

The Potential of Landscape Element at Tourism Parking Area to Mitigate Urban Heat Island in Bengkulu City

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Abstract A parking area is believed as one of urban public open spaces that are potential enough to contribute in mitigating UHI (Urban Heat Island) through the design arrangement of vegetation and other landscape elements. Parking areas in Pantai Panjang Bengkulu Indah Mall (BIM) and Rumah Pengasingan Soekarno, two of most famous tourism destinations in Bengkulu, Indonesia, were chosen as the object study for this research to discover the possibility of landscape elements in reducing air temperature rise by finding the correlation between existing landscape element and air temperature created. Site observation was conducted for 2 days in each location to collect existing physical data of landscape element, and existing air temperature data using a mini weather station and a thermal-hygrometer. Data from both observed locations then will be compared to each other to find which one has a better performance in reducing air temperature through their landscape elements. Simulation using ENVI-met will also be conducted to find the effectiveness of existing vegetation in reducing air temperature. Results of the study showed that both observed parking areas are not giving a huge positive impact on reducing UHI in Bengkulu City because the temperature recorded on the existing site was higher than the temperature data collected from the internet on the same day. However, landscape elements in Pantai Panjang BIM parking area, such as wide-tree vegetation and greater shaded canopy area especially on the west side, have bigger potential to mitigate UHI due to the lower of air temperature compared to Rumah Pengasingan Soekarno Parking Area.

Keywords Air Temperature, Landscape, Parking Area

1. Introduction

The phenomenon of rising temperatures in several cities in Indonesia occurs in line with changes of green open space into built-up land area [1]. Infrastructure development in urban areas reduces natural vegetation, and increases radiation emission from the sun's heat during the day due to building materials and city infrastructure which make urban areas hotter than the surrounding rural areas [2]. Based on climate and air temperature data from Meteoblue.com [3], Bengkulu City has experienced a temperature rise up to 0.8°C. However, there is a potential to decrease temperature in urban area by the additional green area (green coverage) in the city [4] [5] [6]. More in detail, the existence of 60% trees in an area with high leaf area density (LAD) of the trees can reduce temperatures up to 3°C [7]. Thus, the effect of greenery in urban area on the thermal comfort of outer space is an interesting topic to study. It is believed that the decrease of high temperature in a city can provide good benefits for human life because there are studies showing that the higher air temperatures of the city especially on summer day can give a greater effect on the risk of death for urban residents [8].

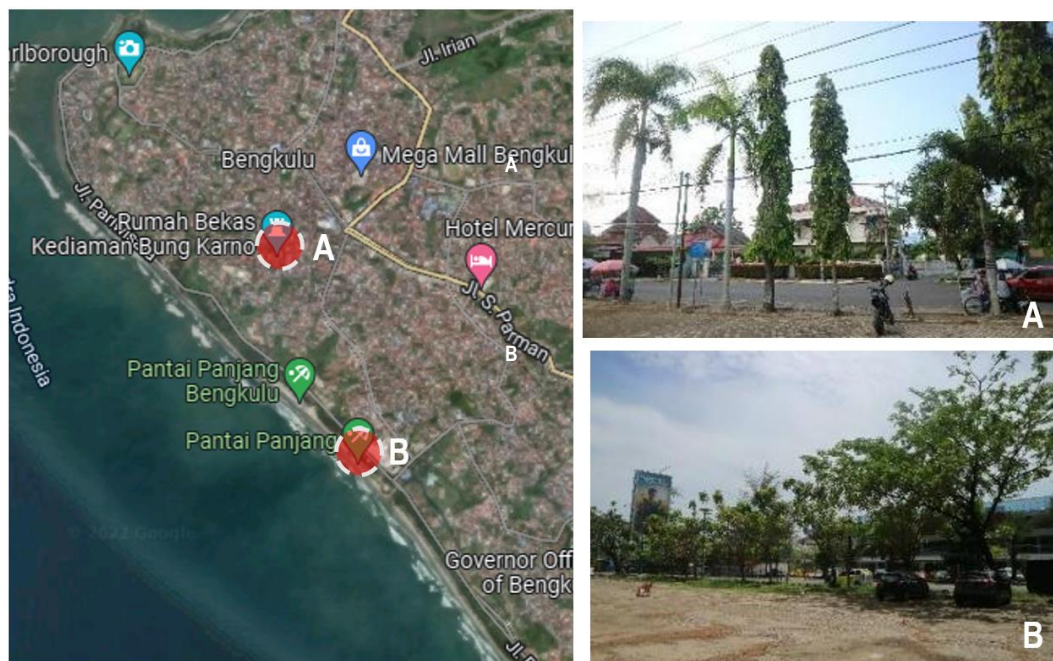
In the structure of a city, the existence of vegetation as green space can be found in open spaces between building

blocks and road corridors. However, parking spaces have the opportunity to contribute in providing more green open space by the effective arranging of its landscape elements [9]. There is also another study showing that landscape condition on several existing parking areas needs to be improved especially for the presence of vegetation elements [10] [11]. It means that parking area as urban open space has the potential to reduce urban temperatures through their green open areas and tree canopy.

Parking areas that will be studied in this research are two parking areas located in two popular tourism destinations in Bengkulu City, Indonesia. The first object is Rumah Pengasingan Soekarno Parking Area, and the second object is Pantai Panjang near Bengkulu Indah Mall (BIM) Parking Area (Figure 1). In previous studies, the characteristics of the landscape elements of the two parking areas have been identified. Results of previous study showed that Pantai Panjang BIM Parking Area has the advantage and enough potential to reduce air temperature because there is a lot of tree vegetation with adequate shade (53% during the day at 11 am until 1 pm). *Mimba Tree* (*Azadirachta Indica*) with an average height of 17 m and an average diameter canopy of 7 m and 9 m is the type of tree vegetation that is mostly found in Pantai Panjang BIM Parking Area. Moreover, the special characteristic of Pantai Panjang which also exists in this parking area is the huge rows of Pine Trees (*Casuarina*

Equisetifolia) with an average height of 12m and an average diameter canopy of 7m, along the beach on the west side of the site. High LAD characteristic at Pantai Panjang BIM Parking Area cannot be found at Rumah Pengasingan Soekarno Parking Area which only has several 9m Palm trees (*Arecaceae*) with an average canopy diameter of 6.5 m, and 12m *Glodokan* trees (*Polyalthia Longifolia*) with an average canopy diameter of 2m. The trees vegetation which is located on the south side of Rumah Pengasingan Soekarno Parking Adjacent to the main road only provides small amount of shade (19% during the day (11 am until 1 pm).

