A Model of Climate-Resilient Urban Tourism in Yogyakarta

Rhisa Aidilla Suprapto, Ani Hastuti Arthasari, Fitria Nucifera. Widiyana Riasasi

Architecture Department of Amikom University, Indonesia (rhisaaidilla@amikom.ac.id)
Architecture Department of Amikom University, Indonesia
Geography Department of Amikom University, Indonesia
Geography Department of Amikom University, Indonesia

Abstract.

Climate change has a significant impact on urban areas. The most obvious effect is an increase in surface temperature, resulting in the urban heat island phenomenon. As a tourist city, Yogyakarta cannot be separated from tourist visits. The convenience of tourists is the primary goal of tourism. One of the influential parameters in determining the comfort of travelling is climate and weather conditions. In order to increase the comfort of tourists, a climate resilience-based tourism development model is needed. Tourist village is one of the urban tourism alternatives that is currently developing in the city of Yogyakarta. This study aims to identify the comfort level of tourism based on climate parameters, monitor the microclimate in tourist villages and design a climate resilience-based tourism village development model. The methods used in this research include identifying the comfort level of tourism through field measurements and detailed area mapping as the basis for developing tourism development models. Experimental research was conducted through a simulation study using Envimet software. The research locations were three tourist attractions in the city of Yogyakarta: Brontokusuman Village, Kauman Village, and Bakpia Patuk. The basis for selecting the site study is that these three locations are in hotspot areas based on the spatial distribution of hotspots in Yogyakarta City.

The modelling design was developed based on the concept of green infrastructure. The process of designing this model was carried out with the community through FGDs. Developing tourist villages with green infrastructure is expected to provide comfort for tourists and can be a buffer for hot temperatures in urban centres. The results of analysis modelling simulations show several recommendations for structuring vegetation and landscape. In addition, changing the type of material on the road surface is needed to improve space optimisation for the area from uncomfortable conditions to optimal comfort. The benefit of this study is to become a guide for the Yogyakarta city government to build sustainable tourism amid the threat of climate change. It is because the comfort of tourists is an asset to improve people's welfare from an increase in the number of visits. Apart from increasing the comfort of tourists, tourism villages based on climate resilience can reduce UHI's intensity and the risk of extreme weather in cities.

Keywords: climate-resilient, green infrastructure, tourist villages, UHI, urban tourism.

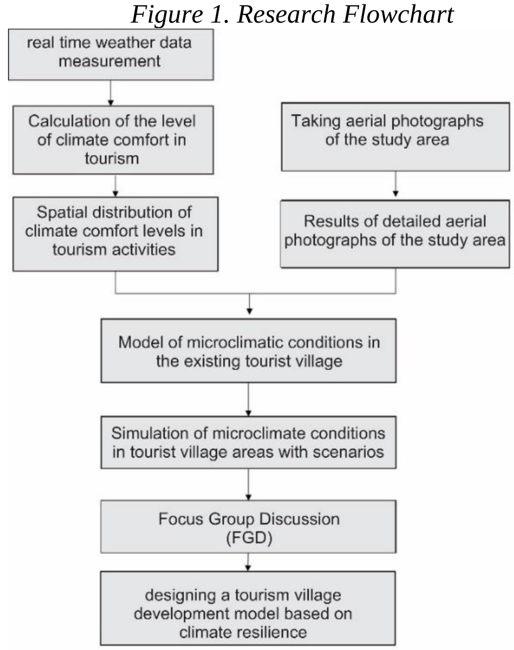
1. INTRODUCTION

Based on the 2017-2022 National Medium-Term Development Plan, the City of Yogyakarta has a vision of "Strengthening the City of Yogyakarta as a City of Livability and a Service Center with Strong Competitiveness for Community Empowerment Based on Privileged Values". One of the keywords in the vision of the City of Yogyakarta is to become a livable city. To realise the vision, one of the Yogyakarta City development missions is strengthening urban planning and environmental sustainability. A city that is comfortable to live in is described as having a supportive environment as a place to live and do activities in physical and non-physical aspects (Wheeler, 2004). The physical environment, including climate and infrastructure, determines a city's comfort level (Monocle, 2013; EIU, 2014). The physical condition of the City of Yogyakarta, which is dominated by built-up land, makes the impact of climate change increasingly felt. The most obvious effect is an increase in surface temperature, resulting in the urban heat island phenomenon. The urban centre of Yogyakarta City has a higher temperature of up to 3°C than the surrounding area (Zahro et al., 2018). This urban heat island phenomenon causes weather discomfort for the people living there and has an impact on the urban tourism development.

