International Journal of Architecture and Urbanism Vol. 10, No. 01 (2026) 13 – 25

International Journal of Architecture and Urbanism

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

Physical Space Elements in Outdoor Comfort of Urban Kampung in Jakarta

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ARTICLE INFO

Article history:
Received 28-10-2024
Revised 12-3-2025
Accepted 2-10-2025
Available online 15-3-2026

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

How to cite:
Inavonna, Saskia C. S., Fadhilah A., Rezandi F. Physical Space Elements in Outdoor Comfort of Urban Kampung in Jakarta. International Journal of Architecture and Urbanism. 2026. 10(1): 13-25.

http://doi.org 10.32734/ijau.v10i1.18711

ABSTRACT

The character of urban villages is very distinctive, where the physical conditions of the area develop organically as a manifestation of local wisdom and community lifestyle. This spontaneous spatial formation reflects the interaction of the community with its environment, which in turn affects the level of comfort, especially the comfort of outdoor spaces that play an important role in daily activities. This study focuses on the exploration of physical elements that form outdoor spaces that affect the physiological comfort of outdoor spaces in urban villages, with a case study of urban villages in Petamburan sub-district, Central Jakarta. The research question is what physical factors form outdoor spaces that affect the physiological comfort of outdoor spaces in urban villages. This study applies quantitative method with a survey approach using a single case study design consisting of 19 communal outdoor space analysis units in urban villages Petamburan Jakarta. The results of the theoretical framework and hypothesis obtained 7 physical element variables (Seating, Vegetation, Kiosks, Height ratio and distance between buildings H/W, % air flow, % roof area, and Walls) to be brought to the field. Field data in the form of quantitative data were collected by conducting questionnaires, observations, measurements and interviews. The results of the field data were analyzed with quantitative analysis using linear regression analysis in the SPSS statistical program 26. According to the result of this study, 7 (seven) variables that form the physical outdoor space in urban villages, there were only 2 (two) variables that influenced the physiological comfort of outdoor spaces in urban villages. These variables are (1) The ratio of the distance and height of the room dividers and (2) The percentage of the roof area. These findings are expected to provide a more comprehensive insight into the function of physical elements in creating a physiologically comfortable space, which ultimately supports the design of outdoor spaces in urban villages to be more conducive to community activities and sustainability.

Keywords: community, physiological comfort, spaces, sustainability

1. Introduction

The role played by outdoor areas within residential environments, particularly in densely populated urban areas, is very important. Such densely populated residential areas are often referred to as “urban villages.” The unique character of urban villages develops organically as a manifestation of the local wisdom of their communities. Gandarum [1] explains that local wisdom reflects the attitudes and actions of a community in responding to unique situations within both the physical and cultural environments. Additionally, the characteristics of urban village communities significantly influence their perception of comfort in outdoor spaces.

The function of outdoor space in housing is very important, especially dense housing in urban areas. The housing is defined as a kampung-kota. The character of the kampung-kota is very distinctive, where the physical condition of the Kampong-kota is formed organically as a representation of the local wisdom of its people. This is in accordance with Gandarum [1] about local wisdom which describes how humans behave and act in responding to situations that are typical in the scope of their physical and cultural environment. The characteristics of people in kampung-kota have an impact on the assessment of the comfort of their outdoor space. Although often under pressure and problems (floods, destruction, and unregulated settlements) or fighting each other, they still want to live there. Their neighbors are their family. Their community is their kampung [2].

The built-up area in the city village is very dense. This is the reason why the unbuilt area becomes an outdoor space, so that the role of outdoor space in the city village is quite large. It can be said that the outdoor space of the city village is the setting of people's lives, known as 'places' and not just 'space' and is a form of civic art [3]. The design features and microclimatic Characteristics of outdoor environments strongly affect the shaping of the use and flow of activities. Thus, it will affect their assessment of its comfort [4]. Peng [5] stated that in determining the quality of the outdoor environment, comfort has become the main measure for the design of public outdoor spaces and their quality assessment.

