International Journal of Architecture and Urbanism Vol. 09, No. 02 (2025) 285 – 297

International Journal of Architecture and Urbanism

Journal homepage: https://talenta.usu.ac.id/ijau

Urban Heat Island Appraisal by Historical Building: A Case Study of Gunongan and Kandang in Banda Aceh City

Laina Hilma Sari*[1], Brit Anak Kayan[2], Zahriah Zahriah[1], Zulfikar Taqiuddin[1]

[1]*Architecture Department, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh, 23231, Indonesia*
[2]*Department of Building and Surveying, Universiti Malaya, 50603 Kuala Lumpur, Malaysia*

*Corresponding Author: laina_hilma@unsyiah.ac.id

ARTICLE INFO

Article history:
Received 21-11-2024
Revised 19-03-2025
Accepted 27-05-2025
Available online 08-08-2025

E-ISSN: 2622-1640
P-ISSN: 2622-0008

How to cite:
Sari L H, Kayan B A, Zahriah Z, Taqiuddin Z.. Urban Heat Island Appraisal by Historical Building: A Case Study of Gunongan and Kandang in Banda Aceh City. International Journal of Architecture and Urbanism. 2025. 9(2):285-297.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International.
http://doi.org/10.32734/ijau.v9i2.22356

ABSTRACT

Urban Heat Island (UHI) remains a persistent challenge, primarily driven by the use of dark materials such as asphalt, steel, and brick in urban environments. Although these materials dominate, heritage buildings, particularly in city centers, continue to exist throughout urban areas. This research focuses on the thermal impact of the heritage buildings Gunongan and Kandang in Banda Aceh, Indonesia. These structures, made from limestone and finished with white surfaces, are situated close to the city center, a location where UHI effects are commonly observed. This study evaluates the thermal performance of Gunongan and Kandang to determine their potential contribution to or mitigation of the UHI effect. Data was collected over two days in June 2022, measuring air temperature (Ta), relative humidity (RH), air velocity (Av), globe temperature (Tg), and surface temperature (Ts). The results revealed that the majority of the Ts of Gunongan and Kandang were lower than the surrounding air temperature, with the exception of the dark brick surfaces within Kandang, where Ts reached up to 58°C. The outdoor thermal comfort of the area was also assessed through Physiologically Equivalent Temperature (PET), which ranged from 34°C to 38°C, categorized as warm. The findings indicate that the white limestone surfaces of the buildings were effective in maintaining a lower Ts than Ta, contributing to the reduction of the UHI effect. Additionally, the study shows that shading plays a significant role in lowering urban temperatures as indicated by the mean radiant temperature (Tmrt), derived from the collected thermal data.

Keywords: buildings, performance, surface, temperature, thermal

1. Introduction

The Urban Heat Island (UHI) effect continues to be a significant concern, contributing to uncomfortable urban environments due to the accumulation of excess heat in cities. This phenomenon is primarily attributed to urban surfaces such as asphalt, concrete, steel, and brick, which absorb and retain heat, raising ambient temperatures. This leads to an increase in the demand for cooling energy in buildings, exacerbating environmental degradation both locally and globally[1]. UHI effects can elevate cooling costs by 20–100% [2] and are linked to various health risks, including thermal discomfort, respiratory problems, and increased mortality rates[3]. The materials used in construction play a pivotal role in the intensity of UHIs due to their specific thermal properties[4]. In response, adopting materials with high reflectivity and thermal resistance has been proposed as an effective solution to mitigate UHI impacts[5].

Building materials, commonly found in urban areas such as concrete, brick, and metals, are known for their high thermal mass, meaning they absorb significant heat during the day and release it slowly at night, which exacerbates UHI [6]. However, historical buildings, often constructed with locally sourced materials, present an opportunity to explore their potential for reducing UHI effects. These buildings typically use materials that are more in harmony with the local environment, offering insights for developing low-carbon cities [7].

Gunongan and Kandang are two historical structures located in Banda Aceh, Indonesia, dating back to the early 1600s, during the reign of Sultan Iskandar Muda. Constructed primarily from limestone and coated with white surfaces, these buildings are situated near the city center, a region prone to UHI. These heritage buildings, despite being made from traditional materials, may have a significant role in moderating the surrounding urban temperature. As seen in Figure 1, Gunongan (a) is an open structure with ten sides and three levels, built from stone, sand, brick, and lime mortar, with intricate ornamentation on the corners. In contrast, Kandang (b) is a square-shaped structure surrounded by a white limestone wall, which houses the grave of Sultan Iskandar Thani. These structures have become iconic landmarks of Banda Aceh and, due to their unique architectural features, might play an important role in influencing the local microclimate. Therefore, this study aims to evaluate the thermal performance of Gunongan and Kandang, determining whether they contribute to or mitigate the UHI effect.

(a) (b)

Figure 1 Gunongan (left) and Kandang (right)

Urban Heat Island and the Impact to Banda Aceh City

Urban Heat Islands (UHIs) are primarily a result of urban morphology, such as building density and street design [8][9]. Research has shown that various materials used in urban environments significantly influence the temperature of both surfaces and the air in urban canyons [10]. Key contributors to UHI include (i) anthropogenic heat and various other heat sources, (ii) the heat absorbed and reradiated by large urban construction materials, and (iii) insufficient vegetated areas [11]. The urban landscape alters the natural balance of heat, moisture, and airflow by generating significant heat from buildings, surfaces, and human activities, contributing to an increase in air pollutants [12]. The consequences of UHIs include greater cooling energy demand, discomfort due to elevated temperatures, increased ground-level ozone, and more widespread health issues [11].

In this study, Banda Aceh city serves as a case study. Located 35 meters (115 feet) above sea level, with a population of approximately 252,899[13], the city has experienced substantial urban expansion. Between 1998 and 2018, the built-up area grew by 100.32%, leading to higher urban temperatures (Figure 3a). This expansion is driven by urbanization, particularly the increase in residential areas (Figure 2) [14]. The urban environment absorbs and retains heat, which significantly contributes to the UHI effect. This urban development has been shown to directly influence the rise in UHI [15]. As Figure 3b illustrates, temperatures in the built-up areas of Banda Aceh are 35-38°C, which is approximately 9°C higher than in rural areas [16]. Although the heritage site, including Gunongan and Kandang, constitutes a small portion of the city, it is situated near key commercial and service areas, meaning the UHI impact is relevant even for these historical structures. Therefore, this issue warrants urgent attention.

