UNDERSTANDING THE IMPACT OF RIPARIAN CORRIDORS ON MICROCLIMATE (CASE STUDY: BOGOR CITY, INDONESIA)

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ABSTRACT: The existence of green open space in urban areas is useful for various ecosystem services, one of which is microclimate amelioration. Microclimate condition is strongly influenced by multiple landscape features. River is widely known as one of waterbodies which has good ability in lowering air temperature. Central Bogor Sub-district, is one of the sub-districts in Bogor City with a lot of green open space in various sizes. This study compares the microclimatic conditions in several parks in riparian and non-riparian corridors in Central Bogor Sub-district. The surface temperature in several parks can be determined by using Land Surface Temperature (LST) analysis in ArcGIS software. Based on the results, there are differences in microclimate conditions between green open spaces in riparian and non-riparian corridors. This condition shows that the presence of river as a landscape feature has a significant influence on the microclimate.

1. BACKGROUND

Urban Heat Island (UHI) is an unavoidable phenomenon in urban areas. Deilami *et al.* (2018) mentioned that UHI can have various impacts such as global warming, increased energy demand in cities, increased precipitation and storms, and increased deaths due to rising temperatures. These conditions show that UHI has a negative impact on the natural environment and penetrates into social problems. UHI phenomenon can increase urban temperatures by 7°C compared to the surrounding area (Chow and Roth, 2006). The high air temperature of urban areas compared to the surrounding areas makes the government need to prepare a strategy to ameliorate the microclimate (Rizwan *et al.*, 2008).

Green open space (GOS) is one solution to improve microclimate conditions in urban areas. According to Zhang *et al*. (2017), green open space in a city can help provide a cooling effect, lower air temperature, reduce energy use, and improve human health conditions. The decrease in air temperature between GOS and urban areas can show significant results (Bowler *et al*., 2010). The performance of decreasing air temperature is also strongly influenced by the type of vegetation cover. The denser the vegetation, the higher the temperature decrease (Richards *et al.*, 2020). Even GOS in Hong Kong showed a decline of 4.1 °C compared to urban areas (Fung and Jim, 2019).

Various studies have stated that in addition to dense vegetation, water features in GOS can also be the key to reducing air temperature. The point of observation of air temperature in GOS with ponds and rivers shows lower air temperature and higher humidity than those without ones. The research results by Ghosh and Das (2018) prove that the presence of GOS with water features can reduce the temperature outside the green open space by 1 °C. Water bodies in green space can create a Water Body Cooling Island to minimize the effect of UHI (Chang *et al*., 2007). Febrita *et al.* (2021) also mentioned that riverside landscape design could be used to improve the microclimate and create comfort so that energy use can be reduced. This thing shows that water bodies can be a critical component in improving the microclimate.

Bogor is one of the satellite cities in the Jakarta Megacities. Bogor has a garden city structure promoted by Ebenezer Howard where in the city center, there is a large city park (Bogor Botanic Gardens) with satellite gardens around it. The area of green open space in Bogor City reaches 2,133 hectares or about 18% of the urban area. The potential of this park city is widely used by the government as a place for recreation, sports, and socializing. Bogor has the potential of the park to be used as a place for community relaxation. In general, parks that have a specific theme such as graffiti park (Taman Corat-Coret), expression parks (Taman Ekspresi),

fountain park (Taman Air Mancur), games park (Taman Kaulinan), etc. Besides having the potential for city parks, Bogor also has an enormous river potential. At least 5 rivers are flowing in this city, Ciliwung, Cisadane, Cidepit, Cipakancilan, Cibalok, etc. Ciliwung, as the main river that flows in downtown Bogor, has its headwaters in the southern area of Bogor and flows into Jakarta Bay. Several city parks are located on the banks of the Ciliwung River as urban riparian parks.

Until now, some city parks with the concept of urban riparian parks have the potential as riverside tourist areas. The arrangement of GOS and blue open space can create an urban riparian park as a good potential for tourist attractions (Ibrahim *et al.*, 2020). Visitors are usually interested in visiting these parks to see the view of the Ciliwung River up close. However, the government has not realized the potential for a river at this location as an element that can provide thermal comfort. Based on this, it is necessary to conduct a study to compare the air temperature in riverside city parks and city parks that are not on the river bank.

2. METHODS

2.1. Study Location

The location of the research was carried out in several parks in Central Bogor Sub-District, Bogor City. Central Bogor is one of the sub-districts in Bogor City, which has many parks. The three riverside parks and three non-riverside parks were selected as observation points to compare land surface temperature (LST) at these six points. The six observation points can be seen in Figure 1. The blue observation points are riverside parks, while the red ones are Non-riverside Park.

Figure 1. Study location in six parks of Bogor

Table 1. Name and Location of Sampling Points

No	Park's Name	Location	Coordinate Points
1	Peranginan Park	Riverside	-6.587175, 106.797192
2	Kaulinan Park	Riverside	-6.592183, 106.800294
3	Sujana Kassan Park	Riverside	-6.592771, 106.800875
4	Kencana Park	Non-Riverside	-6.588886, 106.802085
5	Expression Park	Non-Riverside	-6.592215, 106.801647
6	Teijsmann Park	Non-Riverside	-6.601456, 106.795527

2.2.Data Analysis

ArcGIS software was used to LST value. This study collected Landsat 8 satellite data of Bogor City (Path 122 Row 65) in May 2021 from the USGS web page. Satellite data imagery was used to analyze LST value. The Land Surface Temperature (LST) is the radiative skin temperature of ground. It depends on the albedo, the vegetation cover and the soil moisture.
In most cases, LST is a mixture of vegetation and bare soil temperatures. LST can be analyzed using Bands 10 and 11 from the Thermal Infrared Sensor (TIRS) of the Landsat 8 satellite. Guha to *et al*. (2018) stated that NDVI shows a robust negative correlation with LST.

