EPI International Journal of Engineering
Volume 6, Number 2, August 2023, pp. 101-106
DOI: 10.25042/epi-ije.082023.07

pISSN 2615-5109
eISSN 2621-0541

Identification of Thermal Comfort of Open Space in Soppeng Regency

Nurhasanah[a,*], Rosady Mulyadi[b], Asniawaty Kusno[c]

[a]Laboratory of Building Science and Technology, Faculty of Engineering, Universitas Hasanuddin. Email: an.nurhasanah.996@gmail.com
[b]Department of Architecture, Faculty of Engineering, Universitas Hasanuddin. Email: rosady@unhas.ac.id
[c] Department of Architecture, Faculty of Engineering, Universitas Hasanuddin. Email: asniawaty@unhas.ac.id

Abstract

Thermal comfort is always associated with the climatic situation. Thermal comfort, known as a sense of comfort in the thermal situation in the surrounding environment, is also a necessity for space users. Open space is a place for space users who must be able to create a comfortable situation, one of which is thermal comfort. Temperature, humidity, wind velocity, and radiation intensity are elements of the thermal environment, as well as human metabolism and clothing insulation as human physical and physiological factors, are the six parameters of outdoor thermal comfort level according to ASHRAE Standard. This research is a type of descriptive research that aims to explain the thermal conditions felt by the perpetrators of activities in one of the open spaces in the Soppeng Regency, the Ompo Lake Tourism Area. The results obtained were from 349 respondents and as many as 216 respondents felt comfortable in the most comfortable temperature conditions in the range of 27.1 - 31˚C, with humidity>70%, wind velocity 0.2 – 0.5 m/s, and radiation intensity <150 W/m^2. Activity with a relaxed sitting (1 met) and moderate tropical clothes (0.3 – 0.5 clo).

Keywords: Thermal comfort, open space, thermal environment elements

1. Introduction

Thermal comfort is the condition of the individual feeling comfortable with the thermal situation in the environment around the body. Thermal comfort is one of the needs of space users. Activities can be done anywhere, one of which is in an open space. Open space is something that can accommodate human activities either individually or in groups [1].

Some people are reluctant to do outdoor activities because feeling hot, sweaty and uncomfortable can interfere with outdoor activities. With high air temperature coupled with the amount of solar radiation accompanied by high air humidity, it can cause a feeling of heat and sweating which makes it uncomfortable [2].

With a comfortable outdoor environment, the users of the activity will be more comfortable in their activities. Figure 1 shows that Soppeng Regency is located on the island of South Sulawesi and one of 24 regencies in South Sulawesi. In Soppeng Regency, there are several open spaces for the community that can be used for various purposes, ranging from sports, relaxing, playing, gathering with relatives, or simply being a means of releasing human stress. One of them in the Soppeng Regency is the Ompo Tourism Area. Precisely located in Lalabata District.

*Corresponding author. Tel.: +62-811-4050-955
Aroeppala Street
Makassar, Indonesia, 902221

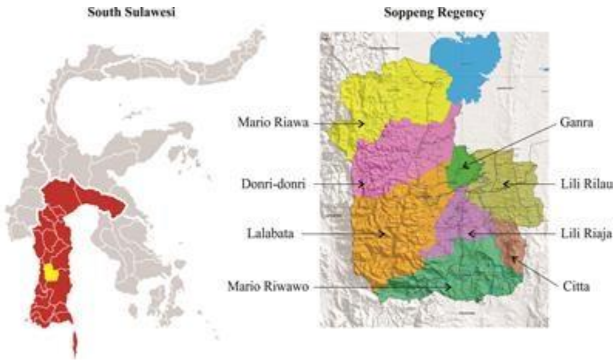


Figure 1. Research sites

2. Literature Review

Thermal comfort is a condition where a person feels comfortable moving in an environment/room with a certain temperature [2]. Thermal comfort is defined as the human perception of the thermal conditions of the environment. Thermal comfort is always associated with climatic situations [3]. Lippsmeier (1994) that three climate components are the parameters for determining thermal comfort [4]:

a. Air Temperature
Based on research by Mom and Wiesebrom in 1940, the criteria for comfort based on air temperature for native Indonesians are divided into three, namely; cool and comfortable, with a

temperature of 20.5°C - 22.8°C (TE); optimal comfort with a temperature of 22.8°C - 25.8°C (TE); and warm comfort with a temperature of 25.8°C - 27.1°C (TE) [5].

b. Humidity
Humidity is the amount of water content in the air expressed in percent. The humidity of the air that is comfortable for the body ranges from 40%-70%. In places like the seaside, it ranges from 80% - to 98%. If the humidity of the air is saturated, then our bodies cannot evaporate sweat anymore [6].

c. Wind Velocity
The wind speed for indoor comfort is within speed limits between 0.1 m/sec to 0.5 m/sec., if it exceeds that limit (above/below) then the sensation is said to be uncomfortable (neutral).