As a tourist city, Yogyakarta must be connected to tourist visits. The convenience of tourists is the primary goal of tourism. One of the influential parameters in determining the comfort of travelling is climate and weather conditions (Scott et al., 2004). A climate resilience-based tourism development model is needed to increase the comfort of tourists. Tourist village is one of the urban tourism alternatives that is currently developing in the city of Yogyakarta. Several tourist villages are located in the urban centre of Yogyakarta, so they experience thermal discomfort. Developing tourist villages with green infrastructure is expected to provide comfort for tourists and can be a buffer for hot temperatures in urban centres. The convenience of tourists is an asset to improve people's welfare from an increase in the number of visits. Apart from increasing the comfort of tourists, tourism villages based on climate resilience can reduce UHI's intensity and the risk of extreme weather in cities. Based on this background, this study aims to provide information about the comfort level of tourism based on climate parameters in Yogyakarta, increase awareness of the microclimate in the tourist village area, and design a climate resilience-based tourism village development model.

2. RESEARCH METHODS

Figure 1. Research Flowchart



Source: researcher, 2022.

The research was conducted from March to July 2022 in three tourist villages in Yogyakarta City: the Brontokusuman, Kauman, and Bakpia Patuk. The selection of the three tourist villages among 17 in the City of Yogyakarta is that these three locations are in hotspot areas based on the spatial distribution of hotspots in the City of Yogyakarta.

The stages of implementing the research include collecting primary and secondary data; analysis of processed data, which includes: calculation of the Tourism Climate Index (TCI) or comfort of the tourist climate; detailed mapping of existing areas, design for the development of tourist villages and microclimate simulations in the design model for the development of tourist villages. The research flow can be seen in Figure 1

3. RESEARCH RESULTS AND DISCUSSION

3.1. Description of Tourist Locations

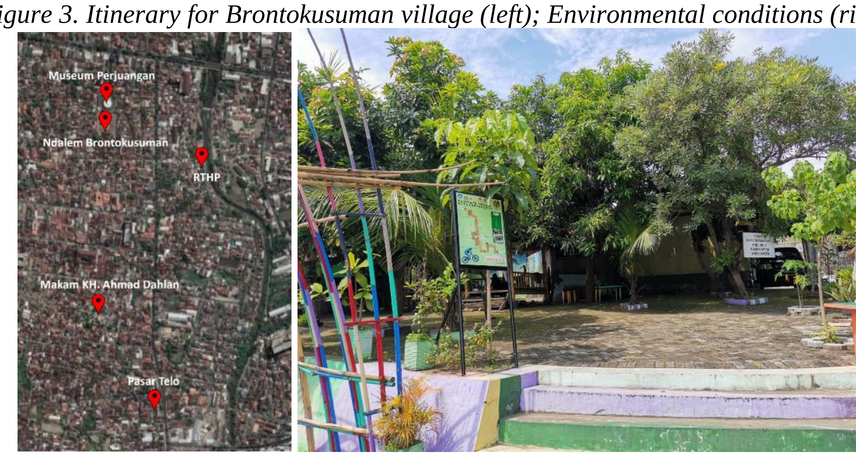
The physical condition of Kauman Tourism Village is built-up residential land dominantly. Open space is quite limited except in the courtyard around the Great Kauman Mosque. Kauman Village tourist itineraries and environmental conditions are presented in Figure 2.

Figure 2. Itinerary for Kauman village (left); Environmental conditions (right)

Source: researcher, 2022.

Brontokusuman Tourism Village is a tourism village based on social eco-tourism and history. The Brontokusuman Tourism Village area is dominated by built-up residential land. However, this area has more expansive green open space when compared to the other two research locations. Public Green Open Space in this area is located on the banks of the Code River. Figure 3 shows The tourist route for Kampung Brontokusuman and green spaces.

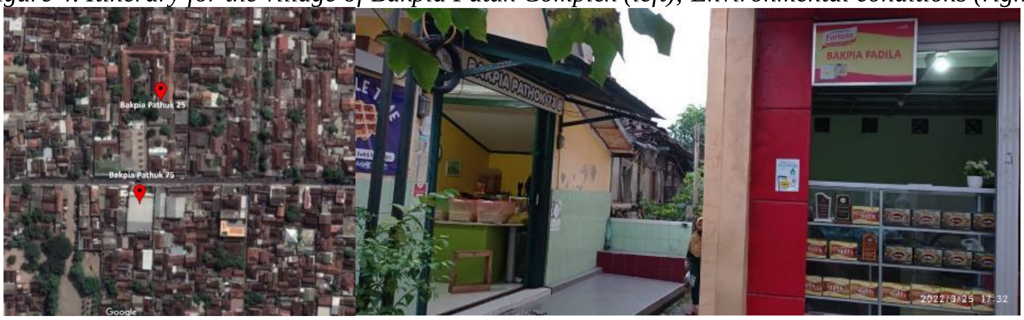
Figure 3. Itinerary for Brontokusuman village (left); Environmental conditions (right)



Source: researcher, 2022.