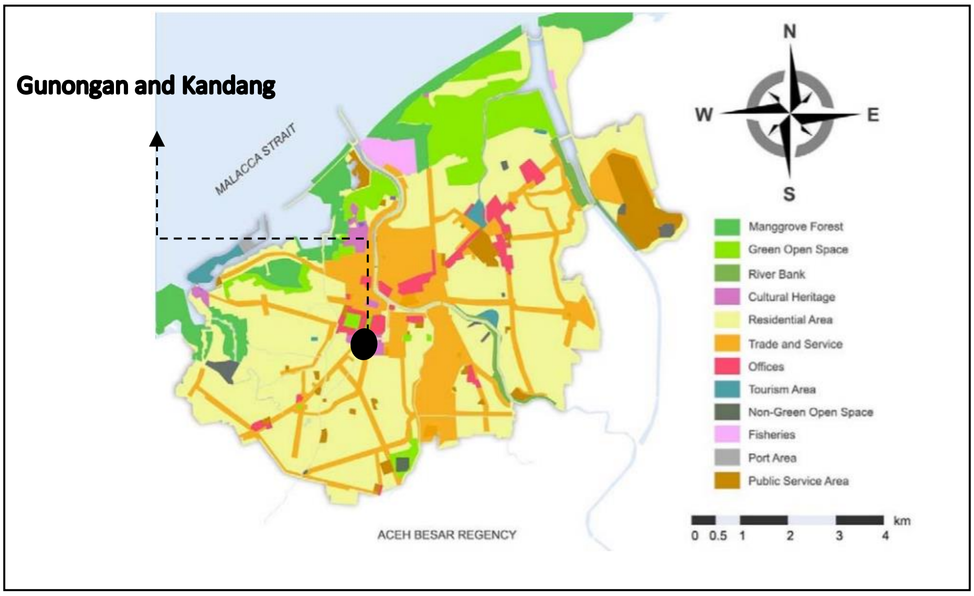


Figure 2 The land use of Banda Aceh city and the position of Gunongan and Kandang within the city [14]

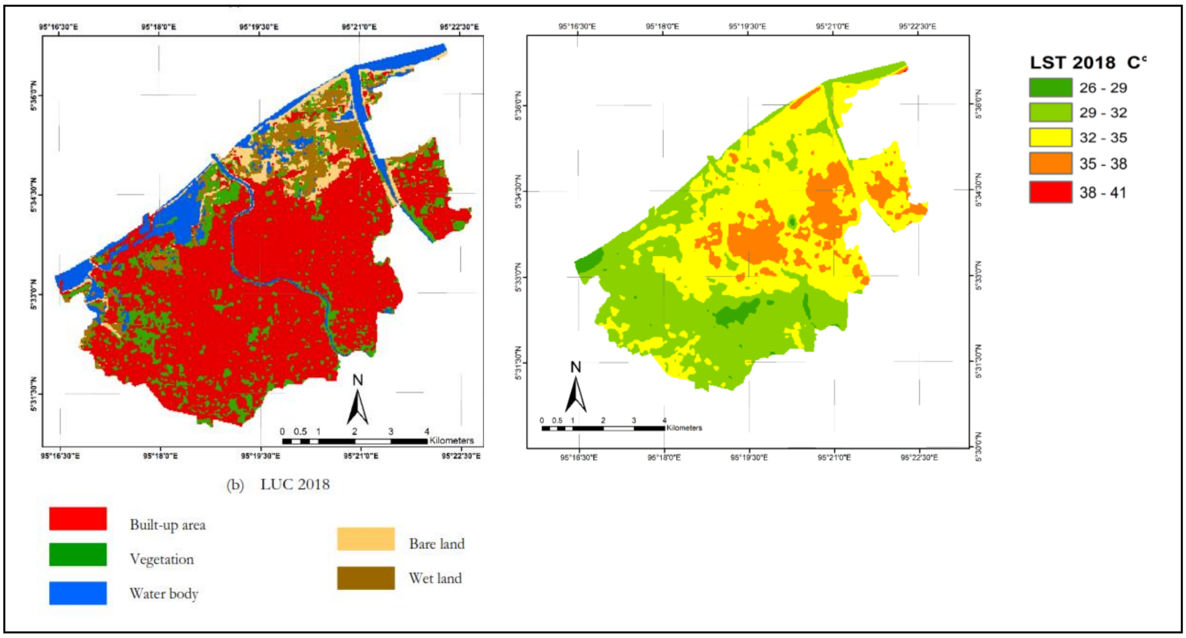


Figure 3 The built-up area with the urban temperature [16]

Heritage Building and Urban Heat Island

Urban Heat Island (UHI) effects are exacerbated by climate change, negatively impacting the environment, especially heritage buildings [2]. Cultural heritage has increasingly been recognized for its potential to contribute to addressing climate change, a role that intersects with UHI impacts [17]. The excessive UHI effects can pose a threat to historical structures, highlighting the need for strategies to mitigate these effects [18]. At the same time, the materials used in heritage buildings also influence the surrounding environment. Preserving these buildings is vital for the identity of a community and contributes significantly to its social and psychological well-being [19].

Therefore, it is crucial for stakeholders, particularly government bodies, to assess the thermal dynamics of the environments surrounding these historical structures. UHIs lead to thermal weathering of materials, which is further intensified by variations in cloud cover and atmospheric dust. Reduced cloud cover and dust levels increase both the diurnal temperature range and the amount of solar radiation hitting exposed surfaces, leading to greater thermal stress on historical buildings [19]. To mitigate the UHI phenomenon, urban strategies must focus on increasing green spaces, employing highly reflective and thermally resistant materials, reducing anthropogenic heat sources, and enhancing wind flow in urban canopies [2]. However, such solutions are challenging to implement in cities with limited space for greenery, and in conservation areas, these measures are further restricted by the need to preserve the historical integrity of heritage sites.

2. Method

Gunongan and Kandang are located in the central area of Banda Aceh, Indonesia, surrounded by major roads and the Krueng Aceh River (Figure 4). The study conducted quantitative research by evaluating the outdoor thermal conditions in the vicinity of these heritage structures. Several environmental parameters were measured, including Air Temperature (Ta) in °C, Globe Temperature (Tg) in °C, Surface Temperature (Ts) in °C, Relative Humidity (Rh) in %, and Air Velocity (Va) in m/s (Table 1). Data collection was done across 19 different points within the Gunongan and Kandang area. Additionally, surface temperature measurements were recorded using infrared thermometers, and thermal images were taken of the building surfaces to further assess the thermal conditions (Figure 4).