In the ASHRAE standard that temperature (˚C), humidity (RH%), wind speed (m/s), radiation intensity (W/m^2), body metabolism (met), and clothing insulation (clo) are the six parameters that determine thermal comfort [7]. Fanger (1970) said that the combination of two factors that affect thermal comfort, in addition to thermal environmental factors, namely air temperature, humidity, wind speed, and radiation, there are also personal factors including metabolic rate based on activity and climate. value-based on clothing [8].

In the human body, there is always a biological process that produces heat. This process is called thermal metabolism. Measurement of activity is expressed in units of "met" (metabolism). The higher or stronger the human activity, the greater the production of heat from the body. This situation causes changes in other variables in the thermal equilibrium process if a stable equilibrium is desired to achieve thermal comfort. To achieve thermal equilibrium of the body which is about 5 - 20 minutes [9]. As clothing forms an intermediate environment between humans and their environment. Each type of clothing has a characteristic number that is associated with the percentage of covering or coating on the skin of the human body to the outside air environment. The standard of tropical human clothing is 0.15 – 0.30 clo (light), 0.30 – 0.50 (moderate), > 0.50 (heavy) with the lowest value being 0 where humans are not dressed at all [3].

Various studies have been conducted by researchers regarding the factors that influence thermal comfort. With the movement of the wind, the effect of wind speed is quite significant on the comfort of humans who are active in outdoor spaces [7]. While radiation has a stronger effect on the thermal environment in the humid tropics than wind [10]. The amount of solar radiation hitting a flat surface in a tropical climate can reach more than 1000 W/m2, which is close to the solar constant of 1368 W/m^2 [3].

In open space, there are physical components that make up the space, one of which is vegetation. Vegetation is a variety of plants or plants that occupy an ecosystem. In the humid tropics, shading through vegetation and outdoor morphology is an effective effort to create thermal comfort in outdoor spaces by preventing direct radiation [5]. The presence of vegetation in several zones is sufficient to help provide shade for active users [11]. Meanwhile, surface materials with a high albedo, such as asphalt and concrete, are capable of storing material heat which will increase the air temperature when the heat is released [12], [13].

Figure 2. Ompo lake tourist area
(Source: instagram.com/ayokesoppeng_/?hl=id, 2018)

3. Methods

This type of research is descriptive research. In this study, a survey will be conducted by measuring the climate component at predetermined measuring points and asking respondents beliefs, opinions, and characteristics of objects through written questions and the same questions (questionnaires). For respondent data collection was carried out on Saturdays and Sundays where at that time more visitors were active than on usual days so the process of collecting respondent data was easier to do. Data collection was carried out only on sunny days for 12 days.

This research was conducted in Soppeng Regency, the research site is in the Ompo Lake Tourist Area (Fig. 2) which is an area within the Lalabata District, Ompo Village. The area chosen as the measuring point is based on the area that contains activities in it, so with this consideration, the number of measuring points is determined to be 10 points. Can be seen in Fig. 3 is the location of the measuring points.

The sampling technique used in this research is quota sampling and purposive sampling. Namely determining the sample that has certain characteristics until the specified amount (quota) has been met. In this study, the number of samples determined was approximately 60 samples in a day of research carried out in 2 time periods, morning and afternoon. Therefore, it will be obtained approximately 30 samples in the morning and approximately 30 samples in the afternoon.

