality and density of vegetation between regions within the urban forest area. Generally, the condition of the vegetation in the BNI Tibang Urban Forest is still quite good, especially in the central and northeastern areas. However, the low NDVI values in some areas need further attention, as they can be an early indicator of environmental degradation or land cover change. Therefore, continuous monitoring and management efforts are needed to maintain the ecological function of the area as a Green Open Spaces (GOS) in the city.

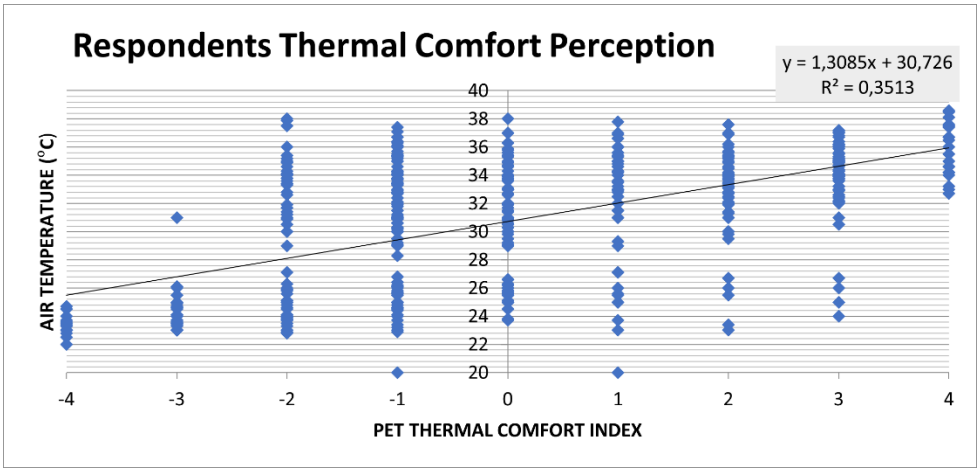



Picture 9. NDVI Map of Urban Park BNI Trembesi in Keudah

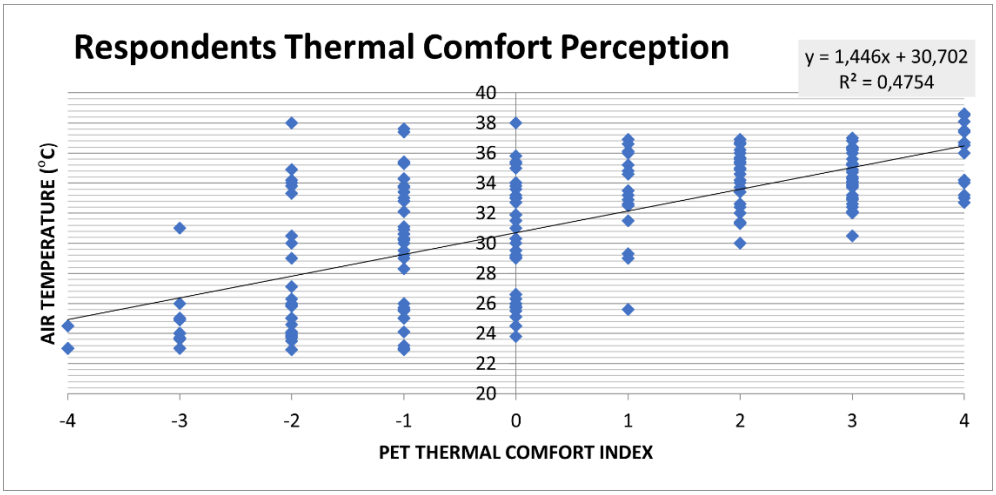
Based on the results of satellite image analysis displayed in the NDVI Map of Urban Park BNI Trembesi, Keudah, Banda Aceh City in 2024, it is known that the NDVI values in the area range from 0.191618 to 0.388942. The NDVI values reflect the condition of vegetation cover in the park area, where higher values indicate denser and healthier vegetation, while lower values indicate the presence of open land, built-up areas, or sparse vegetation. The dark green color on the map indicates areas with relatively dense vegetation, while the red color shows areas with very low vegetation cover. The spatial distribution of NDVI values shows that the central and southwestern parts of the park have relatively good vegetation cover, as indicated by the dominant dark green color. This indicates the presence of vegetation that is growing quite optimally in that area. On the contrary, the northern and southern parts of the park area are dominated by red and orange colors, which reflect low NDVI values and indicate areas with poor or declining vegetation conditions, possibly due to construction activities, weather influences, or limited natural vegetation. Overall, BNI Trembesi Keudah Urban Park still has relatively good vegetation conditions in some areas, although there are also areas that need further attention in conservation efforts and improving the quality of green cover. Periodic monitoring is essential to maintain the ecological function of the urban park as the lungs of the city and a Green Open Spaces (GOS) that supports the quality of life in Banda Aceh.