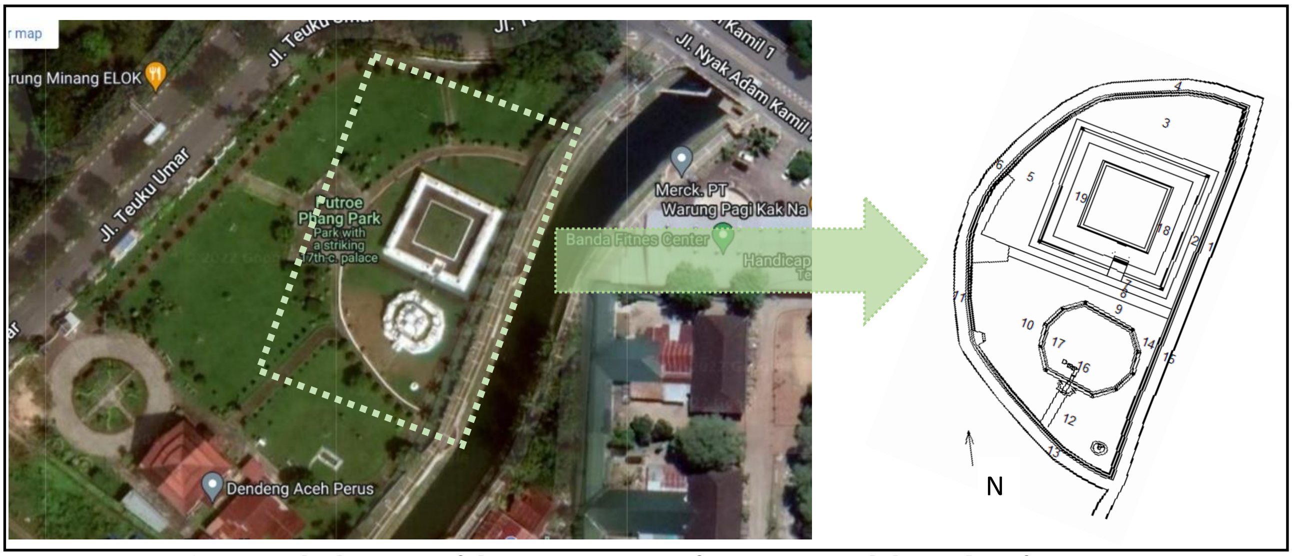


Figure 4 The location of the measurement of environmental thermal performance

Table 1 Environmental parameters measured in the study

Parameter	Tools	Position of Tools
Air Temperature (Ta)^{0}C	WBGT meter	Outside of the building structure (Figure 4)
Globe Temperature (Tg) ^{0}C		
Air Velocity (Va) m/s		
Surface Temperature (Ts) ^{0}C	Infrared Thermometer Krisbow KW06-280	The building structures (Figure 5 and Figure 6)
Image of surface temperature	Infrared Camera	

Urban Heat Island (UHI) refers to the temperature difference observed between urban and rural areas [20]. In this study, Gunongan and Kandang are located in the central part of Banda Aceh, close to key commercial, office, and service areas. Figure 3 illustrates that the temperature in these areas ranges from 35°C to 38°C, which is about 9°C higher than in rural regions. This temperature disparity confirms the presence of UHI effects. However, rather than focusing on the difference between urban and rural temperatures, this study examined the surface temperature (Ts) of the structures and surrounding areas. The goal was to assess the impact of Gunongan and Kandang on the local environment. Surface temperature measurements were obtained using an infrared thermometer. This device works by focusing infrared light emitted from an object onto a detector known as a thermopile. When infrared radiation reaches the thermopile, it is absorbed and converted into heat, which produces a voltage proportional to the energy. This voltage is then used to determine the temperature, which is displayed on the screen.

This study demonstrates the existence of the Urban Heat Island (UHI) effect and the discomfort in the outdoor thermal environment, evaluated through the Mean Radiant Temperature (Tmrt). The calculations were based on collected data, including air temperature (Ta), globe temperature (Tg), and air velocity (Va) using Equation 1. Tmrt is determined by surface temperature and is influenced by the building's enclosure performance. As the quality of surfaces improves, they absorb more heat, leading to a higher mean radiant temperature. Higher Tmrt in urban settings results in more discomfort, contributing to the intensification of the UHI effect. The calculation of Tmrt follows Belding's formula [21]:

$$Tmrt = Tg + 0.24Va \times 0.5\,(Tg - Ta) \tag{1}$$

As Gunongan and Kandang are located in a tourist area, where visitors explore the buildings, their surrounding outdoor thermal comfort was also assessed using the Physiologically Equivalent Temperature (PET). PET, a crucial metric for evaluating outdoor thermal comfort, was calculated using Rayman software, taking into account Ta, Tg, Rh, and Va. The measurements were recorded over two days, June 12th and 13th, 2022, from 8 am to 5 pm, at hourly intervals. The results were categorized based on the PET scale (Table 2).

Table 2. PET range [23]

PET (°C)	Thermal Sensation
<14	Very cold
14-18	Cold
18-22	Cool
22-26	Slightly Cool
26-30	Neutral
30-34	Slightly warm
34-38	Warm
38-42	Hot
>42	Very hot

In this research, thermal images of the building structures were captured using an infrared camera, which detects and measures the infrared radiation emitted by objects. The camera then converts this infrared data into an electronic image that represents the apparent surface temperature of the object being analyzed. The thermal images were taken at various locations to showcase the temperature differences across the surfaces of the building, grass, and pavement (Figures 5 and 6).