In measuring climate, instruments are used in the form of a Thermohygro Meter to measure temperature (˚C) and humidity (%), an anemometer to measure wind velocity (m/s), and a Solar Power Meter to measure radiation intensity (W/m2). This study also use a questionnaire in

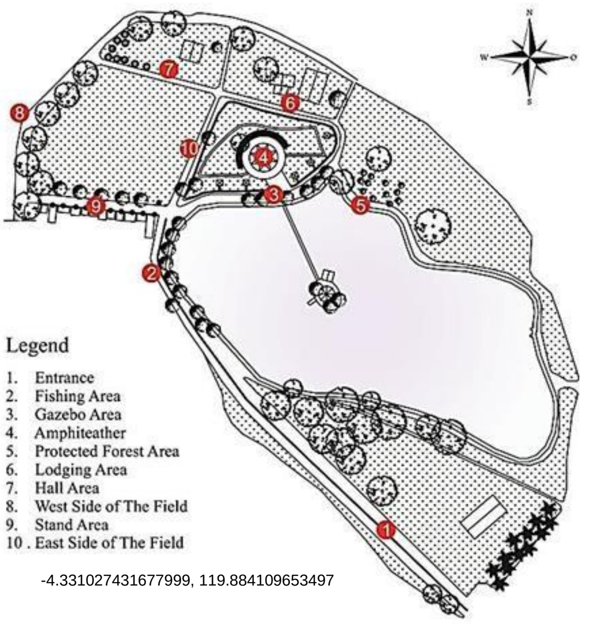


Figure 3. Measuring points

collecting data. Questionnaires are data collection techniques that are carried out by giving a set of questions or written statements to respondents to answer [14]. The questionnaire method is the right way to collect subjective thermospatial perception information from respondents as space users. Thermospatial perception is influenced by the duration of experience of the thermospatial condition [15].

Respondents will be asked to state the type of activity and how long they have been in the open space for each category of thermal quality of the place. This type of activity is to show the kinetic condition of the respondent while in an open space. Achieve thermal equilibrium of the body which is about 5-20 minutes. In the process of this research, respondents were selected based on the activities and the type of clothing used. The respondent's activities in the open space include sitting relaxed, sitting fishing, or sitting down to eat in tropical clothes (clothes that are generally for outdoor activities).

Respondents were selected based on predetermined criteria, namely selecting respondents with sitting and relaxing activities (relaxed sitting, sitting while eating, sitting while fishing), choosing respondents who had been doing activities for 20 minutes or more with the intention that the respondent had achieved thermal equilibrium. As well as the selection of respondents with light tropical to moderate tropical clothing (0.1 – 0.5 clo). The illustration of the respondent's clothes and the value of the insulation can be seen in Fig. 4.

The number population is unknown, then in determining the number of samples refers to the table determining the number of samples by isaac and michael, so the number of samples determined is 349 sample.

4. Results and Discussions

With a total of 349 respondents the questionnaire was asked about the thermal perception of each individual where this perception is influenced by situational factors and personal factors. Thermal perception is divided into

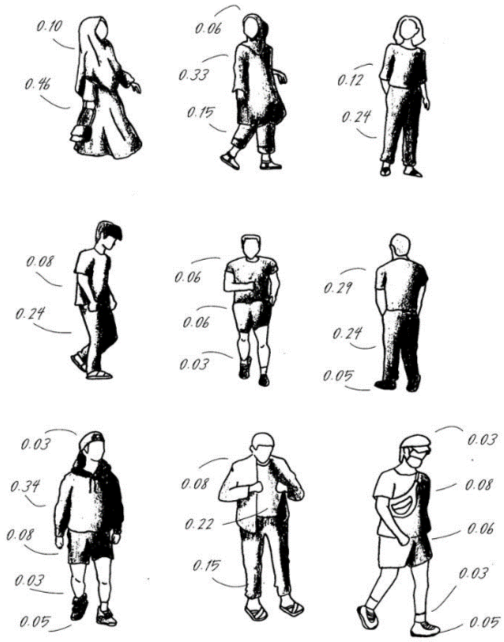


Figure 4. Illustration of the type of clothing used by the respondent

two questions, namely sensation and comfort level related to temperature, wind velocity, and radiation. The sensation is an individual's first response to external stimuli, while comfort level is an individual's comprehensive assessment of his environment. The respondent's characteristic variable consisted of 6 question items ranging from age, gender, domicile, type of shade, duration of activity, activities carried out, and type of clothing used.

Table 1 shows the result of the correlation test between the respondent's characteristics in the form of age, type of shade, activity and the type of clothing having a sig value <0.05 or it can be concluded that there is a correlation or there is a relationship with the sensation felt by the respondent with the value of the strength of the relationship (coefficient).

Based on the results of the correlation test, it is known that there is a relationship between age and sensation or it can be said that the lower age is followed by a decrease in sensation. And there is a strong relationship between the type of shade and sensation or it can be said that the better the type of shade, the better the sensation will be. There is also a moderate relationship between activity and sensation, where the higher the activity, the lower the sensation. There is a moderate relationship between the type of clothing and sensation, namely the lower the insulation value of the clothing, the better the sensation felt.