If the previous research was to figure out the potential of temperature reduction through the condition of existing landscape vegetation based on direct observations, the current research is to find out the correlation of existing landscape vegetation with the air temperature created in both object studies. UHI mitigation potential will be found by looking for the relationship between the air temperature created by the percentage of tree shading and the percentage of cloud cover on the day of observation. Finding of the studies is expected to be a reference for designing the landscape of parking area, especially in Bengkulu City, to mitigate the global warming issue as well as to create a better sustainable environment in the future.

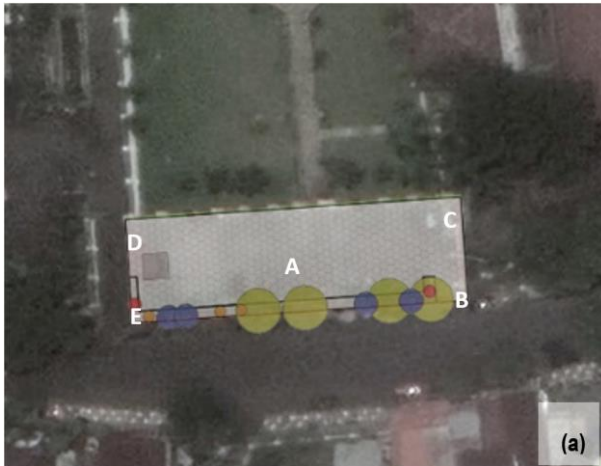


Source: processed from <https://www.google.com/maps/place/Bengkulu...> accessed on June, 2022

Figure 1. Two locus observations of the research; (a) Rumah Pengasingan Soekarno Parking Area; (b) Pantai Panjang BIM Parking Area

2. Materials and Methods

Generally, research on the effect of greenery in a city on outdoor thermal comfort is carried out by simulation and field measurements [12]. Therefore, this research will be carried out in 2 stages, the first one is recording existing climate condition, and the second stage is conducting computer simulation, to finally formulate the research findings.



Source : processed from <https://www.google.com/maps/place/Bengkulu> u... accessed on June, 2022

Figure 2. Measurements location on 2 object studies; (a) Rumah Pengasingan Soekarno Parking Area; (b) Pantai Panjang BIM Parking Area

In the first stage, air temperature of Bengkulu City and cloud cover was recorded based on data available at *Accuweather* mobile apps, and also by the direct field measurement using a mini weather station and a thermo-hygrometer. These two data will be used to find out how much the difference between the air temperatures in macro level of Bengkulu City that was recorded on the internet with the micro level of existing air temperature that was recorded by direct measurement tools. Air temperature

was collected on 4 different days for the two object locations due to limited measurement tools. Climate data collection for Rumah Pengasingan Soekarno Parking Area was carried out on September 15, 2022, and November 29, 2022. While air temperature collection for Pantai Panjang BIM Parking Area was carried out on September 14, 2022, and November 22, 2022. Nearing the end of the year, starting from September, cloudy days all day long happen more in Bengkulu City. Air temperature collection is conducted on those two chosen dates because Bengkulu City was in sunny weather conditions in the morning on these dates. Direct measurements using thermo-hygrometer (figure 3) were taken from 9 am to 4 pm on 5 measuring spots spread across the site (Figure 2) to obtain various data on-site. While a mini weather station gauge is placed in the middle of the site or in spot A. Air temperature collected on various measurement spots will also be used to find the relation of the area with the highest air temperature by the characteristic of its landscape vegetation that exists.



Figure 3. Thermo-hygrometer used for direct measurement tools

On the second stage of the study, creating landscape modeling in ENVI-met software for both object studies was conducted based on the result of the observations on existing landscape elements. ENVI-met is a simulation software for urban and landscape environmental modeling with an integrated approach of temperature and airflow (fluid dynamics and thermodynamics), plants and ground cover elements, and building facades [13]. Thus, ENVI-met software is suited as a tool to prove the impact of climate change mitigation on the microclimate scope of areas by utilizing green infrastructure, especially in increasing the function of trees in urban areas [14]. Generally, ENVI-met software is used to map the thermal comfort of an area by knowing the Effective Temperature from the simulation results to then find suggestions type of vegetation arrangement to improve the quality of landscape design [15]. ENVI-met analysis in this study was to

determine the quality of the landscape design based on the air temperature created. Thus, the day and date of the test to be carried out in the ENVI-met simulation adjusts to the

date of direct observation that has been done before. More details about the modeling of ENVI-met software for both of the object studies can be seen in Table 1 below.

Table 1. Input data for ENVI-met Simulation






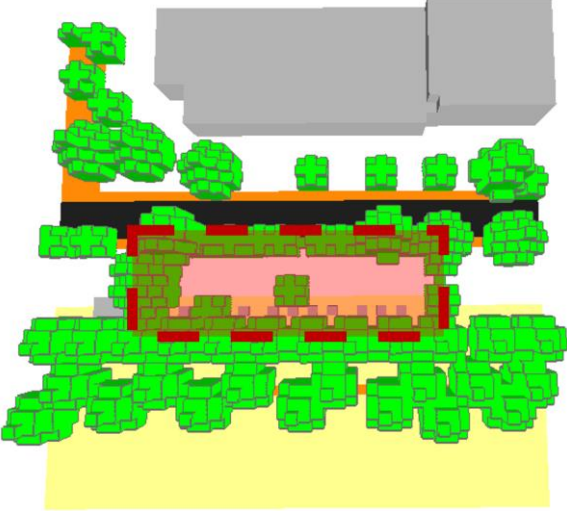




 <p>Landscape of Rumah Pengasingan Soekarno Parking Area</p>		
Latitude	-3.80	
Longitude	102.26	
Rotation out of grid north	4°	
Min. – Max. Temp.	28°C – 36°C	
Wind direction	South	
Wind speed	2.5 m/s	
Date of simulation	September 15, 2022	
Simulation duration	10 am – 12 am 12 am – 2 pm 2 pm – 4 pm	
Types of vegetation	Existing	Envimet
	<i>Casuarina Equisetifolia</i>	<i>Pine Tree</i> (Young)
	<i>Polyalthia longifolia</i>	<i>Carpinus Betulus</i> (middle)
	<i>Polyalthia longifolia</i>	<i>Carpinus Betulus</i> (old)
	<i>Areaceae</i>	<i>Palm</i> Large, Trunk, dense, medium (15m)