Various studies state that the effectiveness of outdoor space use is greatly influenced by its thermal aspects [6]. Comfort, especially thermal comfort, determined by both physical conditions and mental conditions [7] so that good information and understanding of the microclimate and spatial conditions of space can affect the level of acceptance but not with satisfaction with its thermal conditions and the perception of comfort where the outdoor comfort index is not always identical to its thermal comfort [5]. From Peng's statement [5] that spatial conditions of space can affect dissatisfaction with thermal conditions and perceptions of comfort, this study will look at what physical elements or factors form outdoor spaces that affect the physiological comfort of outdoor spaces in urban villages.

Human activities take place in spatial environments designed to support specific functions and social interactions [8]. Outdoor spaces, often referred to as "roofless architecture," are defined by two primary elements: the floor and the wall, or by the space enclosed by these two boundaries. According to Nemeth, Jeremy, and Schmidt [9], public space design serves both literal and symbolic roles in regulating behavior and controlling access to these spaces. Physical elements in the design of public spaces include amenities such as public toilets, food vendors or kiosks, various types of seating (e.g., movable chairs), interactive sculptures and art, as well as environmental factors like daylight, artificial lighting at night, wind barriers, rain-protective overhangs, changing sun and shade patterns, and vegetation such as trees, shrubs, or grass, all of which strengthen the connection between outdoor spaces and the surrounding landscape. The layout of these spaces reflects and fosters relationships within communities, with some spaces easily adaptable to accommodate diverse activities [10][11].

Outdoor activities are greatly influenced by the microclimate and the physical design of the outdoor space. Thus, it will affect their assessment of its comfort [4]. Peng [5] stated that in determining the quality of the outdoor environment, comfort has become the main measure for the design of public outdoor spaces and their quality assessment. Based on the theory developed by several experts [4] [5] [12], it can be seen that physical/environmental comfort is a very dominant type of outdoor comfort. This can be seen from almost all experts stating that physical environmental factors greatly influence comfort, especially comfort in using outdoor space. Microclimate conditions and spatial configuration of outdoor space determine the formation of comfort in this aspect. Zacharias [13] stated that one of the elements of the microclimate, namely temperature, most influences people to do outdoor activities. The microclimate and spatial form of the environment play a significant role in shaping people’s evaluation of thermal comfort [12]. The physical condition of the outdoor space cannot be separated from the elements that form the space, such as walls, roof of the space and so on.

Physiological comfort space requires knowledge of human physiology, particularly factors such as skin temperature, sweat rate, and core body temperature, which are crucial in developing a comfort model [12][14][15]. Physiological comfort can be understood with the concept of 'heat balance', namely the rate of body heat production and the rate of body heat loss to the environment must be balanced. In this process, physiological adaptation will occur. The body's metabolic process generate body heat, as a physiological by-product, body heat will be emitted into environment. It is essential to maintain a balance between the rate of body heat production and the rate of heat loss to the environment. These conditions, people will experience a heat balance process [16]. Normal heat and body temperature balance occurs when the body's metabolic heat generation is in equilibrium with the rate at which heat is transferred to the surrounding environment, influencing the thermal comfort of the space. Humans have an extraordinary ability to tolerate hot temperatures, because of the large number of sweat glands [17].

In addition to the layout of the room, environmental conditions such as microclimate also affect comfort and physiological adaptation [5] [12]. Conceptually, thermal comfort has been described as a state of mind, approaching a person's satisfaction with the environment [18]. However, in the view of physiological thermal comfort, neutral thermal sensation or 'thermal neutrality' is usually used as a substitute for overall comfort [12]. Thermal neutrality refers to a state where an individual favors an environment that is neither warmer nor cooler than the current one. During this process, a physiological adaptation takes place [19].