4. Respondents' Perception of Thermal Comfort

This study involved several respondents from students and the public. The total respondent data reached 594 respondent results in the urban forest and 217 respondent results in the urban park, the data measured throughout the day starting from 09:00 am to 17:00 pm which was carried out simultaneously with the measurement of air temperature and humidity.




(a)




(b)

Graphic 1. Respondents' Perception of Thermal Comfort in the Green Open Spaces (GOS) of Banda Aceh City (a) Urban Forest (b) Urban Park

**Graphic 1** shows the relationship between respondents' thermal comfort perception and actual air temperature based on the PET (Physiological Equivalent Temperature) thermal comfort index at two Green Open Spaces (GOS) locations in Banda Aceh City, namely Urban Forest (graph a) and Urban Park (graph b). This graph displays the distribution of respondents' perceptions of thermal comfort conditions represented by the PET index, with the air temperature they felt at the time of data collection. In graph (a) representing the Urban Forest, it is shown that there is a positive correlation between the PET index and the air temperature, indicated by the linear regression equation $y = 1.3085x + 30.726$ and the coefficient of determination $R^2 = 0.3513$. This indicates that changes in air temperature can explain 35.13% of the variation in respondents' thermal comfort perception. This $R^2$ value reflects a moderate relationship between the actual temperature and the perceived thermal comfort, although other factors also influence the perception of comfort, such as humidity, wind, and shading conditions. Meanwhile, graph (b) depicting the conditions in the Urban Park shows a slightly higher regression value, with the equation $y = 1.446x + 30.702$ and a coefficient of determination $R^2 = 0.4754$. This means that 47.54% of the variation in thermal comfort perception can be explained by air temperature. Compared to the Urban Forest, the relationship between air temperature and respondents' perception of thermal comfort in the urban Park

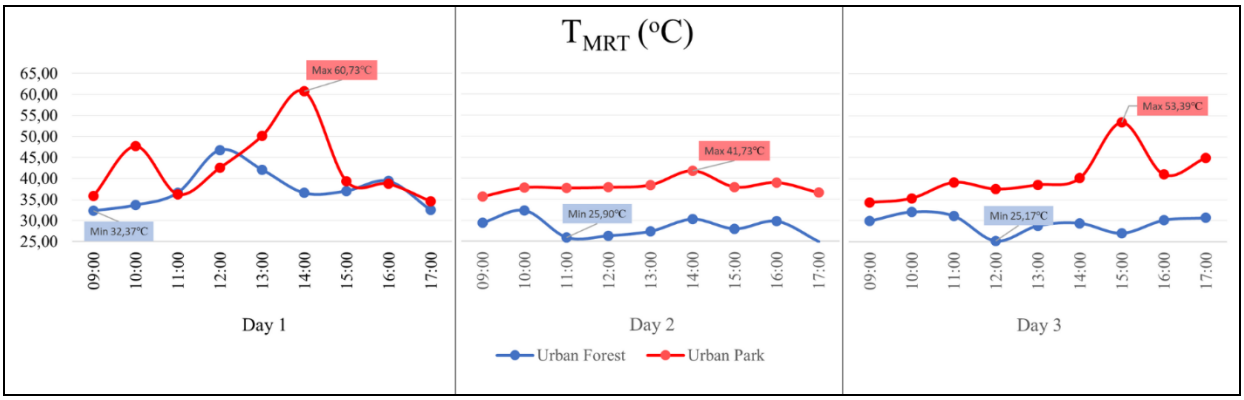
appears to be stronger. This indicates that in the Urban Park, respondents' perception of thermal comfort is more sensitive to changes in air temperature, likely due to the more limited shading elements or vegetation compared to the Urban Forest.