Table 1 continued

		
Landscape of Pantai Panjang BIM Parking Area		
Latitude	-3.81	
Longitude	102.27	
Rotation out of grid north	47°	
Min. – Max. Temp.	22°C – 29°C	
Wind direction	North	
Wind speed	2.5 m/s	
Date of simulation	September 14, 2022	
Simulation duration	10 am – 12 am 12 am – 2 pm 2 pm – 4 pm	
Types of vegetation	Existing	Envimet
	<i>Azadirachta indica</i>	<i>Cylindric</i> , small trunk, sparce, medium (5m)
	<i>Hibiscus tiliaceus</i>	<i>Conic</i> , small trunk, sparce, medium (15m)
	<i>Samanean saman</i>	<i>Larix Decidua</i>
	<i>Casuarina equisetifolia</i>	<i>Pine</i>

Finally, the comparison and correlation of the observed data, such as hourly air temperature, cloud cover, and shadow percentage of tree canopy, were the analysis carried out in this study. More, air temperature differences between two objects' locations which come as the effect of landscape elements will also be discovered through the results of ENVI-met simulations.

3. Result

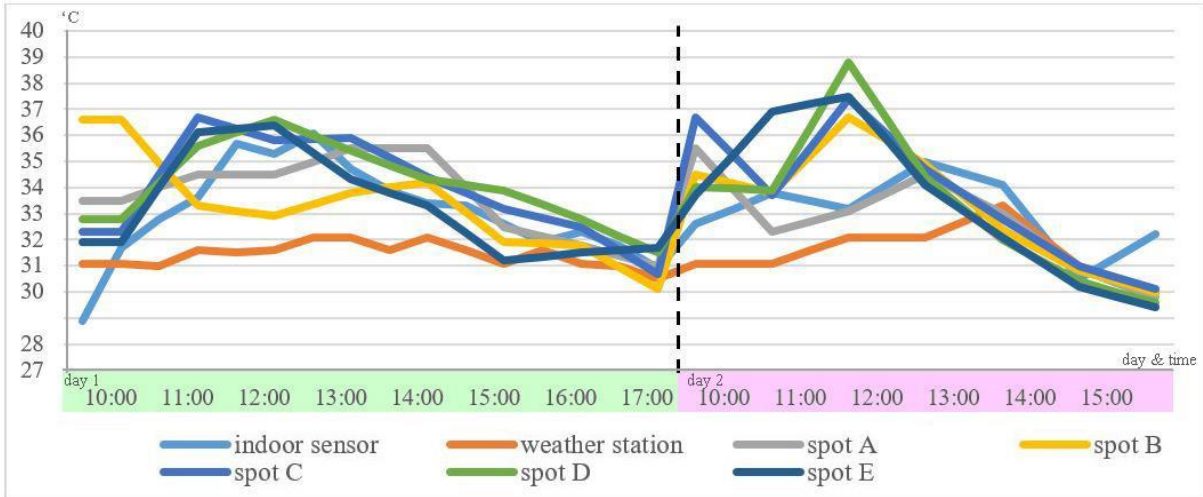
Results of air temperature from direct measurement on both observed locations are different from the air temperature data obtained from the internet. At Rumah Pengasingan Soekarno Parking Area (shown in Figure 3), the air temperature on micro scale which was recorded from direct measurements is 6°C higher than the macro scale air temperature which was recorded from the internet. The biggest temperature difference between direct measurement and data from internet was 9.14°C which occurred at 11.30 am on the first day of measurement. While the smallest temperature difference was 1.24°C which occurred at 12.30 am on the second day of measurement. The trend of two days observed air temperature recorded using direct measurement tools and data from *Accuweather* mobile apps shows the same pattern. Temperature tends to be low in the morning, then hot during the day, and reaches the peak at 11 am to 1 pm, and then drops again in the afternoon. The highest air temperature recorded from direct measurement tools for 2 days observation at Rumah Pengasingan Soekarno Parking Area was 35.54°C which occurred at 11.30 am on the second day of measurement. Meanwhile, based on internet data, the highest air temperature in Bengkulu City recorded happened at 12.30 am, still on the same second-day measurement. Spot C in Rumah Pengasingan Soekarno Parking Area has the highest average temperature based on direct measurement compared to other spots, which is 33.9°C. While the lowest average temperature based on direct measurement is at spot A, which is 33.25°C. However, spot D at 11.30 am on the second day of measurement was the highest temperature recorded ever, which is 38.8°C.

Compared to the air temperature in Rumah Pengasingan Soekarno Parking Area, the trend of air temperature in Pantai Panjang BIM Parking Area from direct measurement is different from the trend of Bengkulu City air temperature recorded from the internet. As shown in Figure 4, air temperature data recorded from the internet for 2 measurement days is getting lower during the day (11.30 am – 3.30 pm), while the air temperature data collected from direct measurement tools for 2 days measurement was increasing during the day (11 am – 1 pm) and then decreased in the afternoon. Even though the trend of air temperature between data recorded from the internet and direct measurement was different, the average of