The Bakpia Pathuk Centre's tourist area has not officially become a tourist village yet. However, the Bakpia producer association initiated village tourism activities in this area. This area is a densely packed shopping and residential with no open tourist space. The tour route for the Patuk Bakpia Complex and environmental conditions can be seen in Figure 4.

Figure 4. Itinerary for the village of Bakpia Patuk Complex (left); Environmental conditions (right)

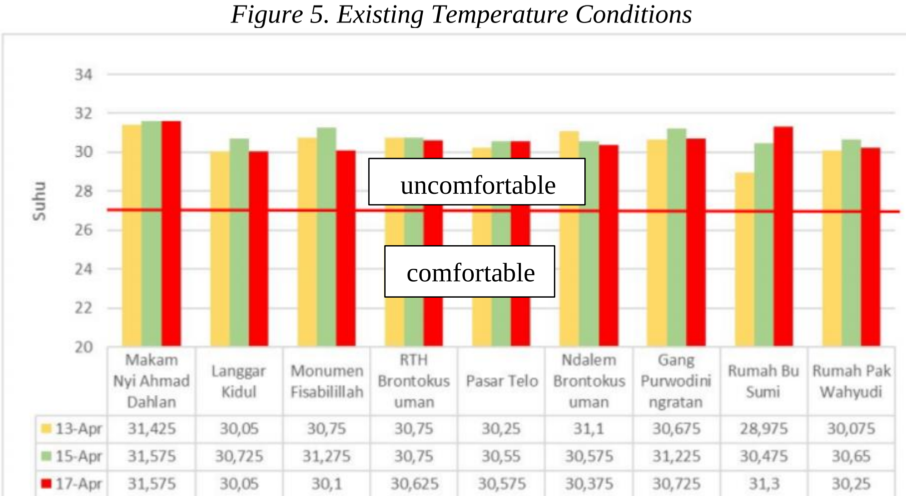


Source: researcher, 2022

3.2. Existing Weather Conditions

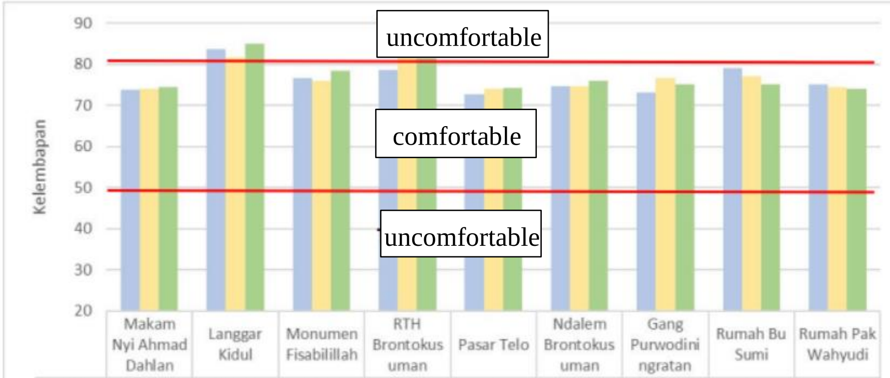
The observation of weather conditions using temperature and humidity parameters. According to the Indonesian National Standard (SNI T-14-1993-03), the Indonesian thermal comfort standard at a maximum temperature of 27.1°C is stated as an almost comfortable condition, where if in a situation the temperature exceeds this value, it is assumed to be an "uncomfortable" condition. The measurements of the temperature values at the sampling points in the three tourist villages show temperatures above 27.1° C (Figure 5). Therefore, based on the results of classifying temperature measurements, the three tourist villages experienced uncomfortable temperature conditions. Meanwhile, the study site's relative humidity measurements, which fall into the comfortable category, were obtained in almost all sampling locations. The average value of the existing relative humidity measured between 72.675% to 85.125%. The relative humidity value at an uncomfortable place is only approximately 10% of the total sampling location. Figure 6 shows the average relative humidity value in the three tourist villages.