Several indices that correlate thermal environmental factors with the human body's energy balance have been employed to assess outdoor thermal comfort. Various indices are used to evaluate outdoor thermal comfort, for instance, the Prediction Mean Vote (PMV) [20], Effective Temperature (ET, in °C), Standard Effective Temperature (SET, in °C) [21], Standard Outdoor Effective Temperature (OUT_SET, in °C) [22][23], and Physiologically Equivalent Temperature (PET, in °C) [24][25]. While PMV, ET, and SET are primarily designed for indoor environments, OUT_SET and PET are specifically intended for assessing outdoor conditions [23][6]. The PET index, introduced by Matzarakis et al., is utilized in this study [26][27], was chosen to evaluate the physiological comfort of outdoor spaces.

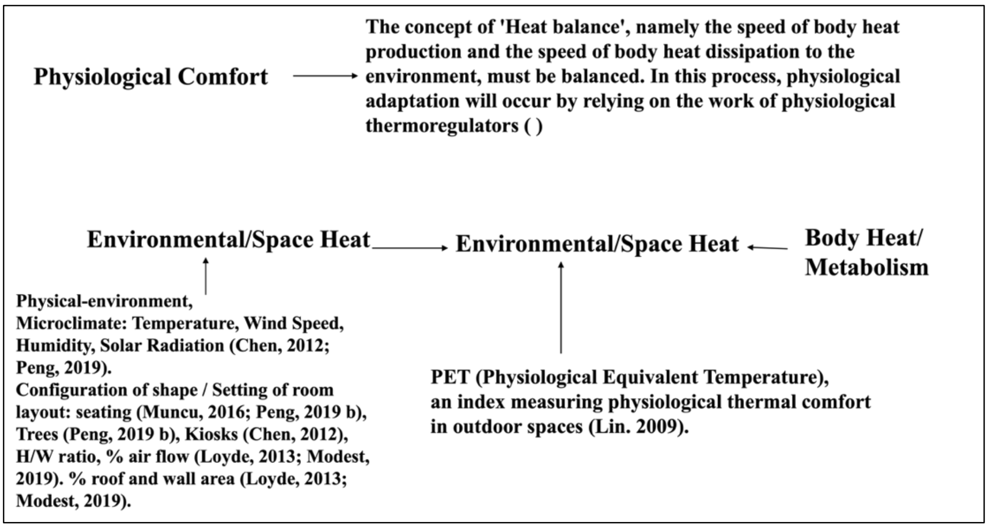

Figure 1. Definition Scheme of Physiological Comfort of Space

Environmental heat influences physiological thermal comfort in outdoor spaces. The physical environmental heat is formed by microclimate conditions and the spatial configuration of outdoor spaces, which are crucial determinants of comfort in this aspect (Figure 1). The physical elements of outdoor spaces include the configuration of forms/layouts, such as: seating[5][28], trees[5], height-to-width ratio (H/W)[29][30], % airflow[29][30], % roof area[29][30], and walls[29][30], kiosk [13].