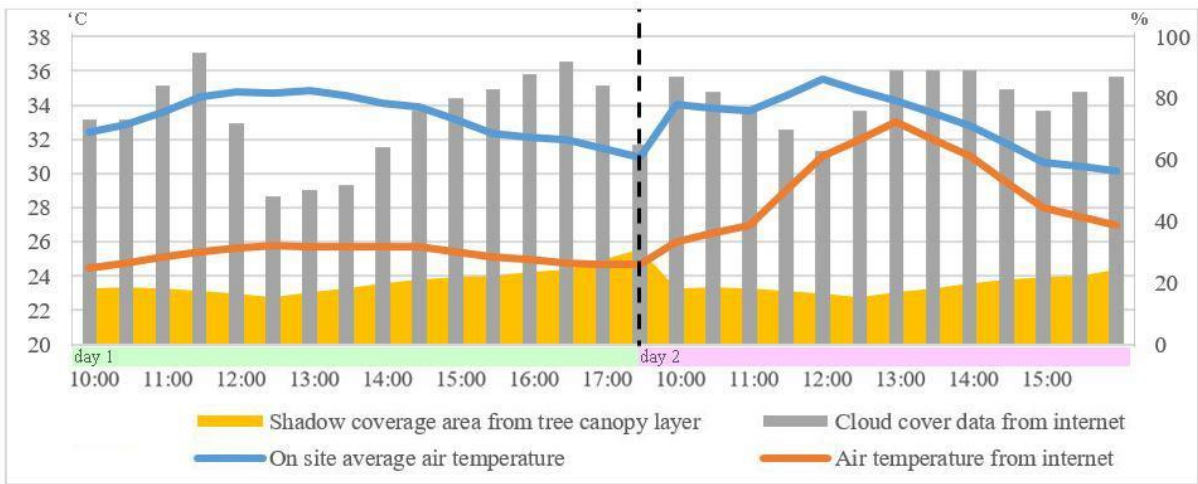
micro-scale air temperature obtained from direct measurements was still 4.7°C higher than the macro-scale air temperature obtained from the internet. The biggest air temperature difference was 10.16°C which occurred at 12 am noon on the second day of measurement. While the smallest temperature difference was 0.75°C which occurred at 4 pm on the first day of measurement. The highest air temperature of Bengkulu City which was recorded from the internet on 2 observed days is similar to the highest air temperature recorded from direct measurements on Pantai Panjang BIM Parking Area, which was 34°C that happened at 10.30 am on the second day of measurement. Spot C of Pantai Panjang BIM Parking Area has the highest average of air temperature based on the direct measurement compared to other spots, which is 32.28°C. While the lowest average of air temperature based on the direct measurement is at spot E, which is 30.5°C. However, at 11 am on the second day of measurement, spot A was the highest air temperature recorded during the two measurement days, which is 35.4°C.

ENVI-met simulation results show that there are various air temperatures distribution at each time of measurement, even though not too significant. At Rumah Pengasingan Soekarno Parking Area (table 2), the higher air temperature is mostly found on the south and west sides of the site, in spite of Palm trees and *Glodokan* trees vegetation that already exists on the south side of the site. The southern area of the site is also adjacent to the main road and the direction of the wind. Air temperature created at 11 am is the lowest air temperature compared to the air temperature at 1 pm and 3 pm. Air temperature differences between 1 pm and 3 pm are not significant. However, lower temperature (marked by a lighter red colour) at 1 pm looks wider than the one at 3 pm. The domination of higher air temperature at each time of simulation occurred at elevation of 0.6 m at 11 am, and at elevation of 1.4 m at 1 pm and 3 pm.

ENVI-met simulation result for Pantai Panjang BIM Parking Area (table 3) shows that the pattern location of higher air temperature (dark red colour) tends to be changeable in each time of measurement. However, it can be seen that the higher air temperature in the middle of the site (spot A) is consistent enough. At 11 am, southwest area of the site is dominated by higher air temperatures. However, higher air temperature is dominant in the middle of the site at 1 pm. Meanwhile, at 3 pm, northeast side is dominated by higher air temperatures. This can happen because there are vegetation surrounding the site. Between the 3 time measurements, it can be seen that the air temperature at 11 pm is higher than the air temperature created at 1 pm and 3 pm. There is only a slight difference in air temperature created at 1 and 3 pm. At each measurement time, it was identified that higher air temperature is dominated at the highest elevation of measurement, which is 1.8 m.

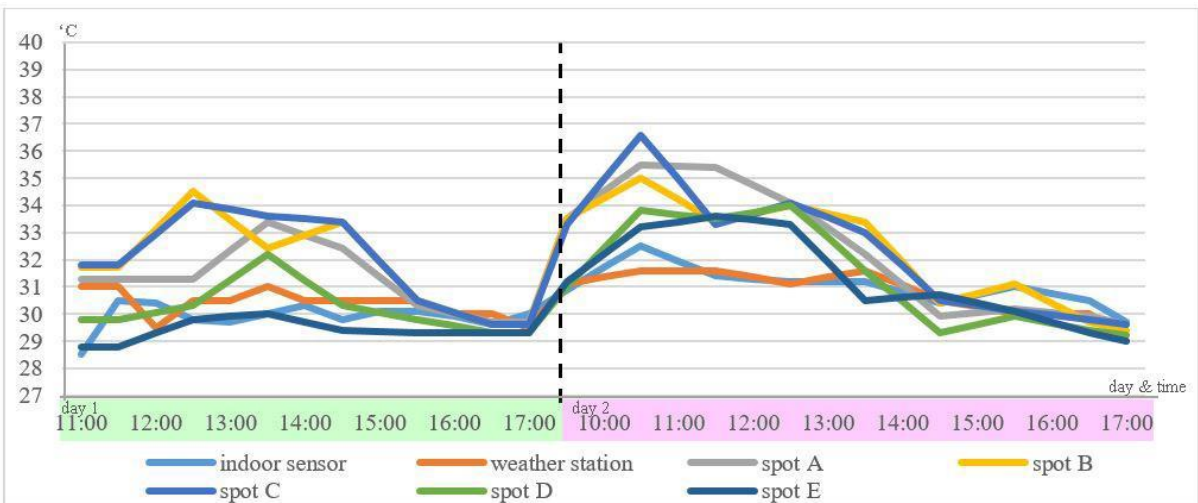


graph a. Temperature data for 2 days observation
location : Rumah Pengasingan Soekarno