Figure 5. Existing Temperature Conditions



Source: analysis researcher, 2022

Figure 6. Relative Humidity Conditions



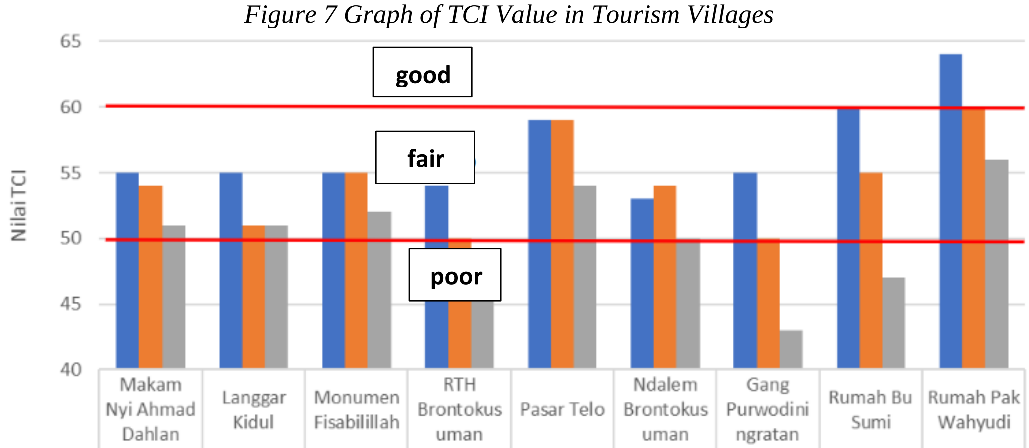
	Makam Nyi Ahmad Dahlan	Langgar Kidul	Monumen Fisabilillah	RTH Brontokusuman	Pasar Telo	Ndalem Brontokusuman	Gang Purwodiningratan	Rumah Bu Sumi	Rumah Pak Wahyudi
13-Apr	73,75	83,625	76,65	78,625	72,675	74,625	73,125	79,15	75,2
15-Apr	74,025	81,65	76,075	81,875	73,95	74,75	76,6	77,075	74,475
17-Apr	74,5	85,125	78,325	81,575	74,225	75,925	75,2	75,225	74,05

Source: analysis researcher, 2022

3.3. TCI Spatial Distribution

The Tourism Climate Index (TCI) is calculated based on daily and monthly weather conditions. The data needed in calculating TCI include temperature, humidity, wind speed, rainfall and duration of sunlight. The results of the calculation and classification of TCI are in Figure 8. The TCI values at three tourist village locations range from 43 to 60. With these values, the TCI at tourist village locations could be better. Temporarily, the highest TCI value occurred on April 13 2022, while the lowest TCI occurred on April 17 2022. A high TCI value indicates better comfortable weather conditions. The TCI value is directly affected by the weather conditions on the day of measurement.

Figure 7 Graph of TCI Value in Tourism Villages



	Makam Nyi Ahmad Dahlan	Langgar Kidul	Monumen Fisabilillah	RTH Brontokusuman	Pasar Telo	Ndalem Brontokusuman	Gang Purwodiningratan	Rumah Bu Sumi	Rumah Pak Wahyudi
13-Apr	55	55	55	54	59	53	55	60	64
15-Apr	54	51	55	50	59	54	50	55	60
17-Apr	51	51	52	46	54	50	43	47	56

Source: analysis researcher, 2022

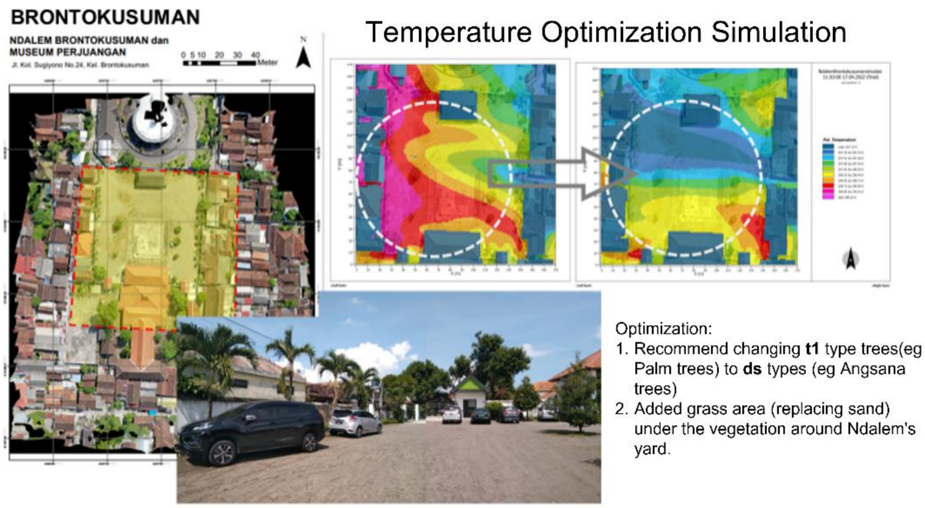
Each tourist village location has its environmental characteristics, causing differences in the level of microclimate comfort, which in this case is represented by the TCI value. Brontokusuman Tourism Village has a relatively wide range of tourist areas. Brontokusuman tends to have a lower TCI value associated with a moderate to less comfortable microclimate level. The most convenient location for the Bakpia Patuk tourist area is in the east.