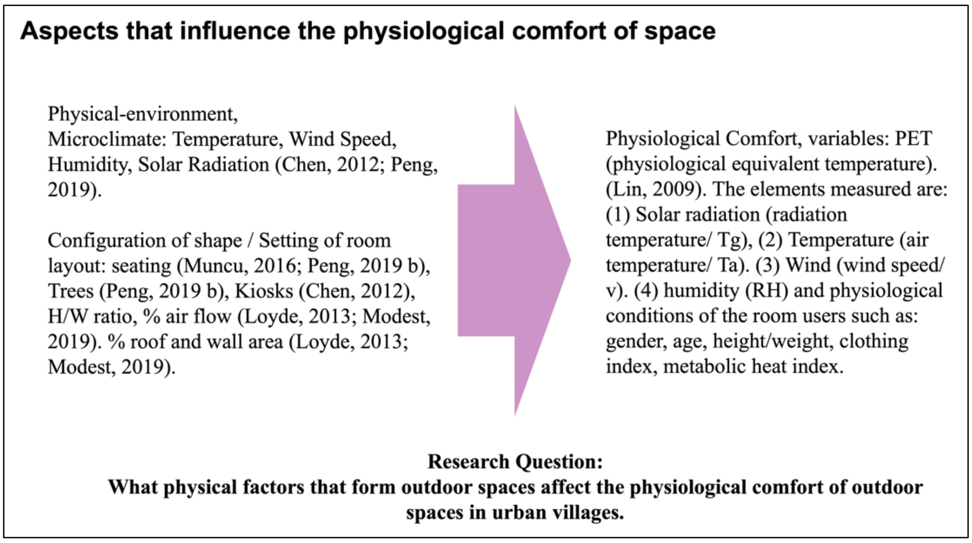

Figure 2. Theoretical framework and research hypothesis

Physiological comfort can be understood with the concept of 'heat balance', namely The rate of thermal energy production by the body and its subsequent dissipation to the environment must achieve a state of equilibrium. Environmental conditions such as microclimate greatly affect the value of physiological comfort. Based on previous theoretical reviews [6][23], namely to assess the physiological comfort of outdoor spaces, measurements are taken on the space and its users using the PET method (degrees Celsius) which is an index that incorporates both thermal environmental variables and the human body's energy balance [31]. In this study, the subject of the study was outdoor space, so the PET index is suitable for determining physiological comfort. PET (physiological thermal comfort) which is an index with the following variables: Age, gender, height/weight, clothing index, metabolic index, temperature, humidity, solar radiation, and wind speed. PET is a software that can integrate all of the above factors (Figure 2).

2. Method

In order to investigate the relationship between theory and research, quantitative research employs a deductive approach that focusses on the collecting and interpretation of numerical data, with a particular emphasis on testing ideas. Assessing a theory using variables, numbers, and statistical analysis to see whether the theory's prediction generalisation is accurate is the foundation of quantitative research, which examines social issues [32]. In this study, the method used is quantitative research with a survey approach. The research design can be selected based on the objectives and research questions (Table 1). Quantitative research focuses on data collection techniques [33]. The formulation of the problem described in the research question will be answered with quantitative data. To obtain quantitative data, quantitative techniques are used with questionnaires, measurements and documentation.

The unit of analysis in this study is the outer space of the urban village. There are certain factors that form the comfort value that is typical of the analysis unit. Therefore, this study's analytical unit is the communal outdoor space unit in the study area, namely, RW 03, Petamburan Village. So the study population is the entire communal outdoor space unit in the research area. Purposive sampling was applied, involving the selection of participants according to specific criteria aligned with the study's objectives. The communal space criteria are adjusted to previous theoretical studies. The sample units (communal outdoor space units) selected (inclusive criteria) are space units that represent characteristics with communal outdoor space criteria such as elements and layout of space and users of space. Determination of the sample and number of samples begins with identifying the criteria for the urban village outdoor space and the characteristics of the space in the study area. The number of samples is determined in the field by meeting these criteria. Space criteria such as; the presence of people carrying out activities, there are limitations to space elements, there are supporting elements of space such as seating, and others.

Table 1. Research Formulation and Questions, Data Collection Techniques, and Data Sources

Research questions	**Data collection techniques**	**Data sources**
What are the physical factors that form the outdoor space that affect the physiological comfort of the outdoor space in urban villages	Interviews, questionnaires, and measurements	Physical outdoor space in urban villages, All users of the outdoor space