3. RESULTS AND DISCUSSIONS

Based on the analysis of LST in Bogor City, the results obtained are as shown in Figure 2. The LST values in Bogor City range from 17.6-32.9°C. The variation in the LST value is closely related to the level of greenness or vegetation index from the land cover. From the results of comparing LST values at the six parks in Bogor City, Sujana Kassan Park has the lowest LST value (25.59°C), followed by Teijsmann Park, Expression Park, Kaulinan Park, Kencana Park, and Peranginan Park (Table 1). The exciting fact found from the results of the LST analysis is that the average value of LST in non-riverside parks is lower than that of riverside parks, 26.78°C, and 26.90°C, respectively.

These conditions indicate that the location of riverside parks did not automatically give them more ability to lower air temperature. To support these abilities, some factors need to be combined. The form of green open space is one of the determinants of park ability to reduce air temperature. Based on Li (2020), the linear park category contributes with a less cooling effect. Peranginan Park (point 1) is a riverside park with a linear shape because it is flanked by Jenderal Sudirman Road and the Ciliwung River. The linear garden shape makes it difficult for vegetation to be planted in clusters and maximizes reducing temperatures.

On the other hand, Teijsmann Park, a non-riverside park, has a lower LST value than Peranginan and Kaulinan Park. The location of Teijsmann Park, located in the Bogor Botanic Gardens, gives it more ability to reduce air temperature. The two parks with the lowest LST values are located in Bogor Botanic Gardens, an urban forest with 87 hectares consisting of several gardens. This condition shows that the position of green open space adjacent to other green open spaces can maximize its ability to reduce air temperature compared to green open space which is limited by roads and buildings.

Based on this, it is no wonder if Sujana Kassan Park has the lowest LST value. Its position in an urban forest with a river flowing in the middle completes its ability to reduce air temperature. Based on research by Permatasari *et al*. (2021), the size of GOS can affect its ability to reduce air temperature. However, many other factors in green open space can affect air temperature. Plants, water bodies, slope direction, height difference, and spatial morphology also have the important roles to improve the microclimate comfort in a portion of sites (Suming *et al*., 2017).

According to the explanation above, we need to consider various strategies to reduce the air temperature in urban areas. The addition of new GOS should consider the aesthetic function and the ecological function of GOS in ameliorating the climate in urban areas. The potential for rivers in urban areas can be used as a riverside park location. However, to maximize the function of decreasing air temperature in a riverside park, it is also necessary to consider the shape and size of green open space, vegetation types, and land slope to maximize its ability to reduce air temperature.

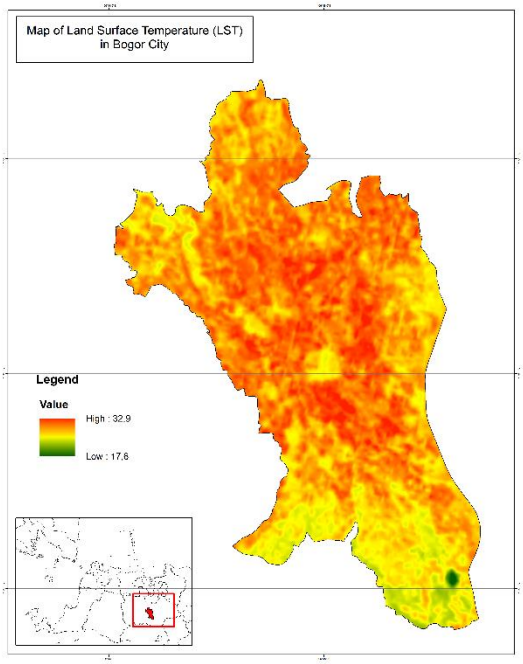

Figure 2. Map of LST Value in Bogor City

Table 1. LST Value in six sampling points

No	Park's Name	Location	Coordinate Points	LST Value (°C)
1	Peranginan Park	Riverside	-6.587175, 106.797192	28.49
2	Kaulinan Park	Riverside	-6.592183, 106.800294	26.64
3	Sujana Kassan Park	Riverside	-6.592771, 106.800875	25.59
4	Kencana Park	Non Riverside	-6.588886, 106.802085	27.82
5	Expression Park	Non Riverside	-6.592215, 106.801647	26.39
6	Teijsmann Park	Non Riverside	-6.601456, 106.795527	26.13

4. CONCLUSION

Based on the results and discussion, the average LST value of non-riverside parks is lower than riverside parks. Although not significantly different, it shows that park location is not the only factor that can reduce the LST value in urban areas. The two parks with the lowest LST values are Sujana Kassan Park and Teijsmann Park, located in Bogor Botanic Gardens, an urban forest with many gardens. This condition shows that the size and shape of GOS have a big role in maximizing the ability of green open space to ameliorate climate. The location of GOS adjacent to other GOS is also a factor that strengthens this ability. Based on this, Sujana Kassan Park, a riverside park, has a non-linear shape within the Bogor Botanic gardens. It has many factors that can increase its ability to reduce LST values. The more factors that can lower the air temperature, the higher its ability to ameliorate the urban climate. This study only uses satellite imagery in analyzing LST so it is necessary to conduct a field survey to measure air temperature in future studies so that the results can be more accurate. However, the results of this study can provide an initial overview to stakeholders in determining the criteria for developing GOS in urban areas.

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