3.4. Microclimate Comfort Optimization Simulation

3.4.1. Brontokusuman Tourism Village

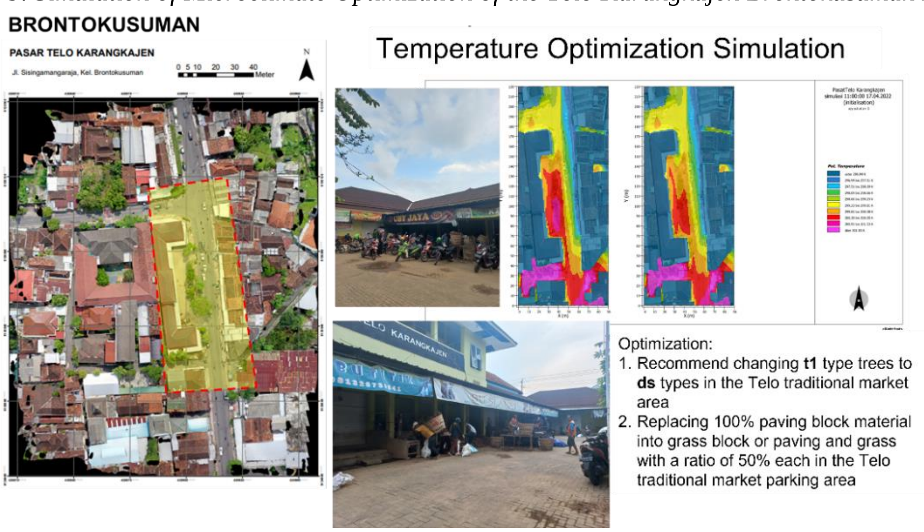
Based on the simulations, land cover material and vegetation types can affect temperature conditions around the area. The optimization effort simulated in the Ndalem Brontokusuman courtyard area is to use a vegetation replacement simulation, originally a type t1 in the form of palm trees to vegetation with the type ds, which has dense leafy vegetation characteristics. The second simulation that was carried out was to add a land cover area in the form of grass (grass/g) along the underside of the vegetation around the Ndalem Brontokusuman yard, replacing the dry sand area under the vegetation, as shown in the following figure. With these two efforts, it can be seen from the optimization simulation results that temperature decreases significantly in the Ndalem Brontokusuman courtyard area. The figure below is an area design recommendation based on optimization simulations on the Ndalem Brotokusuman yard which is emphasized (1) selecting dense leafy vegetation (type ds) and (2) adding grass material to the edge of the Ndalem Brontokusuman yard.

Figure 8. Ndalem Brontokusuman Microclimate Optimization Simulation



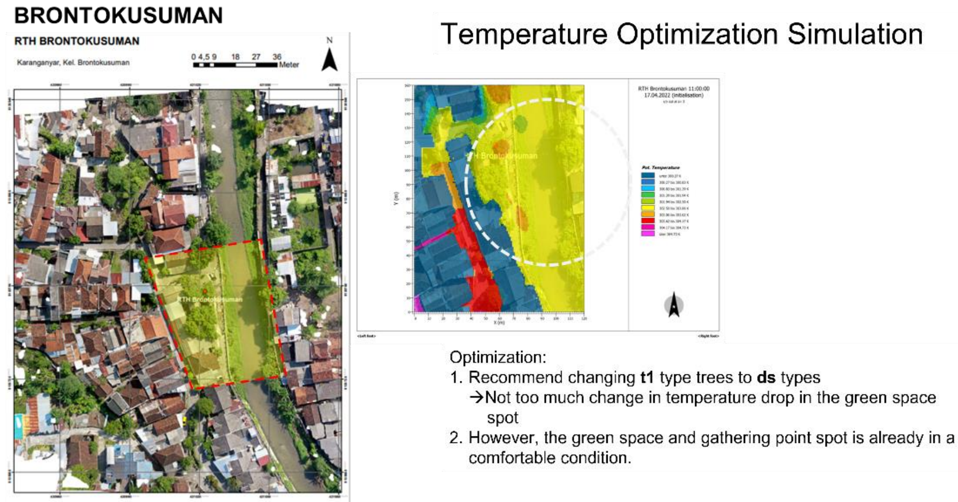
Source: analysis researcher, 2022

Figure 9. Simulation of Microclimate Optimization of the Telo Karangkajen Brontokusuman Market



Source: analysis researcher, 2022

Figure 10. Microclimate Optimization Simulation of the Brontokusuman green open space