The comparison of the two graphs shows that although both indicate a positive linear relationship between the PET comfort index and air temperature, the relationship is stronger in the urban parks compared to the Urban Forest. This can be interpreted to mean that in environments with lower vegetative shading, air temperature has a more dominant influence on thermal comfort perception. Conversely, in environments with good shading, such as Urban Forests, other microclimatic factors also play a role in shaping comfort perception, so the relationship between air temperature and thermal comfort is not as strong as in more open areas. These findings reinforce the importance of vegetation and microclimatic elements in enhancing thermal comfort in Green Open Spaces (GOS). An environment with good landscape design not only affects physical conditions but also directly impacts the perception and comfort of space users.

5. Calculation of TMRT

a. Calculation of Average Radiation Temperature ($T_{mrt}$)

The mean radiant temperature (MRT) is calculated under microclimate conditions with natural shading to evaluate the influence of vegetation elements on thermal radiation exposure in Green Open Spaces (GOS).




Picture 10. Graph of the Comparison of Average Radiation Temperature in Parks and Urban Forests with Natural Shade

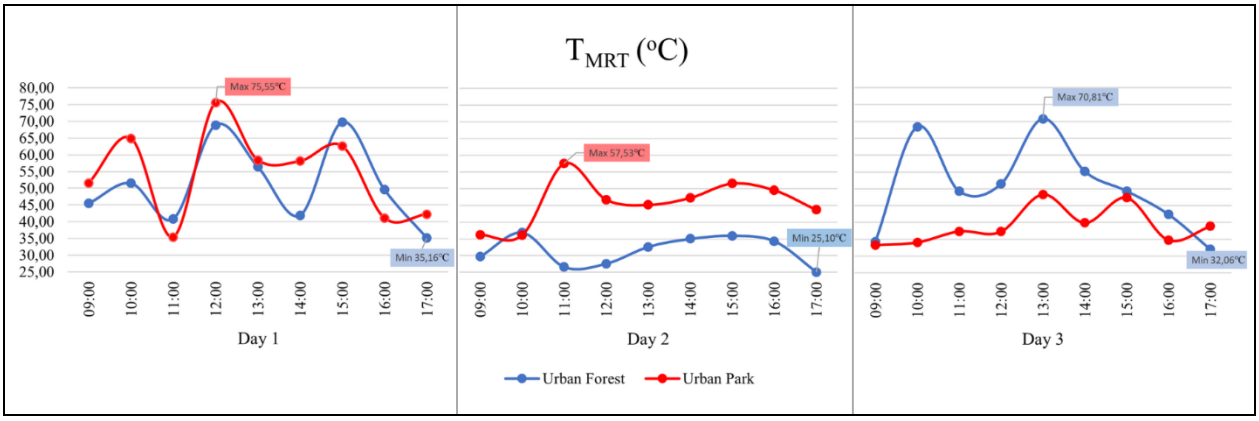
Picture 10 shows the results of the average mean radiant temperature (TMRT) calculations in the Parks and Urban Forests in Banda Aceh. The results of this calculation use formula 1 found in Chapter 3. Several indicators that affect the measurement of average radiation temperature are air temperature, globe temperature, wind speed, globe diameter, and globe emissivity value. Based on the overall accumulation from 09:00 to 17:00, the maximum TMRT occurs at 12:00 and the minimum TMRT at 17:00.This occurs due to the level of solar radiation. At 12:00 PM, the sun is directly overhead, while at 5:00 PM, there is no longer high-intensity solar radiation.