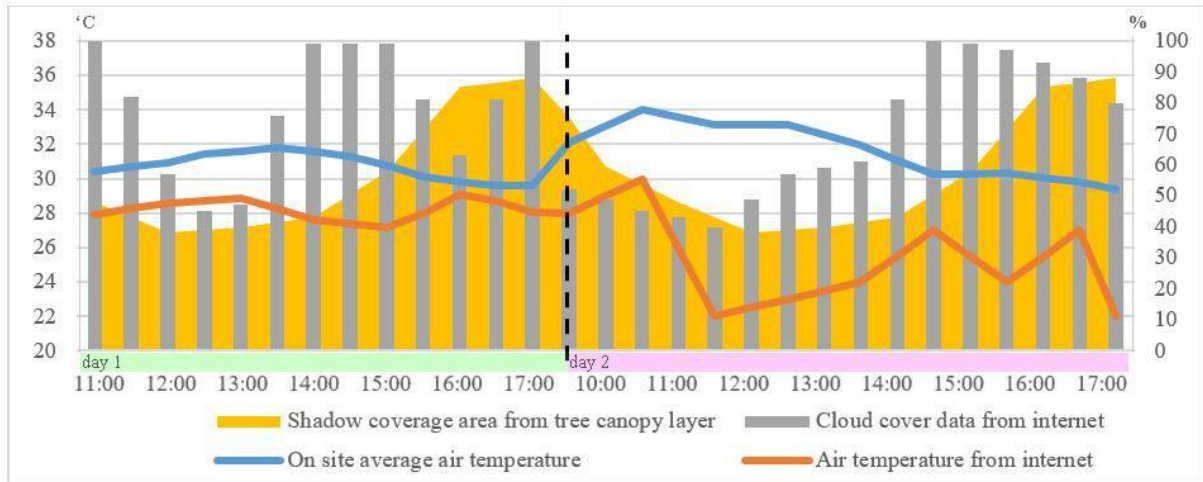


graph b. Average climate data for 2 days observation and shadow percentage from tree canopy layer
location : Rumah Pengasingan Soekarno

Figure 4a. Air temperature result on Rumah Pengasingan Soekarno Parking Area large figure in one column



graph a. Temperature data for 2 days observation
location : Pantai Panjang BIM



graph b. Climate data for 2 days observation and shadow percentage from tree canopy layer location : Pantai Panjang BIM

Figure 4b. Air temperature result on Pantai Panjang BIM Parking Area

Table 2. ENVI-met Simulation result for Rumah Pengasingan Soekarno Parking Area

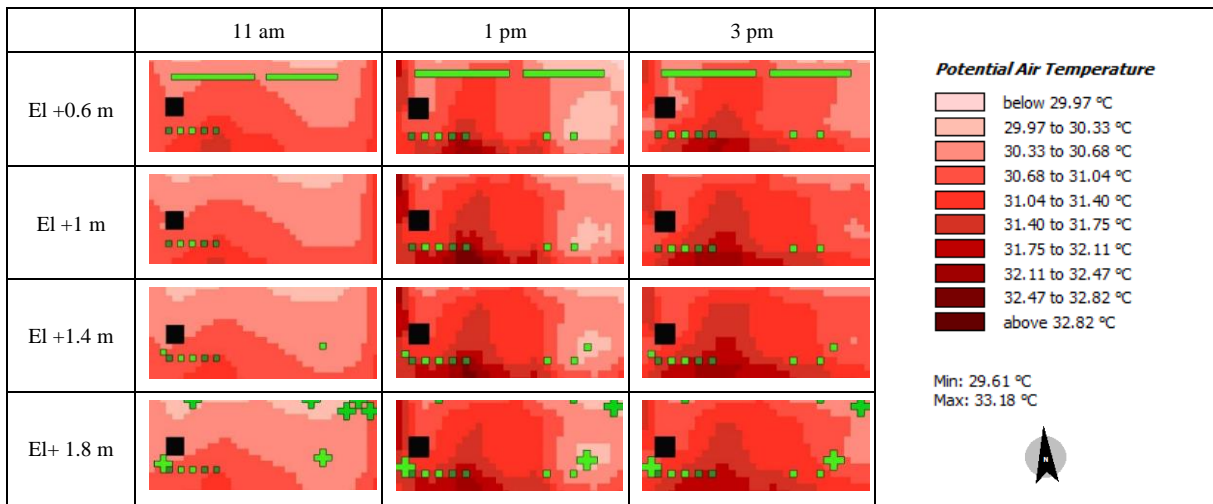
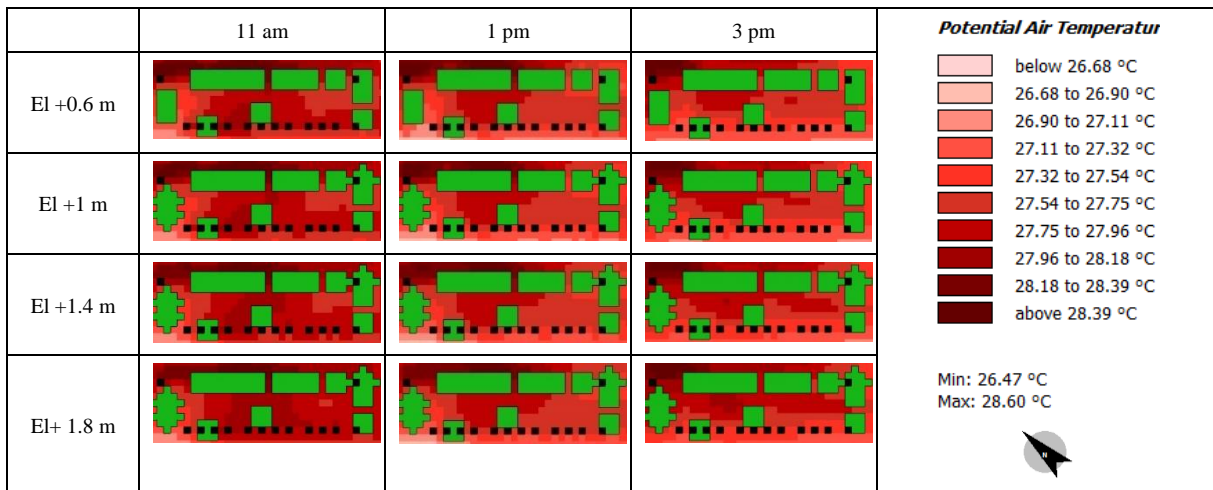


Table 3. ENVI-met Simulation result for Pantai Panjang BIM Parking Area



4. Discussion

Based on the results collected showed on Figures 4a and 4b, the existing air temperature recorded through direct measurement on two observed object studies is higher than the Bengkulu City air temperature recorded on the internet. This means that air temperature on the micro-scale (observed parking area) is warmer than macro-scale (urban scale), especially during the daytime. Thus, these two parking areas with their landscape condition and characteristic are not contributed enough or do not give a meaningful impact on reducing urban air temperatures to mitigate UHI. However, this finding still needs to be confirmed by conducting another research by measuring the air temperature in other urban structure places to compare and get more various and more specific results.