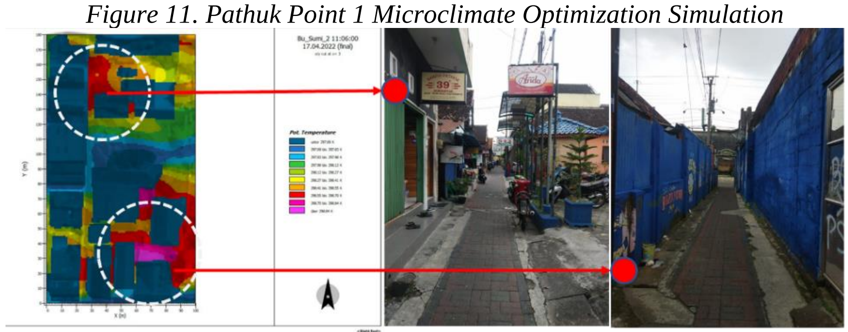
Source: analysis researcher, 2022

The simulations in another Brontokusuman Tourism Village, Pasar Telo Karangkajen, used the same approach as the previous one. The optimization simulation was also carried out using dense leaf vegetation (type ds) and replacing the land cover material in the parking area, which was initially in the form of fully simulated block blocks, was replaced with grass blocks which allowed the ratio of concrete and grass cover to be 50:50. The following figure explains the simulation results showing a decreased temperature in the parking area. Meanwhile, in another hotspot of this village, the Brontokusuman Green Open Space area has relatively comfortable temperature conditions, so the optimization simulation by replacing dense leaf vegetation (type ds) does not contribute significantly to a decrease in temperature. So it can still be maintained in its existing condition. It can be seen in the following figure.

3.4.2. Bakpia Patuk Tourism Center Area

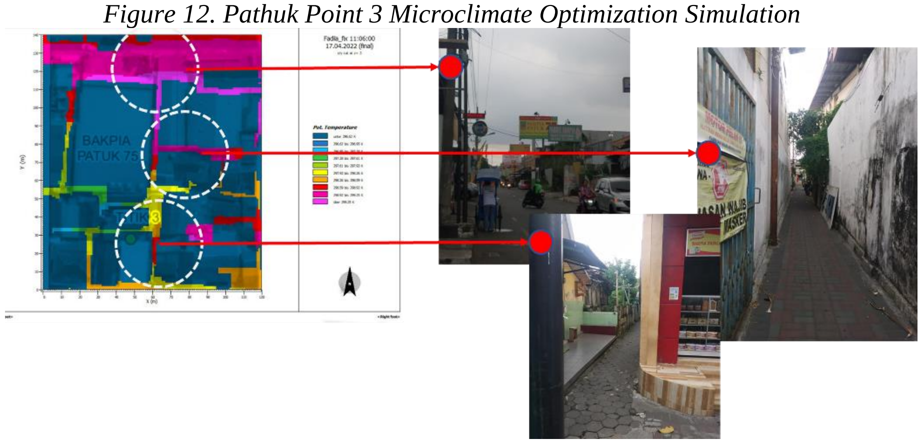
The area's characteristics are dense settlements with relatively narrow footpaths circulation routes. Pedestrians share with users of motorcycles, carts, and others. This condition causes the area to be used for simulation optimization in the ENVI-Met software to be very limited. Substitution of concrete blocks for other materials is impossible because of the various types of users who pass through these roads. Hence, pavements in blocks and concrete are still the choice in terms of function but are a contributing factor to the temperature, which is quite influential—coupled with the addition of tall and densely leafy vegetation (type ds). This condition is illustrated in the visualization of the states in the following figure.

Figure 11. Pathuk Point 1 Microclimate Optimization Simulation



Source: analysis researcher, 2022

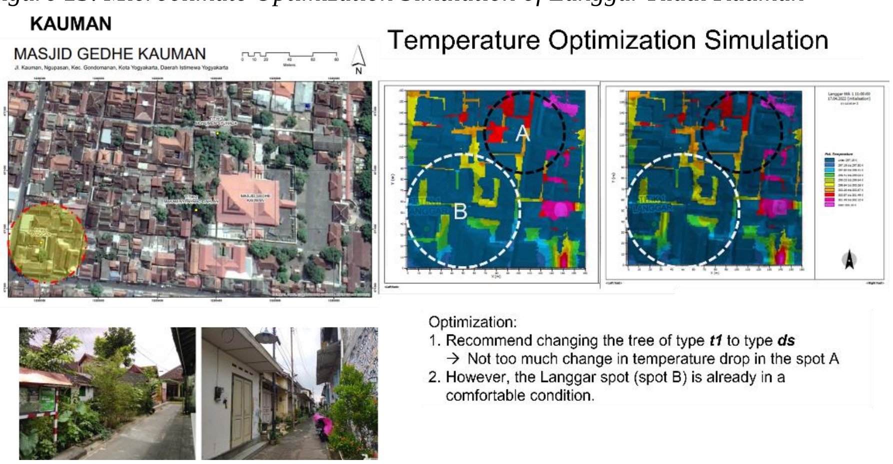
Figure 12. Pathuk Point 3 Microclimate Optimization Simulation