The results of the theory tracing (deductive) produce variables and then the variables are given operational definitions, and then the indicators to be measured are determined. The following is Table 2. describing the variables, definitions, operations, scales and instruments. In quantitative research with statistical tools, there is a requirement that the number of variables must be smaller than the number of analysis units. In this study, there are variables that are condensed into one variable using special software, namely PET (Physiological Equivalent Temperature) which is one of the indexes for measuring the physiological comfort of outdoor spaces by integrating microclimate conditions with body heat balance. The elements measured are: (1) Solar radiation (radiation temperature/ Tg), (2) Temperature (air temperature/ Ta). (3) Wind (wind speed/ v). (4) humidity (RH) and physiological conditions of space users such as: gender, age, height/weight, clothing index, metabolic heat index. In this study, the RayMan model, devised by Matzarakis et al. (2007; 2010) [26][27][23][6], is employed. This model is purposefully crafted to simulate radiative conditions and assess thermal comfort within urban contexts.The tool used to measure air temperature is a dry bulb thermometer. Humidity measurements are carried out using a dry bulb hydrometer and wind speed is measured using an anemometer. While radiation temperature is the temperature caused by heat generated by radiation. For outdoor spaces, radiation temperature comes from solar radiation and measurements are made using a solarimeter. Radiation from the sun is measured in watts per area. Data analysis uses a type of causal analysis (regression analysis) which is a study of how one or more variables (outdoor physical space) affect changes in other variables (outdoor physiological comfort). SPSS 26 was utilized for performing linear regression analysis.

Table 2 outlines the research variables along with their operational definitions:

Table 2. Research Variables and Operational Definitions

Variable	**Operational Definition**	**Scale**	**Instrument**
PET, Physiological	Physiological thermal comfort index	Interval	Survey and secondary data Age, gender, height/weight, clothing index, metabolic index, temperature, humidity, solar radiation, wind speed.
Age, Gender, Body Metrics	Personal attributes (age, gender, height/weight)	Interval	Survey and secondary data
Cross Ventilation	Percentage of open partitions	Interval	Survey and secondary data
Number of Vertical Walls	Number of vertical wall sides with openings	Interval	Survey and secondary data
Greenery	Percentage of foliage coverage	Interval	Survey and secondary data

Variable	Operational Definition	Scale	Instrument
Benches	Number of seating options	Interval	Survey and secondary data
Roof Coverage	Percentage of roof covering	Interval	Survey and secondary data
Kiosks	Number of kiosks	Interval	Survey and secondary data
D/H Ratio	Ratio between distance and height of space boundaries	Interval	Survey and secondary data

Following the condensation of variables, eight variables were identified, each with 30 analysis units. The table 3 describes the variables, their operational definitions, scales, and instruments:

Table 3. Research Variables, Definitions, Operationalization, Scale, and Instruments

Variable	Operational Definition	Scale	Instrument
PET (Physiological)	Physiological thermal comfort index	Interval	Specialized software
Air Temperature	Ambient temperature of the outdoor environment	Interval	Dry Bulb Thermometer
Humidity	Moisture level in the air	Interval	Hygrometer
Wind Speed	Speed of air movement in the outdoor space	Interval	Anemometer
Solar Radiation	Heat from solar radiation	Interval	Solarimeter

3. Result and Discussion

The selection of `the object is closely tied to the definition of urban villages, which are characterized as traditional, spontaneous settlements that contribute to the diversity of urban habitats [33]. The emergence of urban villages is a result of a prolonged evolutionary process, historically rooted in the Dutch colonial period. It is crucial to recognize that urban villages cannot exist independently of the city, and conversely, cities depend on these villages [33]. The Dutch colonial administration preserved Jakarta's urban structure by designating specific areas as centers of economic and political activities while designating villages as residential zones for the majority population. The development of Petamburan as an urban village is significantly influenced by the rapid growth of the Tanah Abang market [34].

Figure 3. Petamburan District
Source: Universal Transverse Mercator (UTM)

The administrative boundaries of Petamburan sub-district are seen to the north: Kota Bambu sub-district, south: Bendungan Hilir sub-district, west: Slipi sub-district, east: Kebon Kacang sub-district and Kebon Melati sub-district (Figure 3). Geographically, the boundaries of Petamburan sub-district are on the border between West Jakarta and Central Jakarta. The western boundary is the Ciliwung River (western flood canal). Petamburan sub-district is the sub-district with the highest density in Tanah Abang sub-district, Central Jakarta (Figure 4).