Table 1. The results of the correlation test of respondents' characteristics with sensation

No	Characteristics of Respondents	Level Comfort		Description
		Sig	Coeff	
1	Age	0.000	-0.288	Corelate
2	Domicile	0.649	0.024	Uncorrelated
3	Shade Type	0.000	0.719	Corelate
4	Activity Duration	0.860	0.092	Uncorrelated
5	Activity	0.000	-0.420	Corelate
6	Visit Frequency	0.768	0.016	Uncorrelated
7	Clothing Type	0.017	0.560	Corelate

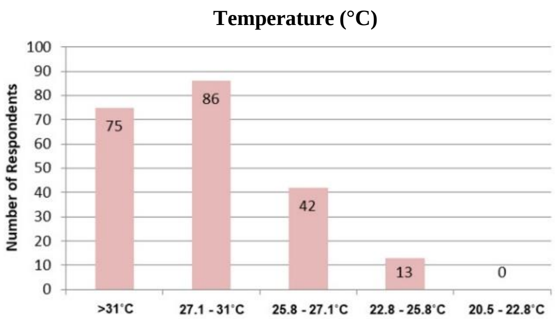
Table 2. The results of the correlation test of the respondent's characteristics with the level of comfort

No	Characteristics of Respondents	Level Comfort		Description
		Sig	Koef	
1	Age	0.974	-0.002	Uncorrelated
2	Domicile	0.860	0.009	Uncorrelated
3	Shade Type	0.525	-0.034	Uncorrelated
4	Activity Duration	0.409	0.044	Uncorrelated
5	Activity	0.770	0.016	Uncorrelated
6	Visit Frequency	0.724	0.019	Uncorrelated
7	Clothing Type	0.369	-0.048	Uncorrelated

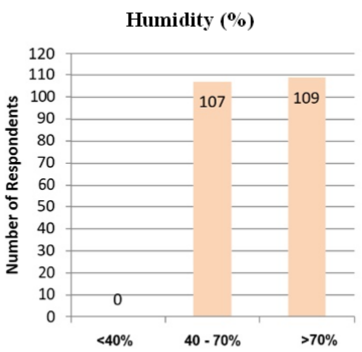
While the characteristics in the form of domicile, duration of the activity, and frequency of visits have a sig value > 0.05 or it can be concluded that there is no correlation or there is no relationship with the sensation of the respondent. Based on assumptions, there is no relationship between domicile and sensation because the sensation is the individual's first response to external stimuli. As well as the duration of activity with the frequency of visits.

Table 2 shows the result of the correlation test between the characteristics of the respondents and the comfort levels of the respondents. Overall, with the sig value > 0.05 or it can be concluded that there is no correlation or there is no relationship between the characteristics of the respondents and the level of comfort.

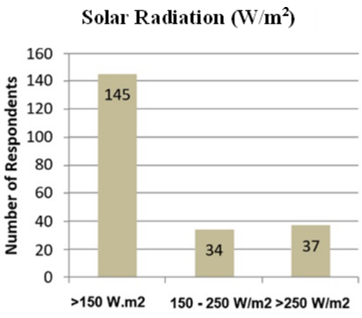
Based on the assumption, there is no relationship between the characteristics and the level of comfort because the level of comfort is an individual assessment of the environment, in this case, it is related to adjustments to environmental conditions. So even though the respondent feels a hot sensation, with this condition the respondent feels comfortable because it has adapted to its environment and because of other influencing factors such as the wind.