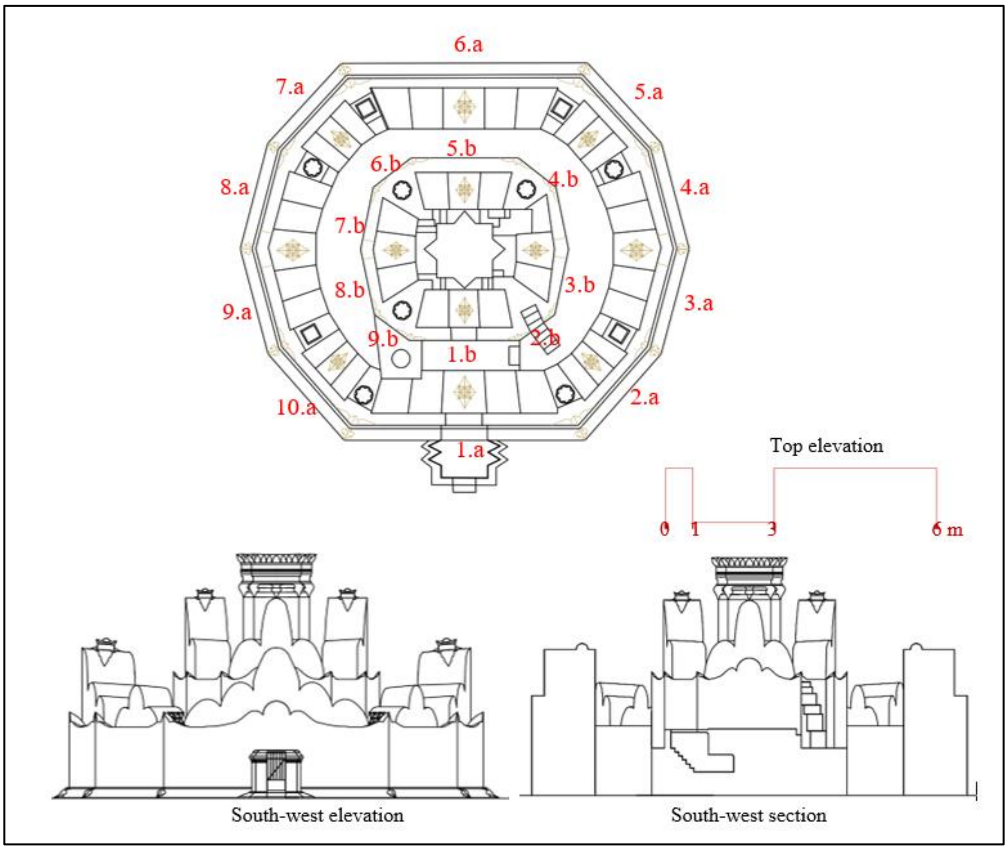


Figure 5 The Structure of Gunongan and the position of the measurement of the surface temperature

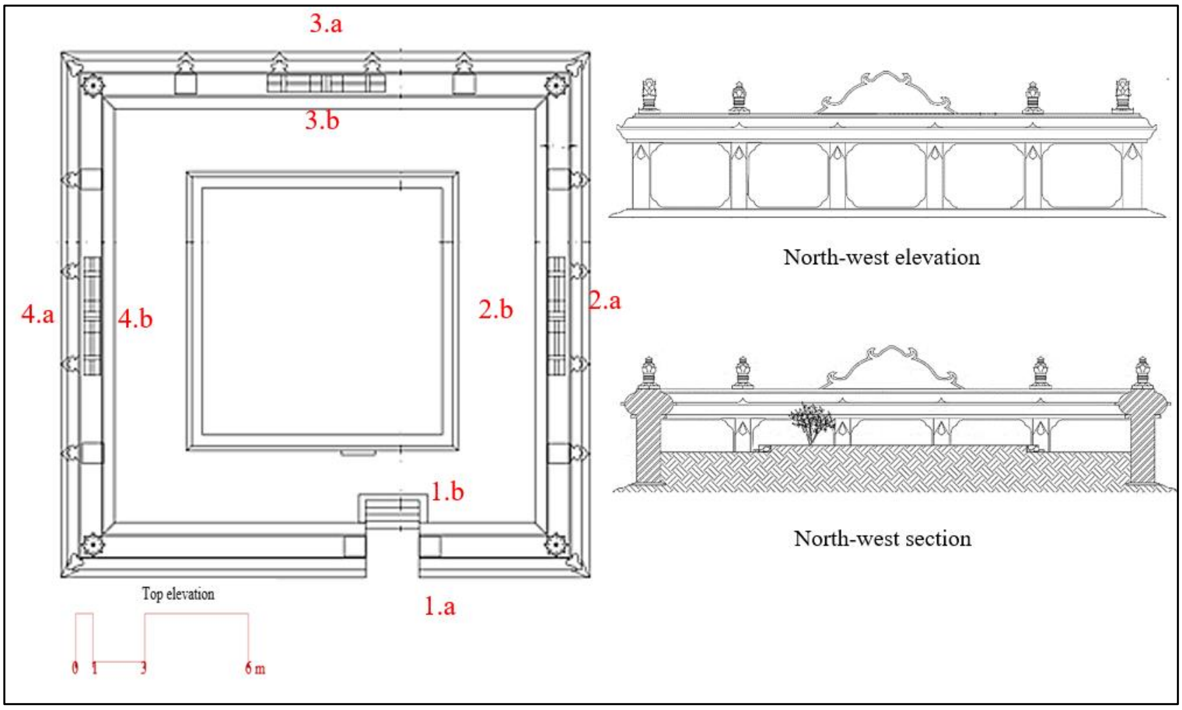


Figure 6 The structure of Kandang and the position of the measurement of the surface temperature

3. Result and Discussion

Environmental Thermal Performance

The initial focus of this study was to assess the surface temperature of Gunongan and Kandang, as the surface temperature plays a crucial role in the development of Urban Heat Island (UHI) effects. The recorded surface temperatures (Ts) of both structures over two days are shown in Figure 7. On Day 1, measurements began at

14:00 due to missing data in the morning, while on Day 2, data collection took place from 09:00 to 17:00. On Day 2, the surface temperature of both buildings increased from 11:00 to 16:00. Most surfaces showed Ts values lower than the ambient air temperature, with many remaining below 32°C. However, certain surfaces, such as Gunongan 3.a and Kandang 2.1, which face east and northeast, respectively, exhibited higher Ts due to direct sunlight exposure during the morning hours (Figure 8). Similarly, surfaces facing the west and southwest, such as Gunongan 10.a and Kandang 4.a, experienced elevated Ts levels in the afternoon due to sunlight exposure (Figure 9). Additionally, the brick surfaces inside Kandang were recorded, and these surfaces exhibited significantly higher Ts, reaching temperatures as high as 58°C, surpassing the ambient air temperature.