Source: analysis researcher, 2022

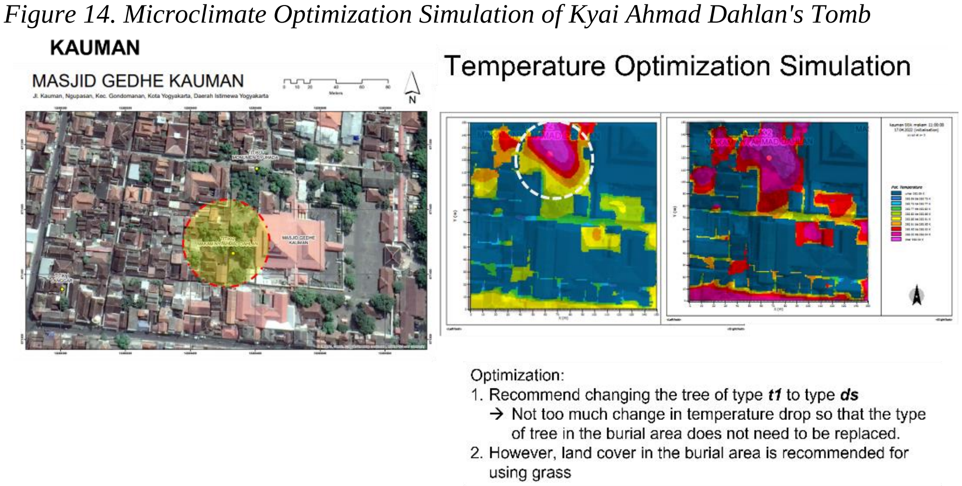
3.4.3. Kauman Tourism Village

Figure 13. Microclimate Optimization Simulation of Langgar Kidul Kauman



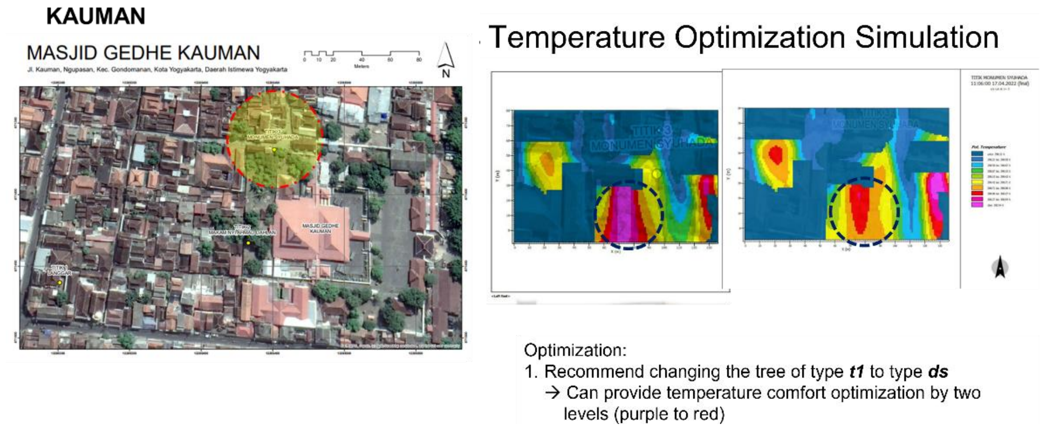
Source: analysis researcher, 2022

Figure 14. Microclimate Optimization Simulation of Kyai Ahmad Dahlan's Tomb



Source: analysis researcher, 2022

Figure 15. Microclimate Optimization Simulation of the Syuhada Kauman Monument



Source: analysis researcher, 2022

At the study location of the Kauman tourist village, the simulation was carried out based on the results of observations at three observation points, namely optimization simulations in the Langgar Kidul area by replacing dense leafy vegetation (type ds) did not have too much of an effect on decreasing temperature in the northern part of Langgar Kidul. Even so, the Langgar Kidul spot is already in an existing comfortable condition to maintain this condition. Subsequent simulations at the point of Kyai Ahmad Dahlan's grave, the conditions were almost the same in the Langgar Kidul area, where the replacement of dense leaf vegetation types did not significantly contribute to a decrease in temperature. Meanwhile, at the location of the last simulation, namely the Martyrs' Monument, it is recommended that the land cover in the tomb area be replaced with grass. Based on optimization simulations in areas with the highest temperatures, replacing tree species with dense leaves can reduce temperatures to two more comfortable levels. Thus, selecting thick leafy vegetation types contributes sufficiently to the comfort of the microclimate in the surrounding area.