Based on graph 4.25, the average radiation temperature ($T_{mrt}$) in the urban parks tends to be higher compared to the urban forest on all three observation days. The peak temperature occurred on Day 1 in the urban parks at 60.73°C at 14:00, while in the urban forest it only reached around 47°C. This temperature difference illustrates the effective role of shade vegetation in mitigating radiation heat. Generally, the $T_{mrt}$ values in urban forests remain within a lower and more stable range, reflecting more

comfortable thermal conditions. In areas with natural shading, the presence of tree canopies can lower the $T_{mrt}$ value, creating more comfortable thermal conditions for users.

b. Microclimate Conditions Without Natural Shading

The calculation of the mean radiant temperature ($T_{mrt}$) under conditions without natural shading aims to determine the level of thermal radiation exposure in areas fully open to sunlight. Without shading elements such as trees, the ground and surrounding surfaces directly absorb and reflect solar radiation, which has the potential to increase the Mean Radiant Temperature ($T_{mrt}$), leading to an increase in heat load on the human body and a decrease in thermal comfort in open spaces.




Picture 11. Comparison graph of average radiation temperature in urban parks and urban forests without natural shading

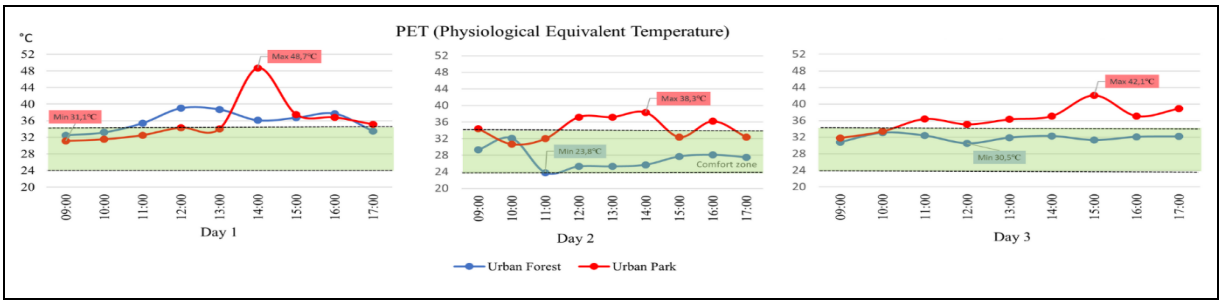
Figure 11 shows that both the urban parks and the urban forest without shade experience a significant spike in $T_{mrt}$, especially during the daytime.The urban parks recorded a maximum temperature of 75.55°C on Day 1 at 12:00 PM, while the urban forest reached 72°C on Day 3. These figures are well above the thermal comfort threshold, indicating that without natural shading elements, open space conditions become extremely uncomfortable and even potentially hazardous to health. The $T_{mrt}$ value above 50°C is highly likely to cause thermal discomfort and even heat stress, especially if the duration is long. This condition occurs throughout the day on the graph without natural shade, both in parks and urban forests. On the other hand, in areas with natural shade, although the temperature briefly rose, it did not last long and did not consistently exceed the danger threshold.

6. Thermal Comfort Evaluation PET

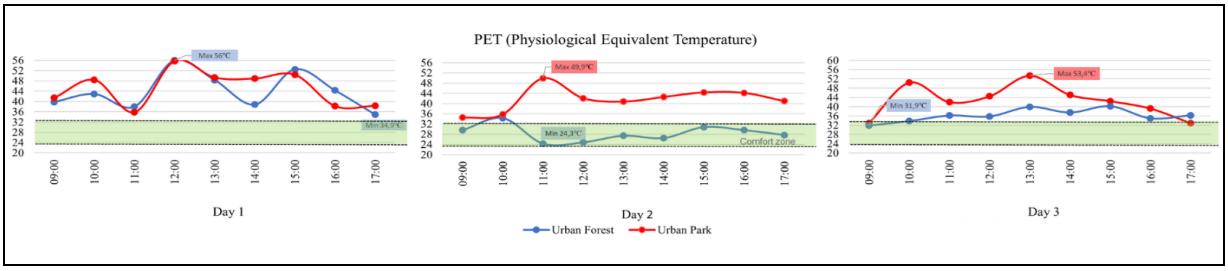
After obtaining the results of microclimate measurements and respondents' thermal perceptions, the next step is to evaluate the thermal comfort levels in parks and urban forests using Rayman 2.1 software.

a. PET evaluation with Rayman 2.1.