If we look at the shaded coverage area from tree canopy in two observed locations, landscape condition and characteristic from both parking area are not effective in reducing air temperature, especially during the day. The high existing air temperature during the day at the two observation object locations (Figures 3 and 4) can occur due to the lack of existing tree canopy. The difference between air temperatures obtained from direct measurements with air temperature recorded on the internet during the daytime is high. This means that shaded coverage area from the tree canopy is inadequate to shade the parking area from sunny day time. This inadequate shade is in accordance with the results of previous study, where the presence of existing vegetation still does not meet UHI mitigation requirements, especially in providing large trees, arranging space between tree canopy to become closer, and minimizing pavement area. Nevertheless, afternoon air temperature recorded from direct measurements does not have high differences with the air temperature recorded from internet. It means that afternoon shaded area from tree canopy is quite effective in reducing afternoon air temperature.

In Figure 5, it can be seen that Pantai Panjang BIM Parking Area has more shaded coverage area from tree canopy than Rumah Pengasingan Soekarno Parking Area. This high shadow coverage area causes less temperature variation for Pantai Panjang BIM Parking Area, and the air temperature created also tends to be lower than air temperature at Rumah Pengasingan Soekarno Parking Area. The direct measurement results of air temperature in Rumah Pengasingan Soekarno Parking Area (Figure 3) show that the average value of each measurement spot, even the average value of the hottest spot (Spot C) and coldest spot (spot A), does not show huge differences. This means that existing vegetation (Palm tree and *Glodokan* tree) of landscape condition and characteristic in Rumah Pengasingan Soekarno Parking Area does not give a huge impact on lowering air temperature. Besides shadow coverage area from the tree canopy layer, cloud cover conditions also have a role in creating the variation of air temperature. Generally, higher air temperatures will also

be created when the cloud cover is low, just as recorded at 11.30 am – 12.30 am during direct measurements (Figure 4a and 4b).

ENVI-met simulation result shows that the variation of air temperature distribution at Pantai Panjang BIM Parking Area is smaller than the variation of air temperature distribution at Rumah Pengasingan Soekarno Parking Area. It can be seen from dark red colour gradations in the simulation results (Table 2 and Table 3) which are larger than the light red colour gradations. This condition also confirms the findings in Figure 5 which has been discussed in the previous paragraph. In addition, wind flow from south along with smaller crown type of trees also gives an impact on higher air temperature on the southern area of Rumah Pengasingan Soekarno. The small variation of air temperature at Pantai Panjang BIM Parking Area can happen due to the numerous amounts of high LAD tree vegetation given on ENVI-met modeling according to existing conditions.

The air temperature created from the ENVI-met simulation at the two object studies of parking area shows a different pattern. Morning air temperature in Rumah Pengasingan Soekarno Parking Area is lower than the air temperature on the day and in the afternoon. This pattern is different from the air temperature pattern on Pantai Panjang BIM Parking Area, where the air temperature in the morning is higher than the air temperature on the day and in the afternoon. Lower air temperatures in the afternoon at Pantai Panjang BIM Parking Area can occur due to the large amount of high LAD vegetation on the southwest side of the site, which finally gives a big amount of shaded area and becomes more effective in reducing afternoon air temperature. Thus, the addition of tree canopy on Pantai Panjang BIM Parking Area as proposed in previous studies is still needed, especially in the middle of the site which consistently has high temperatures (marked with dark red in the figure in Table 5) to provide enough shade. While the shadow created by low LAD existing vegetation on the south side of Rumah Pengasingan Soekarno Parking Area is less effective, the addition of high LAD tree vegetation in the west and south areas is highly recommended to anticipate the daytime and afternoon heat.

From the previous study, ground material of Rumah Pengasingan Soekarno consists of 88,5% concrete block paving and 11,5% soil. Meanwhile, ground material of Parkir Pantai Panjang BIM consists of 66% concrete block paving, 16% grass, and 18% sand. Simulated air temperature on Rumah Pengasingan Soekarno is higher than simulated air temperature on Pantai Panjang BIM (Figure 6) because ground cover material is dominated by concrete block paving. In addition, based on ENVI-met simulation for both object studies, it shows that the higher the measurement elevation the lower the air temperature. This happened because at lower elevation, there is hard solid ground cover such as concrete block paving which

contributes to heating the parking area due to the radiation from the ground. This indicated that ground cover materials also play an important role for the microclimate temperature. However, according to the figures in Table 2

and Table 3, darker red colour which indicates higher air temperature, was dominant at the higher level. It shows that the existing tree canopy is effective in lowering air temperature at human level of height.