4. CONCLUSIONS AND RECOMMENDATIONS

The conditions of thermal comfort in the three tourist villages, as indicated by the temperature parameter, suggest that the average temperature value at the three observation locations is between 29.975° C to 31.425° C, which means that it indicates uncomfortable conditions in terms of temperature because according to SNI, the maximum comfort limit temperature is at 27.1° C. Meanwhile, the air humidity parameter shows that almost all locations are in comfortable relative humidity conditions, namely 72.675% to 85.125%. It shows that the water vapour conditions in the three tourist villages are pretty good, not too dry or wet.

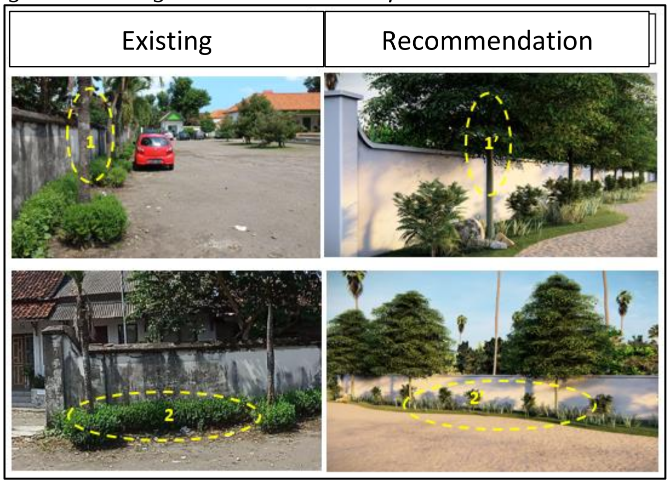
The value of the Tourism Climate Index (TCI) or the tourist convenience index in the three tourist villages is 43 to 60, which means it is in the less to good category. It is because each tourist village location has its environmental characteristics, causing differences in the comfort level of the microclimate. Conditions of vegetation density, building density and land cover materials significantly influence the value of TCI.

4.1. Microclimate Comfort Optimization Recommendations

4.1.1. Brontokusuman Tourism Village

The following are design recommendations to optimize the comfort of the microclimate from the temperature factor at the Brontokusuman Tourism Village study location with the addition of changes in vegetation types to reduce the temperature at the study site. In addition, changes in land cover material are also recommended in areas that were previously filled with block paving to grass blocks.

Figure 16. Design Recommendations for Ndalem Brontokusuman



Source: researcher, 2023

Figure 17. Recommendations for the Telo Karangkajen Market Design

Source: researcher, 2023

Figure 18. Design Recommendations for Brontokusuman Open Space

Source: researcher, 2023

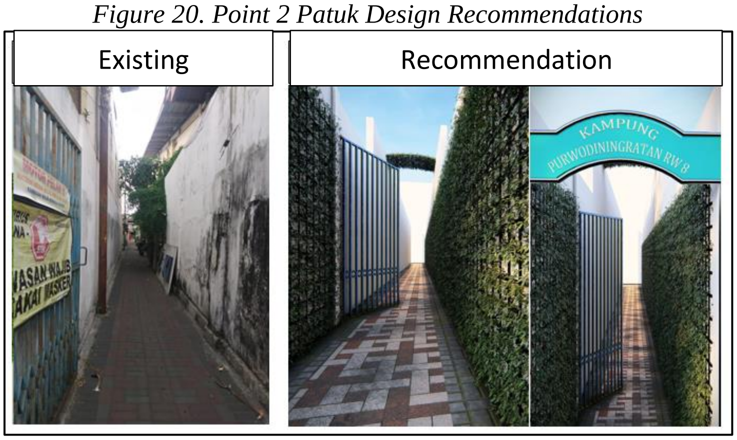
4.1.2. Bakpia Pathuk Tourism Center Area

Adding tall and dense leafy vegetation is impossible to overcome the limited land. It is necessary to provide design recommendations in the form of vines expected to contribute to lowering the temperature. Design recommendations for the Bakpia Pathuk Tourism Center area can be seen in the following figure.

Figure 19. Pathuk Point 1 Design Recommendations

Source: researcher, 2023

Figure 20. Point 2 Patuk Design Recommendations



Source: researcher, 2023

4.1.3. Kauman Tourism Village

Figure 21. Design recommendations for the area to the north of Langgar Kidul

Source: researcher, 2023

Figure 22. Design recommendations for the area next to the Syuhadaa Monument

Source: researcher, 2023

Design recommendations in this area are directed to make a visual contribution and overcome the limitations of landing on footpaths in spots with temperatures that look uncomfortable from the simulation results. While the design recommendations for the area around the Syuhada Monument are (1) replacing existing vegetation with dense leafy vegetation and (2) adding vines. The following is an overview of design recommendations for the Kauman Tourism Village study location.

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