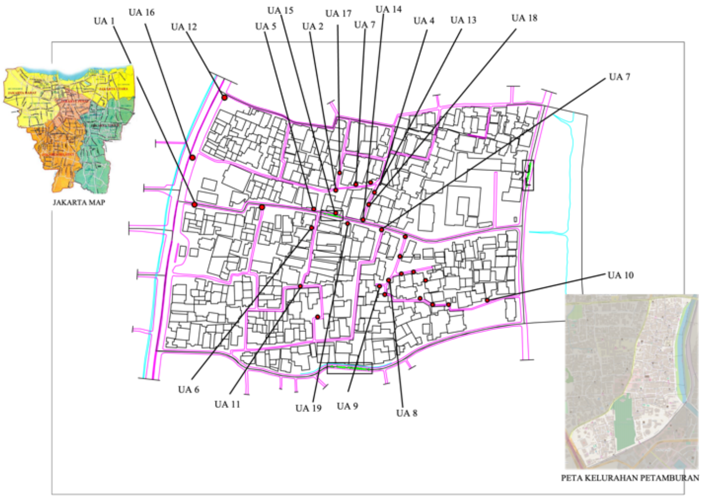

Figure 4. Location Analysis

Field Measurement Results

The data collected from field measurements are presented in Table 4. Y1 represents the Physiological Equivalent Temperature (PET) represent dependent variables, while X21 through X27 represent various independent variables. The coding scheme for X21 (% cross ventilation), X22 (vertical wall), X23 (% vegetation), X24 (sitting area), X25 (% roof area), X26 (number of kiosks), and X27 (Building Height to Width Ratio (D/H) is as follows:

Table 4: Measurement Results

Y1	X21	X22	X23	X24	X25	X26	X27
56.4	60	3	80	3	2	0	3
44.2	40	2	0	2	1	1	0.4
43.5	40	2	0	3	1	1	0.3
43.8	40	2	0	2	1	0	0.3
44.0	50	3	50	2	1	1	0.5
53.6	40	2	10	2	1	1	0.8
61.0	40	2	10	2	1	1	0.8
50.5	50	2	10	3	2	0	0.7
45.6	40	2	30	2	2	0	0.8
50.3	40	2	0	3	2	0	0.6
44.6	50	2	0	2	1	1	0.6
58.9	50	2	10	2	3	0	0.3
42.0	40	2	0	2	2	1	0.7
51.1	40	2	0	1	1	1	0.6
71.5	50	3	0	1	1	1	2
66.2	50	4	10	3	1	2	2
57.8	75	2	0	2	3	0	0.7
46.2	75	2	0	3	2	0	0.6
58.1	90	3	50	2	3	0	1.7

Data analysis uses a type of causal analysis (regression analysis) which is a study of how one or more variables (outdoor physical) affect changes in other variables (outdoor physiological comfort). Data analysis uses linear regression analysis with SPSS 26. Table 5 presents the Model Summary of Regression Analysis, which includes the Coefficient of Determination. This coefficient, ranging from 0 to 1, quantifies the effectiveness of the statistical model in predicting the outcome.

The model summary of the regression analysis is presented in Table 5.

Table 5. Model Summary of Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics
1	.854a	.730	.644	4.7943	R Square Change
					.730

Predictors: (Constant), X27, X25, X24, X23, X21, X26, X22

The R value signifies the correlation coefficient, with a value of 0.854, reflecting a substantial correlation between the variables under investigation. The R squared, also known as the coefficient of determination, indicates the extent to which the independent variables elucidate the variance in the dependent variable. The appropriateness of an R square value depends on the context and nature of the data, although generally, a value approaching 1 is considered preferable. Typically, an R square value exceeding 0.67 is classified as strong. Based on the SPSS output, the regression model summary indicates an adjusted R^2 of 0.644, suggesting that approximately 64.4% of the variation in physiological comfort (PET), as the dependent variable, is accounted for by the seven independent variables: seating, vegetation, kiosks, height-to-width (H/W) ratio, air flow percentage, roof area percentage, and kiosks. The remaining 35.6% is attributed to other factors not included in the model. Furthermore, the Standard Error of Estimate (SEE) is reported as 4.7943, where a lower SEE value reflects greater accuracy of the regression model in predicting the dependent variable.