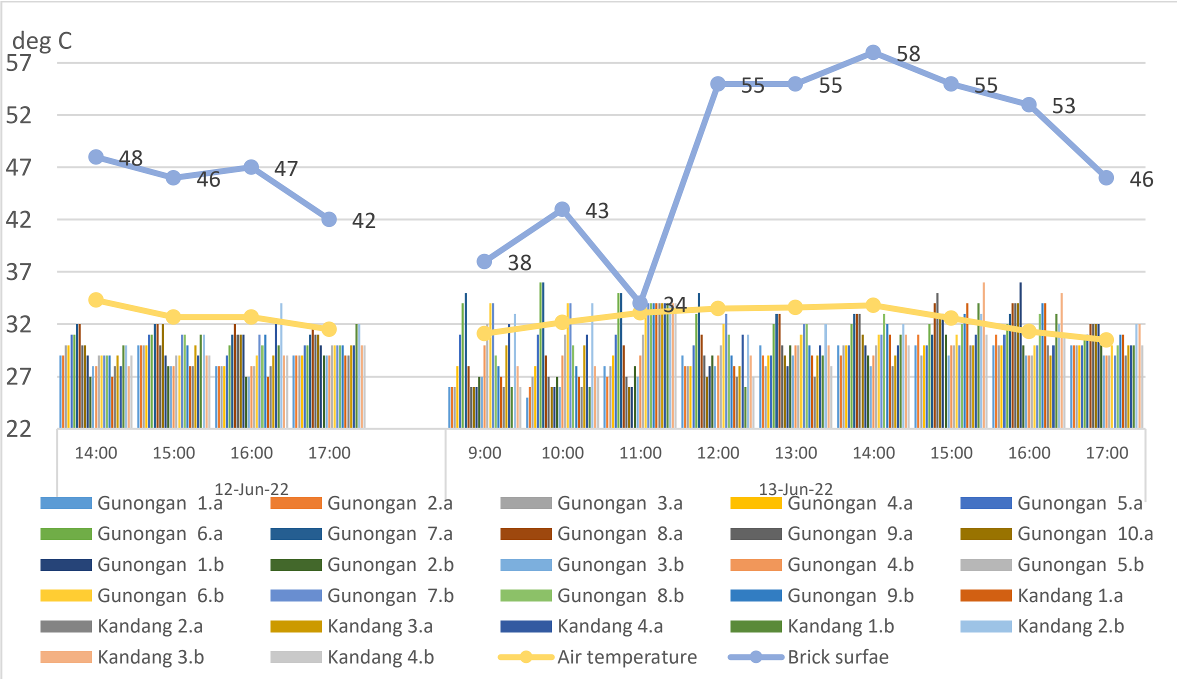
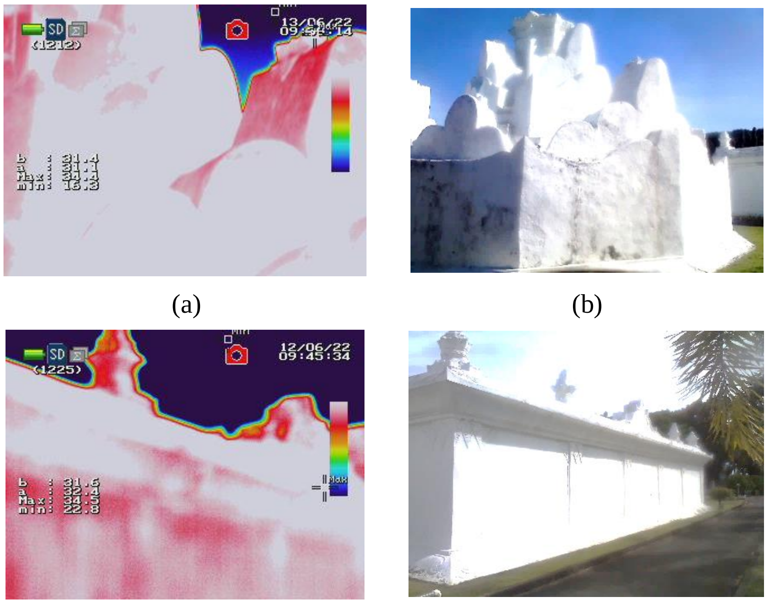


Figure 7 The environmental thermal performance of Gunongan, Kandang and the surroundings

Figure 7 illustrates that the limestone material used in the construction of Gunongan and Kandang effectively helps in maintaining surface temperatures lower than the surrounding air temperature. The white surfaces of both Gunongan and Kandang play a significant role in mitigating the Urban Heat Island (UHI) effect. White surfaces are known to absorb less heat and reflect more sunlight, which scientifically contributes to reducing heat in the surrounding environment[22]. Recent studies have shown that increasing the reflectivity of surfaces can greatly impact temperature reduction, not only in urban areas but also in rural settings[24]. In contrast, areas with darker materials absorb as much as 95% of solar radiation, leading to increased heat absorption and consequently higher urban temperatures. This is clearly demonstrated in Figure 7, where the dark brick pavement exhibits the highest surface temperature (Ts) of up to 58°C, while the air temperature (Ta) is 36°C. The elevated Ts is not only due to the angle of the radiation striking the horizontal surface but also because of the high thermal mass of the brick, which absorbs and retains heat.

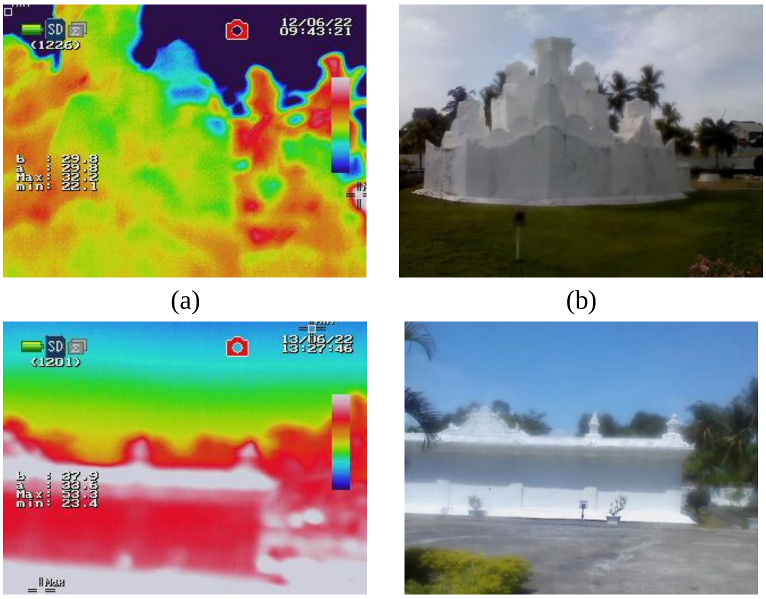
Figure 8 presents thermal images of the eastern sides of Gunongan and Kandang, which are exposed to direct morning sunlight. At 09:45, the surface temperature of Gunongan reaches 34.4°C, while Kandang's surface temperature is 34.5°C. In contrast, the western sides of the structures have significantly lower surface temperatures, approximately 32°C (Figure 9). This supports the observation in Figure 7 that direct sunlight exposure results in higher surface temperatures.

This study also highlights the importance of shading in lowering surface temperatures. Figure 10 demonstrates that the surface temperature of the pavement peaks at 53.6°C at 13:27, but drops to 43.5°C by 17:28 when the sun sets. While the grass surface remains cooler than the pavement, there is a noticeable difference in the surface temperature between shaded and unshaded areas of grass. The shaded grass registers at 30.9°C, while the unshaded grass shows a temperature of 42.4°C (Figure 11).