In the PET evaluation with Rayman 2.1, several microclimatic factors that influence include air temperature, air humidity, wind speed, and radiation temperature. The results of the PET (Physiological Equivalent Temperature) calculations can be seen in Graph 2 as follows.




(a)

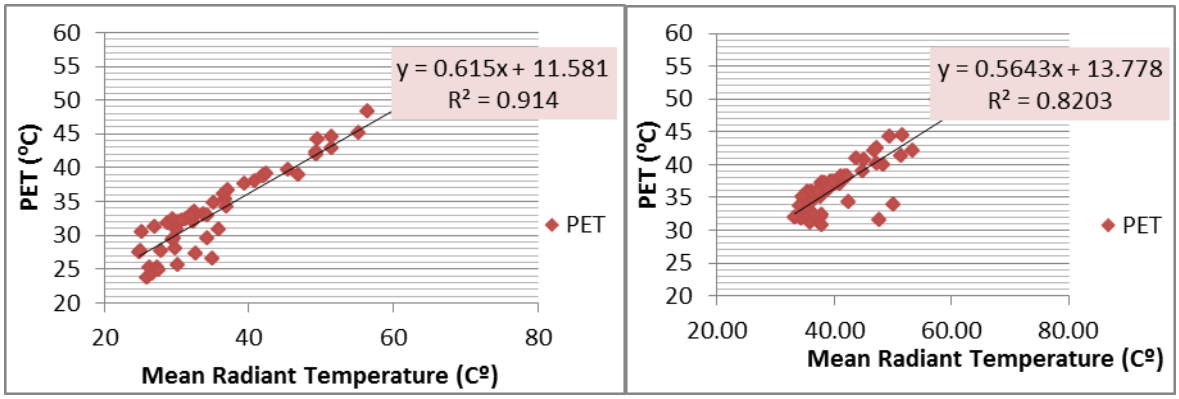



(b)

Graphic 2. Results of PET Calculation using Rayman 2.1. (a) condition with shading (b). condition without shading

Graphic 2 shows the results of the Physiological Equivalent Temperature (PET) calculations performed using Rayman 2.1 software, comparing two different conditions, namely shaded and unshaded conditions, at two different locations, namely Hutan Kota and Taman Kota, over three consecutive days. In shaded conditions (graph a), it is observed that the PET values in the Urban Forest are consistently lower compared to the Urban Park. The PET values in the Urban Forest range from 24°C to 34°C, while in the Urban Park, they peak at around 40°C on the first day at 1:00 PM. This indicates that the presence of shading elements such as vegetation and trees can reduce thermal stress levels and enhance thermal comfort in the environment. Vegetation in the Urban Forest serves as an effective shade provider, offering protection from direct sunlight radiation and increasing air humidity, thereby creating cooler and more stable microclimate conditions throughout the day.

Conversely, under conditions without shading (graph b), the PET values increased significantly at both locations. The PET values reached 30°C to 60°C, with the highest value occurring in the urban parks on the first day at 1:00 PM, approximately ±58°C. Without the presence of shading elements, direct sunlight radiation and increased surface temperatures make thermal conditions very uncomfortable for users of open spaces.Although both locations experienced an increase in PET values, the Urban Forest still showed relatively lower values compared to the Urban Park, indicating that the dense vegetation structure in the Urban Forest continues to provide better thermal protection, even without shading elements. The comparison between the two conditions shows that the presence of shading plays an important role in controlling PET temperature fluctuations, especially during hours of high sun intensity, specifically between 11:00 AM and 3:00 PM. The decrease in PET values due to shading is quite significant, ranging from 6°C to 18°C depending on the time and observation location.These results show that shading elements, especially vegetation, can enhance thermal comfort in urban open spaces. Thus, the results of this analysis reinforce the importance of urban landscape planning that considers shading aspects, in order to create comfortable, healthy, and sustainable outdoor spaces for the community.