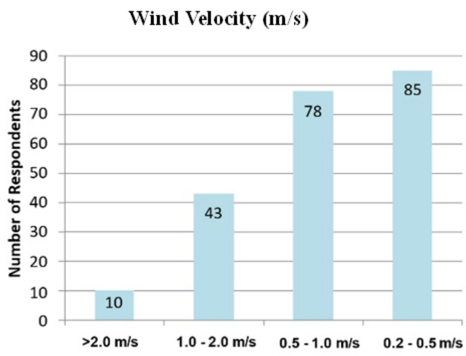
(a) Temperature



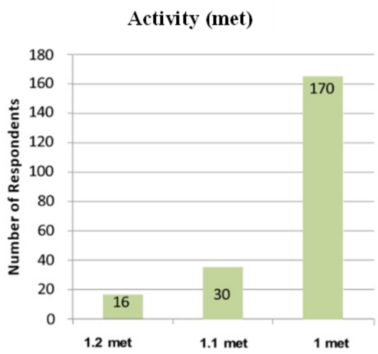
(b) Humidity



(c) Solar radiation



(d) Wind velocity



(e) Activity

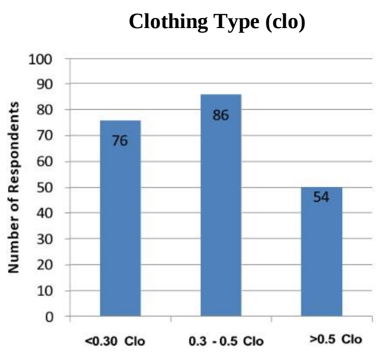


Figure 5. Respondents with comfortable conditions based on six elements that determine thermal comfort

Figure 5 is the number of respondents with comfortable conditions based on the six elements that determine thermal comfort according to ASHRAE, namely air temperature, humidity, wind velocity, radiation intensity, type of activity, and type of clothing. The number of respondents who felt slightly comfortable (Scale 5) comfortable (scale 6) was 216 respondents from 349 respondents.

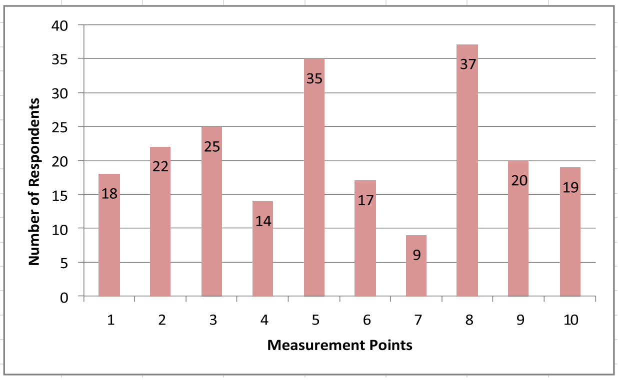


Figure 6. Number of respondents with comfortable conditions based on measuring points

Based on the large number of respondents who answered that they felt comfortable, it can be concluded that comfortable conditions are felt when the air temperature is at a range of 27.1˚C - 31˚C, with humidity > 70%, wind velocity 0.2 m/s – 0.5 m/s, radiation intensity <150 W/m^2, with the type of activity relaxed sitting and wearing moderate tropical clothes (0.3 Clo – 0.5 Clo).

Based on a large number of respondents can be seen in Fig. 6, it can be concluded that comfortable conditions are felt at measuring points 8 and 5. Measuring points 5 and 8 are measuring points that have vegetation other than measuring points 2, 3, and 9. However, measuring points 5 and 8 have a high level of canopy density, wide tree canopy, and the distance between trees that are close to each other. When taking measurements, the two measuring points always have a value that is included in the comfortable category.

Based on age in Fig. 7, out of 216 respondents who felt comfortable were teenager, 116 responded with a percentage of 54.2%. Based on gender who feel comfortable are men. Local people are more comfortable with their thermal conditions. Trees are a more comfortable type of protection than buildings and other types of protection. Respondents felt comfortable after being in the research location for more than one hour.

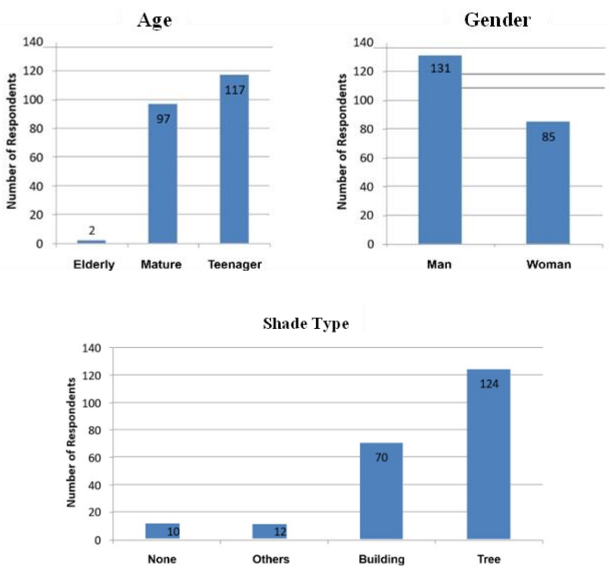


Figure 7. Number of respondents with comfortable conditions based on age, gender, domicile, shades type, and activity duration

5. Conclusions

By the 349 respondents, 216 (61.9%) of respondents felt comfortable. With the most comfortable temperature in the range of 27.1 - 31˚C, with humidity >70%, wind velocity 0.2 – 0.5 m/s and radiation intensity <150 W/m^2. And with a relaxing sitting activity (1 met) with moderate tropical clothes (0.3 – 0.5 clo). The most comfortable measuring points felt by respondents are measuring points 5 and measuring points 8.