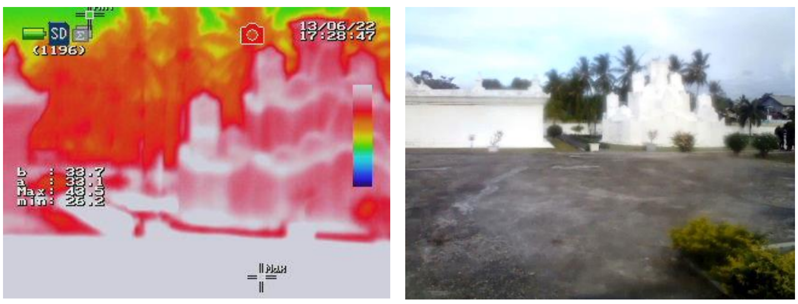
(a) (b) (c) (d)

Figure 8 The thermal image of Gunongan dan Kandang façade facing east in the morning



(a) (b) (c) (d)

Figure 9 The thermal image of the western side of the Gunongan in the morning



(a) (b)

Figure 10 The thermal image of the Gunongan, Kandang and the surroundings

(a) (b)

Figure 11 The themal image of the surrounding grass surface (Loc.5)

The next analysis involves the Mean Radiant Temperature (Tmrt), which is calculated using Equation 1. As discussed earlier, Tmrt depends on the values of Tg (Globe Temperature), Ta (Air Temperature), and Va (Air Velocity). Figure 12 illustrates that Tmrt is very close to Tg in most instances. However, specific locations within the Gunongan and Kandang area show variations. For instance, locations 1 and 17 have lower Tmrt values compared to other areas. Location 1, situated to the southeast of Kandang, benefits from shading provided by nearby palm trees, while location 17, located centrally in Gunongan, experiences shading due to the structure itself (Figure 13). The highest Tmrt is recorded at location 10, which has a hard, unshaded surface, followed by location 5, where grass is exposed to sunlight without shading.

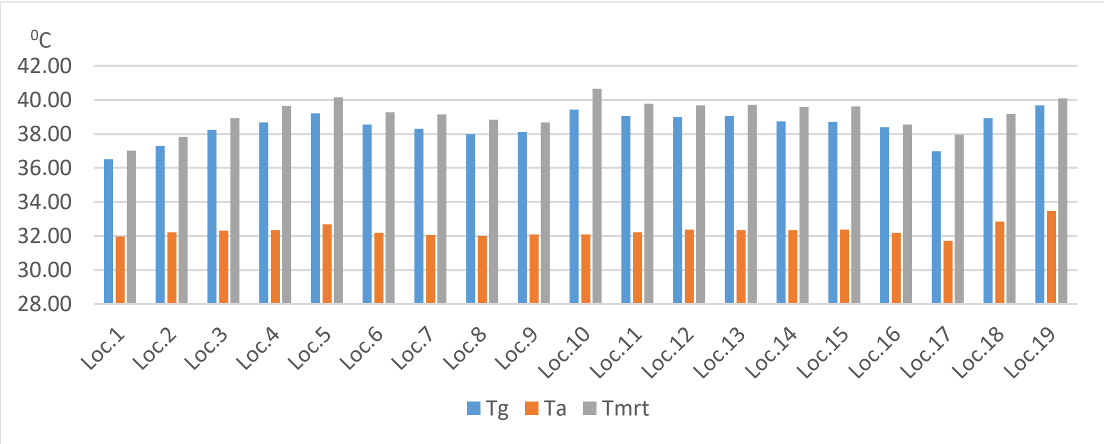


Figure 12 The value of Tg, Ta, and Tmrt of the surrounding environment of Gunongan and Kandang

Figure 13 The center of Gunongan

Outdoor Thermal Comfort

The evaluation of outdoor thermal comfort was also conducted in this study. Although no significant relationship was found between Urban Heat Island (UHI) mitigation and the improvement of thermal comfort, a stronger correlation is observed when considering surface temperatures (Ts) as a key factor in UHI mitigation. Lower surface temperatures are associated with improved thermal comfort [25]. Surface temperature influences the Mean Radiant Temperature (Tmrt), which is linked to thermal comfort and is assessed using the Physiologically Equivalent Temperature (PET). PET values are calculated with the Rayman

1.2 software. In addition to air temperature (Ta), globe temperature (Tg), air velocity (Va), relative humidity (Rh), and Tmrt, the amount of cloud cover and global solar radiation are also important factors. These parameters were obtained from the climatology office of Banda Aceh. The cloud cover in the city ranges from 0.1 to 1.8 octas, while solar radiation levels vary between 450 and 1000 W/m².

In this study, the average PET (Physiologically Equivalent Temperature) values fell within the 'warm' category. The lowest recorded PET was in the 'slightly warm' range, while the highest value reached the 'hot' range. Only a few locations, such as Loc. 8, 16, and 17 (Figure 14), had PET values that were in the 'neutral' range. PET is an important indicator of how humans perceive thermal comfort, making it a valuable measure for understanding how visitors experience the thermal environment. The area under study lacks large trees, and most of the surrounding surfaces are hard pavements and thin grass, with minimal shading. This lack of adequate shading likely contributes to the slightly elevated Tmrt and PET values observed in these areas.