b.Comparison of PET respondents and Rayman 2.1

(a) (b)

Graphic 3. Comparison Results of PET respondents with Rayman 2.1. (a) Urban Forest (b). Urban Park

Graphic 3 presents the comparison of Physiological Equivalent Temperature (PET) values based on respondents' feedback with simulation results using Rayman 2.1 software at two different locations, namely Urban Forest BNI (graph a) and Urban Park BNI Trembesi (graph b). The relationship between PET values and Mean Radiant Temperature (Tmrt) is depicted through linear regression equations on each graph.

In graph (a), which depicts the Urban Forest location, it is evident that there is a fairly strong linear relationship between PET values and Tmrt. The resulting regression equation is $y = 0.6154x + 11.581$ with a coefficient of determination $R^2 = 0.934$. The $R^2$ value approaching 1 indicates that the Mean Radiant Temperature variable significantly affects the PET value perceived by respondents in the Urban Forest location. This indicates that Urban Forests with denser vegetation characteristics can significantly influence thermal comfort perception, where variations in Tmrt can explain most of the variations in perceived PET.

Meanwhile, in graph (b) showing the conditions in the urban parks, the relationship between PET and Tmrt also forms a linear pattern, but with a lower coefficient of determination, namely $R^2 = 0.8203$. The obtained regression equation is $y = 0.5643x + 13.778$. The smaller $R^2$ value compared to the Urban Forest indicates that the correlation between Tmrt and PET in the Urban Park is weaker, which could be due to lower shading levels, greater surface heat absorption variation, or the influence of other environmental factors such as surface albedo and air humidity.

The comparison between the two graphs shows that respondents in the Urban Forest exhibit a higher correlation between their perception of thermal comfort and the Rayman simulation results compared to the Urban Park. This indicates that environments with more dominant and dense vegetation, such as Urban Forest, have a more consistent thermal influence on human thermal comfort. In other words, the Urban Forest not only provides physical protection from solar radiation but also creates stable microclimatic conditions, making human perception of heat more predictable through thermal parameters such as Tmrt.

The results of this graph show that the level of correlation between the simulated PET values and respondents' perceptions is influenced by the physical environmental characteristics of the location. Environments with optimal shading elements have a significant impact on thermal comfort and produce a stronger correlation between thermal parameters and subjective perception. These findings reinforce the importance of vegetation management and landscape planning in creating thermally comfortable open spaces for urban communities.

## *Conclusion*

In conclusion, it can be concluded that the landscape design characteristics at the two research locations show a striking difference between the BNI Tibang Urban Forest and the BNI Keudah Trembesi Urban Parks. Thermal comfort at the two research locations shows a significant difference. In the Tibang Urban Forest, the PET (Physiologically Equivalent Temperature) values range from 28 to 32°C, which falls into the comfortable category. On the other hand, in Trembesi Park, the PET value is higher, ranging from 34 to 38°C, which falls into the hot category. The main factors influencing the difference in thermal comfort include vegetation density, the presence of water bodies, and the proportion of hard elements in the area. The results of the questionnaire survey support this finding, where 78% of visitors to Tibang Urban Forest feel comfortable with the existing thermal conditions, while only 45% of visitors to Trembesi Park express similar comfort. This indicates that landscape design prioritizing vegetation and natural elements plays a crucial role in creating thermal comfort in urban Green Open Spaces (GOS).

## *Suggestion*

It is suggested that the Banda Aceh City Government needs to implement clear green design standards that regulate a minimum proportion of 70% soft elements in every urban parks design. This aims to ensure the presence of sufficient vegetation to provide ecological benefits and thermal comfort. In addition, routine maintenance, such as periodic vegetation pruning, needs to be carried out in the Tibang Urban Forest to maintain optimal air circulation. With good management policies in place, it is hoped that Green Open Spaces (GOS) in Banda Aceh City can function optimally and provide maximum benefits to the community.

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