There is a relationship between age and sensation or it can be said that the lower age is followed by a decrease in sensation. And there is a strong relationship between the type of shade and sensation or it can be said that the better the type of shade, the better the sensation will be. There is also a moderate relationship between activity and sensation, where the higher the activity, the lower the sensation. And there is a moderate relationship between the type of clothing and sensation, namely the lower the insulation value of the clothing, the better the sensation felt.

References

[1] R. Hakim, *Komponen Perancangan Arsitektur Lansekap: Prinsip Unsur dan Aplikasi Desain*. Jakarta: Bumi Aksara, 2011.

[2] T. H. Karyono, "Kenyamanan Termal dalam Arsitektur Tropis," in *Arsitektur dan Kota Tropis Dunia Ketiga: Suatu Bahasan tentang Indonesia*, RajaGrafindo Persada, 2013.

[3] Sangkertadi, *Kenyamanan Termis di Ruang Luar Beriklim Tropis Lembab*. Alfabeta, 2013.

[4] Santi, S. Belinda, and H. Rianty, "Identifikasi Iklim Mikro dan Kenyama Termal Ruang Terbuka Hijau di Kendari," *NALARs J. Arsit.*, vol. 18, pp. 23–34, 2019.

[5] E. Johansson, M. W. Yahia, I. Arroyo, and C. Bengs, "Outdoor Thermal Comfort in Public Space in Warm-Humid Guayaquil, Ecuador," *Int. J. Biometeorol.*, vol. 62, pp. 387–399, 2018.

[6] B. Suyono and E. Prianto, "Kajian Sensasi Kenyamanan Termal dan Konsumsi Energi di Taman Srigunting Kota Lama Semarang," *MODUL*, vol. 17, pp. 17–25, 2017.

[7] ANSI/ASHRAE Standard 55, "Thermal Environmental Conditions for Human Occupancy," 2021.

[8] C. Ekici and I. Atilgan, "A Comparison of Suit Dresses and Summer Clothes in the Terms of Thermal Comfort," *J. Environ. Heal. Sci. Eng.*, vol. 11, p. 32, 2013.

[9] Y. Sangaji, Sangkertadi, and A. Sembel, "Kajian Kenyamanan Termal bagi Pejalan Kaki pada Jalur Pedestrian Universitas Sam Ratulangi," *Spasial*, vol. 2, pp. 98–106, 2015.

[10] N. Makaremi, E. Salleh, M. Z. Jaafar, and A. Ghaffarianhoseini, "Thermal Comfort Conditions of Shaded Outdoor Spaces in Hot and Humid Climate of Malaysia," *Build. Environ.*, vol. 48, pp. 7–14, 2012.

[11] I. W. W. Sastrawan and I. G. S. Darmawan, "Perception of Thermal Comfort Level in Outdoor Space on Urban Public Space (Case Study: Lumintang Park in Denpasar)," in *Proceedings of the 3nd Warmadewa Research and Development Seminar, WARDS 2020*, 2021.

[12] M. J. Santamouris, "Cooling the Cities – A Review of Reflective and Green Roof Mitigation Technologies to Fight Heat Island and Improve Comfort in Urban Environments," *Sol. Energy*, vol. 103, pp. 682–703, 2014.

[13] G. Evola *et al.*, "UHI Effects and Strategies to Improve Outdoor Thermal Comfort in Dense and Old Neighbourhoods," *Energy Procedia*, vol. 134, pp. 692–701, 2017.

[14] Sugiyono, *Metode Penelitian Kualitatif, Kuantitatif dan R&D*, 2nd ed. Alfabeta, 2020.

[15] S. Lenzholzer, W. Klemm, and C. Vasilikou, "Qualitative Methods to Explore Thermo-Spatial Perception in Outdoor Urban Spaces," *Urban Clim.*, vol. 23, pp. 231–249, 2018.