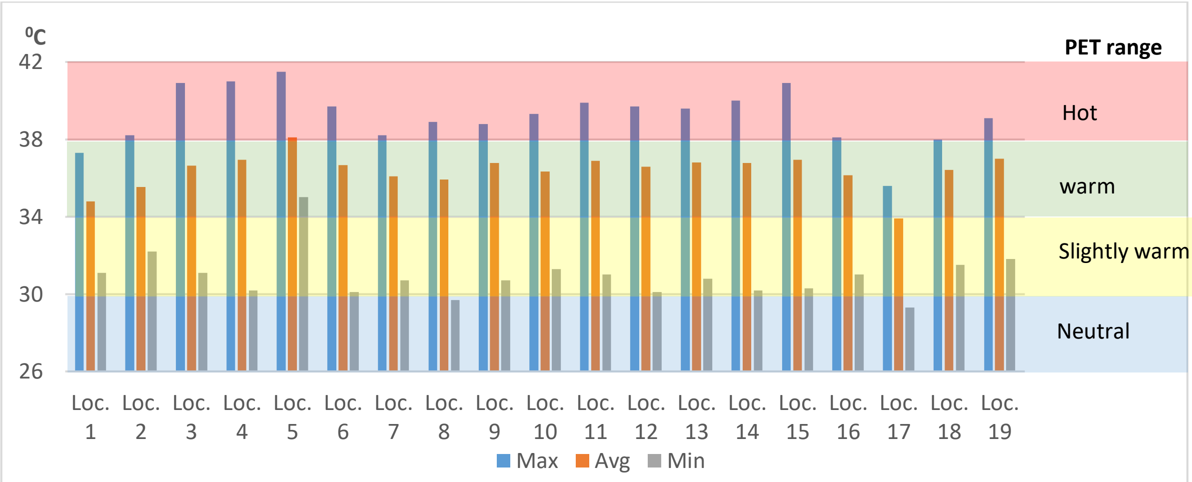


Figure 14 PET of each location measured in the study

This study confirms the presence of the Urban Heat Island (UHI) effect in Banda Aceh, as observed by Achmad et al. [16], which is indicated by the temperature difference between the rural and urban areas. The heritage buildings of Gunongan and Kandang, located near the center of Banda Aceh, are evaluated for UHI impact based on surface temperature (Ts) and mean radiant temperature (Tmrt). As shown in Figure 12, air temperature (Ta) has minimal impact on the globe temperature (Tg) and Tmrt. However, Tg closely follows Tmrt, as Tg is a more representative measure of thermal comfort than Ta alone. Tmrt, which is influenced by the surface temperature, is controlled by the properties of the building enclosures, with surface temperature being a significant factor[26]. In this study, we observe that the white limestone of Gunongan and Kandang results in a lower surface temperature compared to the air temperature, whereas the brick surfaces are approximately 23K higher than Ta (Figure 7). The white limestone is particularly effective at reflecting heat due to its high emissivity, and shaded areas, as well as those near the river (with its cooling effects), show lower surface temperatures. Furthermore, the Ts of unshaded ground is 12K higher than that of shaded grass surfaces. The thermal properties of limestone, as shown in Table 3, are similar to those of brick and soil. However, due to the highly reflective nature of the limestone's surface, it performs better in mitigating heat absorption.

Table 3 Thermal properties of several mineral such as, limestone, soil, brick and concrete

Material	Density (Kg/m^3)	Specific Heat Capacity (J/g K)	Thermal Conductivity (W/m.K)
Limestone	2750	840	1.3
Soil	2620	733	2.9
Brick	1800	800	1.31
Concrete	2400	1050	0.5

This study also evaluates the outdoor thermal comfort using Physiologically Equivalent Temperature (PET). Previous research has indicated that PET is strongly influenced by shading and air velocity [25]. Our findings confirm the significant role of shading, with higher mean radiant temperature (Tmrt) correlating with higher PET, as shown in Figure 15(a). Additionally, air velocity significantly affects thermal comfort, as faster air speeds correspond to lower PET, as seen in Figure 15(b). Another key factor observed is the relationship between Relative Humidity (Rh) and PET, where increased humidity results in a lower PET, as illustrated in Figure 15(c). In tropical climates, neutral PET typically falls within the range of 26-30°C, meaning environments should prioritize shading to reduce Tmrt and enhance Rh for better thermal comfort.

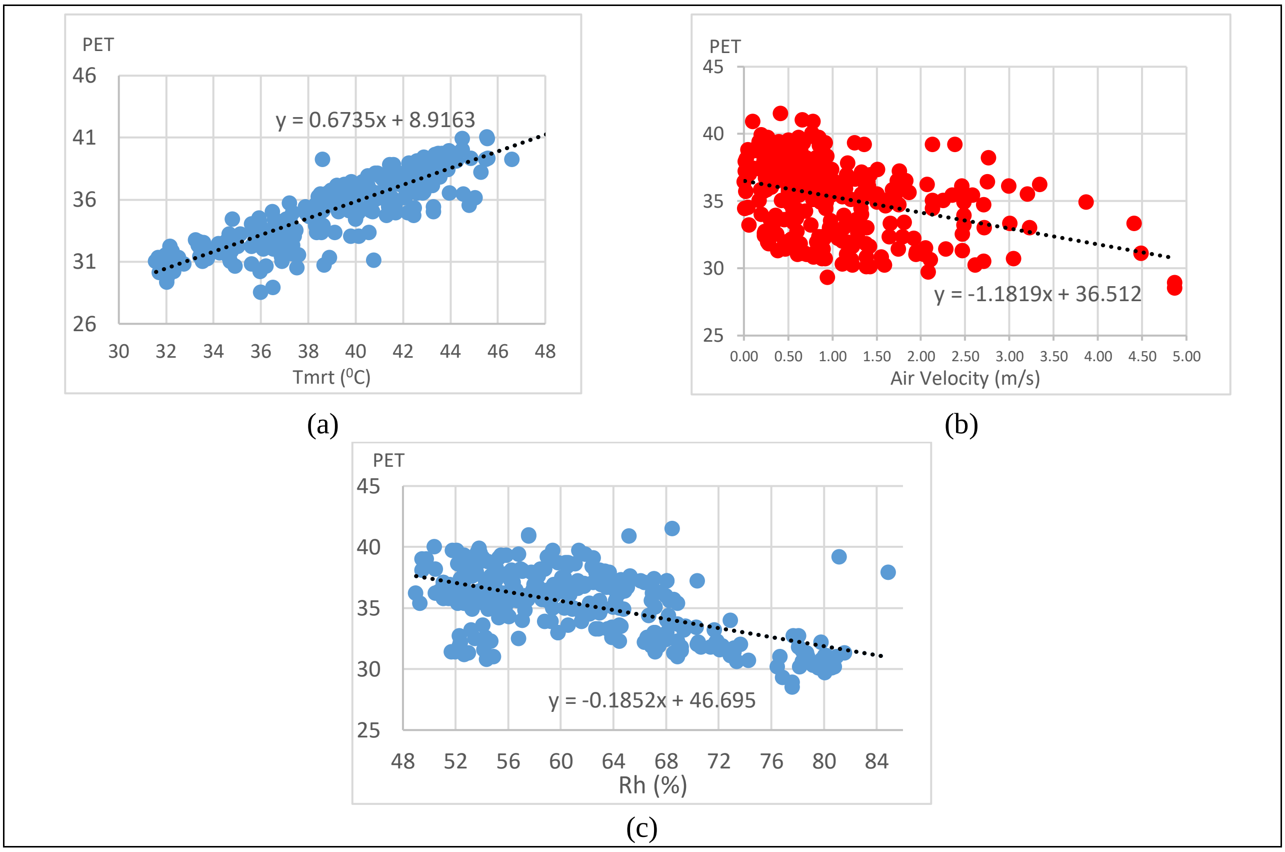


Figure 15 The relationship of Tmrt, Va, and Rh toward the PET value

4. Conclusion

This study appraises the heritage building in Banda Aceh, i.e., Gunongan and Kandang, toward the impact of Urban Heat Island. Gunongan and Kandang were built of limestone, sand, and lime mortar. The surface temperature of Gunongan and Kandang are dominantly below the air temperature variously. While, the Ts of the dark brick surface inside Kandang were much higher than others, up to 580C. This study also evaluated the outdoor thermal comfort within the surrounding environment of Gunongan and Kandang indicated by PET (Physiologically Equivalent Temperature). The average PET is 34 to 380C regarded as warm. This study found that the white surface of the limestone building structure effectively maintained the Ts lower than the Ta, which is very good for reducing the UHI. Through the mean radiant temperature (Tmrt) obtained from the collected thermal parameters, this study indicates that the shade contributed to the lower urban temperature. This study would be helpful for the government to conserve the heritage building since the local material employed in the structure is friendly to the environment and minimizes the impact of the urban heat islands

5. Acknowledgments

We would like to express our sincere gratitude to Universitas Syiah Kuala (USK) for funding this research through the MBKM research grant for the year 2022. Our thanks also go to the Architecture students of USK for their assistance in data collection and field measurements, which were crucial for the success of this study.