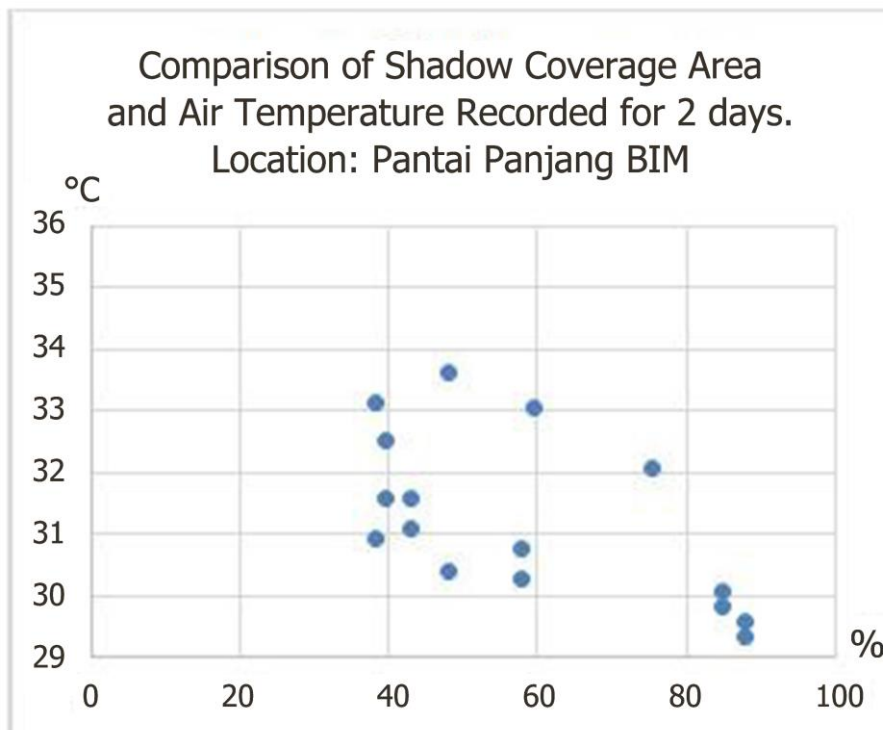
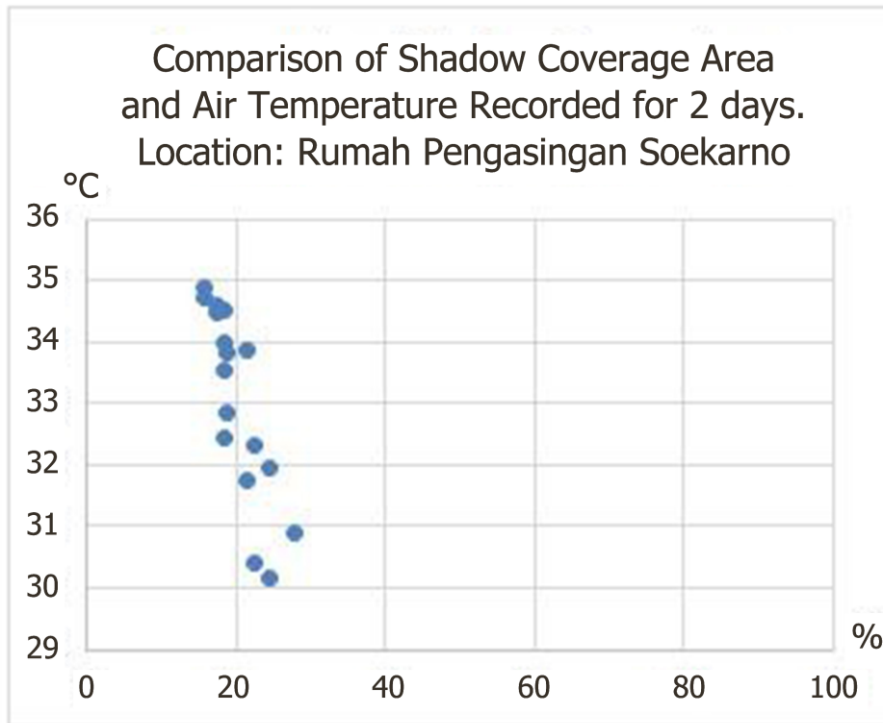


Figure 5. Comparison of shadow coverage area with air temperature recorded on both site

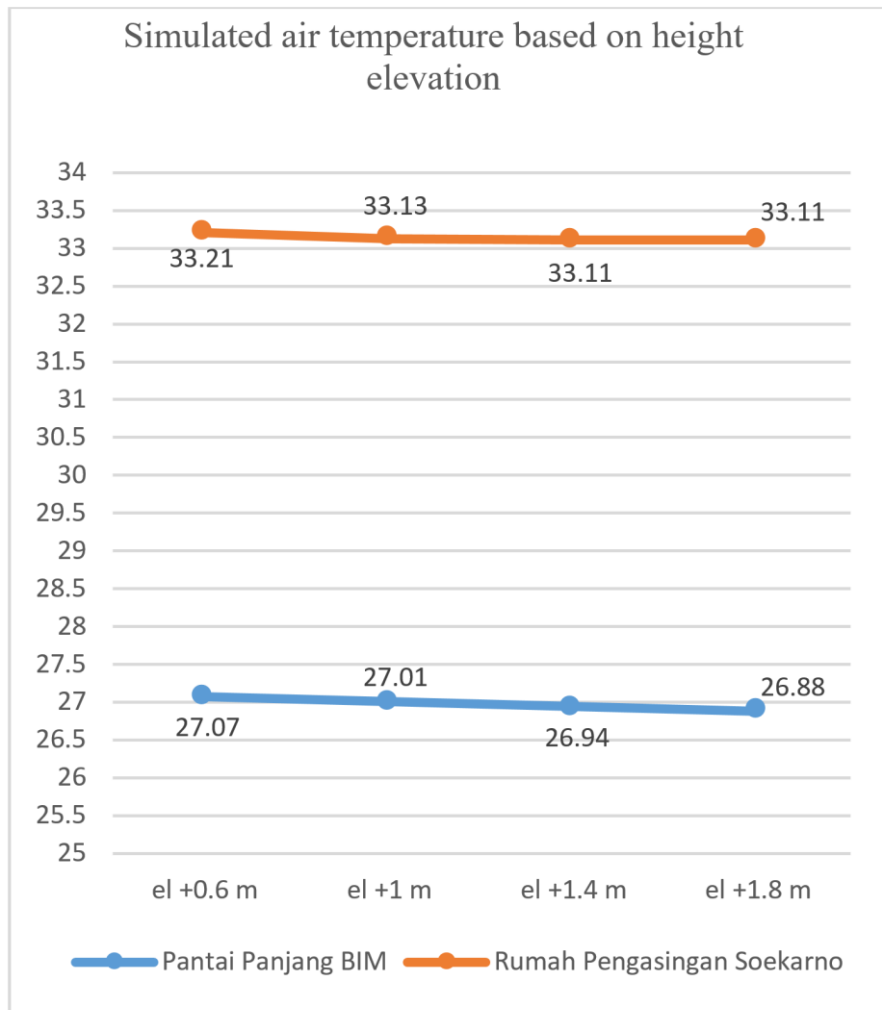


Figure 6. Simulated air temperature based on height elevation

Output images from ENVI-met simulation result are slightly different from the existing air temperature collected from direct measurement at each measurement spot and by the shaded area created by tree canopy. For example, spots A, C, and E in Rumah Pengasingan Soekarno Parking Area should be the spot with higher air temperature due to lack of shaded area from tree canopy. Direct measurement shows that spot C is having the highest average of air temperature, which is still aligned with the previous idea. However, direct measurement also shows that spot A is having the lowest average of air temperature, which contradicts the first idea. Moreover, ENVI-met simulation result shows that spot C area is mostly identified as having lower air temperature (light-red in the figure of Table 2), even though spot A is identified as being consistent enough to have a higher temperature in the morning to evening (dark red colour in the image of Table 2). The distribution of air temperature in certain spots from ENVI-met simulation at Pantai Panjang BIM Parking Area is fairly consistent with the results of direct measurement. For example, both results show that spot A has consistency at higher temperatures, while spot E has consistency at