6. Conflict of Interest

The authors declare no conflict of interest regarding the publication of this manuscript.

References

[1] T. Karlessia, M. Santamourisa, A. Synnefaa, D. Assimakopoulosa, P. Didaskalopoulosa and K. .Apostolakis, "Development and testing of PCM doped cool colored coatings to mitigate urban heat island and cool buildings," *Building and Environment*, vol. 46, no. 3, (2011)

[2] Kandyaa and M. Mohan, "Mitigating the Urban Heat Island effect through building envelope Modifications," *Energy & Buildings*, pp. 266–277, (2018)

[3] Heaviside, "Urban Heat Islands and Their Associated Impacts on Health locked," *Environmental Science, (*2020)

[4] F. Rosso, I. Golasi, V. L. Castaldo, C. Piselli, A. L. Pisello, F. Salata, M. Ferrero, F. Cotana and A. L. Vollaro, "On the impact of innovative materials on outdoor thermal comfort of pedestrians in historical urban canyons," *Renewable Energy*, pp. 825-839, (2018)

[5] C. M. Nwakaire, C. C. S. P. Y. C. W. Onn and P. D. Yuen Onodagu, "Urban Heat Island Studies with emphasis on urban pavements: A review".," *Sustainable Cities and Society*, vol. 63, (2020)

[6] S. M. Khamseh and P. Noor, "Global Need for Low Carbon Architecture," *Journal of Sustainable Development*, vol. 7, no. 1, (2014)

[7] Kemdikbud, "Taman Sari Gunongan," 2011. [Online]. Available: http://cagarbudaya.kemdikbud.go.id/cagarbudaya/detail/PO2015111600550/taman-sari-gunongan 2022).. (accessed 2022).

[8] J. Daud, "Pesona Indonesia," 15 Juni 2019. [Online]. Available: https://acehtourism.travel/situs-sejarah-tsunami/06/2019/gunongan-bukti-cinta-sultan-ke-putri-pahang/. (Accessed August 2022)

[9] W. Peng, X. Yuan, W. Gao, R. Wang and W. Chen, "Assessment of urban cooling effect based on downscaled land surface temperature: a case study for Fukuoka, Japan," *based on downscaled land surface temperature: a case study for Fukuoka, Japan*, vol. 36, (2021)

[10] S. Eva, S. Bart, O. Marc and H. Jonkers, "Comparative analysis in thermal behaviour of common urban building materials and vegetation and consequences for urban heat island effect," *Building and Environment*, vol. 213, (2022)

[11] F. Rossi, E. Anderini, B. Castellani, A. Nicolini and E. Morini, "Integrated improvement of occupants' comfort in urban areas during outdoor events," *Building Environment*, vol. 93, p. 285e292, (2015)

[12] Rizwan and C. L. DLYC, "A review on the generation, determination and mitigation of Urban Heat Island," *J. Environ. Sci*, vol. 20, (2008)

[13] BPS, "Badan Pusat Statistik Kota Banda Aceh," 2021. [Online]. Available: https://bandaacehkota.bps.go.id/. (Accessed August 2022)

[14] M. Irwansyah, S. Zuliansyah and I. H, "Sustainable Landscape For High Urban Temperature Mitigation In The Disaster-Prone Coastal City Of Banda Aceh, Indonesia," in *IOP Conference Series: Earth and Environmental Science*, (2021)

[15] P. Larasati, B. Rahman and J. Kautsary, "Pengaruh Perkembangan Perkotaan Terhadap Fenomena Pulau Panas (Urban Heat Island)," *Jurnal Kajian Ruang*, vol. 2, no. 1, (2022)

[16] Achmad, L. H. Sari and I. Ramli, "A study of urban heat island of Banda Aceh City, Indonesia based on land use/cover changes and land surface temperature," *Aceh Int. J. Sci. Technol*, vol. 8, no. 1, pp. 41-51, (2019)

[17] M. Hall, "Heritage, Heritage Tourism and Climate Change," *Journal of Heritage Tourism*, vol. 11, no. 1, pp. 1-9, (2016)

[18] S. A. Orr, J. Richards and S. Fatorić, "Climate Change and Cultural Heritage: A Systematic Literature Review (2016–2020)," *The Historic Environment: Policy & Practice*, vol. 12, no. 3-4, pp. 434-477, (2021)

[19] N. Brooks, J. Clarke, G. W. Ngaruiya and E. E. Wangui, "African heritage in a changing climate," *Archaeological Research in Africa*, vol. 55, no. 3, pp. 297-328, (2020)

[20] Z. Zhao, A. Sharifi, L. S. X. Dong and B. J. He, "Spatial Variability and Temporal Heterogeneity of Surface Urban Heat Island Patterns and the Suitability of Local Climate Zones for Land Surface Temperature Characterization," *Remote Sens*, vol. 13, no. , 4338, (2021)

[21] P. Hoppe, " The Physiological Equivalent Temperature – A Universal Index for The Biometeorological Assessment of The Thermal Environment," *Int J Biometeorol*, , vol. 43, pp. 71-75, (1999)

[22] Givoni, M. Noguchi, H. Saaroni, O. Pochter, Y. Yaacov, N. Feller and S. Becker, "Field measurement of albedo for different land cover materials and effects on thermal performance,"," *Building and Environment*, vol. 59, p. 59, (2013)

[23] T. P. Lin, S.-R. Yang, Y.-C. C and A. Matzarakis, "The potential of a modified physiologically equivalent temperature (mPET) based on local thermal comfort perception in hot and humid regions," *Theoretical and applied climatology* , vol. 135, no. 3-4, (2019)

[24] F. Pearce, "Urban Heat: Can White Roofs Help Cool World's Warming Cities?," 2018. [Online]. Available: https://e360.yale.edu/features/urban-heat-can-white-roofs-help-cool-the-worlds-warming-cities. (Accessed 2022)

[25] H. Farhadi, M. Faizi and H. Sanaieian, *Mitigating the urban heat island in a residential area in Tehran: Investigating the role of vegetation, materials, and orientation of buildings* (Sustainable Cities and Society 46 2019)

[26] S. Yoshida, AtsumasaYoshida and hinichiKinoshita, "Chapter 5 - Evaluation methods of adaptation cities," in *Adaptation Measures for Urban Heat Islands* (Academic press, 2020), pp. 115-159.