lower temperatures. Even though there are already small trees that exist near spot A on the Pantai Panjang BIM Parking Area, the created shade from tree canopy is less effective. In the end, the description of air temperature pattern from ENVI-met simulation result still needs further research to improve the quality of the result.

To improve parking area ability in lowering the air temperature, some recommendations that can be applied are tree arranging, considering wind patterns optimum proportion between hard ground cover material and soft green cover by reducing paving concrete block or changing into grass block, and implementing shading structure where the tree cannot be provided. In detail, incorporating water features, and adding larger crown with high LAD trees in the western and southern areas to increase tree coverage, are recommended to be given for Rumah Pengasingan Soekarno Parking Area. Whereas for Pantai Panjang BIM Parking Area, it needs to add a combination of multi-layered vegetation. Another important thing is rearrangement of parking circulation and placement of tree vegetation to not interrupt the function of both parking area.

5. Conclusions

Based on the results from direct measurement, landscape of both observed parking areas does not give a very effective impact on mitigating UHI in Bengkulu City. The vegetation in Rumah Pengasingan Soekarno Parking Area does not significantly reduce the air temperature, while the vegetation in Pantai Panjang BIM Parking Area effectively provides shade in the afternoon only. There is also a correlation between shadow coverage from tree canopy and cloud cover in reducing air temperature, where the higher shadow coverage and cloud cover will lower the air temperature. In addition, site context such as wind flow direction, types of smaller tree crown and smaller LAD, and hard ground cover material also gives an impact on increasing the temperature.

Further research that needs to be done is to expand measurement periods into more days and at different months along the year, increase measurement points, and utilize thermal sensing camera. Direct measurement of air temperature in another characteristic of places of urban structure can also be conducted to find out the potential of parking area in reducing urban air temperature in more details. Then, proposed landscape design as recommended also needed to be implemented in further ENVI-met simulation as a pilot project of effective UHI mitigation strategies in Bengkulu city.

Acknowledgements

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REFERENCES

- [1] L. Tursilowati, "Urban Heat Island Dan Kontribusinya Pada Perubahan Iklim Dan Hubungannya Dengan Perubahan Lahan," in *Prosiding Nasional Pemanasan Global dan Perubahan Global - Fakta, Mitigasi, dan Adaptasi*, 2002.
- [2] U.S. Environmental Protection Agency, "Urban Heat Island Basics." In: *Reducing Urban Heat Islands: Compendium of Strategies*, 2008.
- [3] Meteoblue, "Meteoblue," [Online]. Available: https://www.meteoblue.com/en/climate-change/bengkulu_indonesia_1649150. [Accessed August 2022].
- [4] J.-i. G. Tsutsumi, A. Ishii and T. Katayama, "Quantity Of Plants And Its Effect On Local Air Temperature In An Urban Area," in *Fifth International Conference on Urban Climate-5 Proceedings*, Lodz, 2003.
- [5] D. Rosleine and A. Irfani, "Fungsi Taman Kota untuk Mitigasi Dampak Urban Heat Island di Kota Bandung," *Jurnal Sumberdaya HAYATI*, vol. 6, no. 1, pp. 1-7, Juni 2020.
- [6] W. Liao, T. Hong and Y. Heo, "The effect of spatial heterogeneity in urban morphology on surface urban heat islands," *Energy and Buildings*, vol. 244, 2021.
- [7] A. T. Esfehankalateh, J. Ngarambe and G. Y. Yun, "Influence of Tree Canopy Coverage and Leaf Area Density on Urban Heat Island Mitigation," *Sustainability*, vol. 13, 2021.
- [8] J. Ngarambe, M. Santamouris and G. Y. Yun, "The Impact of Urban Warming on the Mortality of Vulnerable Populations in Seoul," *Sustainability*, vol. 14, 2022.
- [9] T. Simonds, "The Benefit of Trees in Parking Lots: Analysis of Six New England Cities and Recommendations for Better Development," Plymouth State University, New Hampshire, 2018.
- [10] L. S. Tatura, "Analisis Penataan Ruang Parkir Pasar Central Kota Gorontalo," *Jurnal Sainstek*, vol. 07, no. 1, 2013.
- [11] V. R. Sari and R. Hidayah, "Kajian Vegetasi Pada Area Parkir Kampus," *ECOTROPHIC : Jurnal Ilmu Lingkungan (Journal of Environmental Science)*, vol. 12, no. 2, p. 125 – 131, November 2018.
- [12] Elmira Jamei, Priyadarsini Rajagopalan, Mohammad mehdi Seyedmahmoudian and Yashar Jamei, "Review on the impact of urban geometry and pedestrian level greening on outdoor thermal comfort," *Renewable and Sustainable Energy Reviews*, vol. 54, pp. 1002-1017, 2016.
- [13] ENVI_MET, *Decoing Urban Nature*, Essen: ENVI_MET GmbH, 2017.
- [14] I. Langer, S. Sodoudi and U. Cubasch, "Using the ENVI-MET program to simulate the micro climate in new Town Hashtgerd," in *The international conference on Computing, Networking and Digital Technologies (SDIWC)*, 2012.
- [15] P. Febriarto, "Tata Hijau Pada Ruang Jalan Menuju Kenyamanan Termal Iklim Mikro Studi Kasus: Jalur Pedestrian, Penggal Jalan Slamet Riyadi Di Surakarta," *Jurnal Arsitektur, Kota dan Permukiman (LOSARI)*, vol. Vol 1, no. No 2, pp. 111-116, Agustus 2016.