The ANOVA results yield an F statistic of 8.486 with a significance level of 0.000, as shown in Table 6.

Table 6. ANOVA Significance Test Results

Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1365.386	7	195.055	8.486
	Residual	505.677	22	22.985	
	Total	1871.063	29		

DependentVariable: Y1
Predictors: (Constant), X27, X25, X24, X23, X21, X26, X22

The F-test is applied to assess the linearity of the regression model, where a Sig. value below 0.05 suggests linearity. Table 5 shows a Sig. value of 0.000, this suggests that the regression model is statistically significant at the 0.05 level and fulfills the linearity assumption. Subsequently, the t-test is performed to assess the significance of individual parameters, using either unstandardized or standardized coefficients to interpret the independent variables. To interpret the coefficients of the independent variables, both unstandardized and standardized coefficients can be employed, as shown in Table 7.

Table 7. Individual Parameter Significance Test (t-Statistics)

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	36.531	5.873		6.220	.000	24.351	48.712
	X21	-.100	.084	-.198	-1.192	.246	-.274	.074
	X22	5.678	3.352	.429	1.694	.104	-1.273	12.630
	X23	-.177	.064	-.468	-2.772	.011	-.310	-.045
	X24	-3.334	1.450	-.282	-2.300	.031	-6.341	-.328
	X25	5.799	1.979	.541	2.930	.008	1.695	9.903
	X26	1.151	2.834	.090	.406	.689	-4.728	7.029
	X27	7.998	2.526	.685	3.167	.004	2.760	13.237

Dependent Variable: Y1 (Physiological Comfort)

Table 7 presents the regression equation model, displaying both the constant and variable coefficients listed under the Unstandardized Coefficients B column. Among the seven independent variables included in the regression model, only variable X27 has a significance value below 0.05, while variable X25 has a value slightly above 0.05, specifically at 0.08. This indicates that the Physiological Comfort variable is primarily influenced by the percentage of roof area and the height-to-distance ratio between buildings. The regression equation (mathematical formula) is derived based on the data presented in this table.

Y = 36,531- 0.100 X1 + 5,678 X22 - 0.177 X23 - 3,334 X24 + 5,799 X25 + 1,151 X26 + 7,998 X27.

Physiological Comfort = 36,531- 0.100 (% cross ventilation) + 5,678 (Vertical walls) - 0.177 (% vegetation) - 3,334 (benches) + 5,799 (% roof area) + 1,151 (number of kiosks) + 7,998 (H/D). The results of the statistical analysis show that of the 7 (seven) physical elements that form the outdoor space, the element that greatly affects the physiological comfort of the space is the ratio of height and distance between buildings (H/D). This is very reasonable when associated with the characteristics of urban villages. The physical characteristics of urban villages are the ratio of built space to unbuilt space is very high, it can be said that the solid void ratio is around 0.8. The statement put forward by Chen, 2012 and Peng, 2019 that the setting of the layout of space and environmental conditions such as microclimate affect physiological comfort and adaptation, does not apply to the outdoor space of urban villages. This is very reasonable because the research conducted by Chen [12] and Peng [5] was on public outdoor spaces in general. The characteristics of urban village communities also influence their assessment of the physiological comfort of their outdoor spaces. For them, as stated by Gandarum [3] that the outer space of the urban village is a setting for people's lives, known as 'places' and not just 'space' and is a form of civic art. In urban village communities, there are other comforts that influence the assessment of the comfort of their outdoor spaces. Chen [12] stated that in addition to physiological comfort, there are other comforts in assessing the thermal comfort of an outdoor space. Lenzholzer et al. [4] conducted research indicating that outdoor activities are strongly influenced by the microclimate and physical design of spaces, which shape users' perceptions of comfort. However, these findings do not apply to outdoor spaces in urban villages. The results of the study also strengthen the statement that the layout of space is able to express relationships between communities. Some spaces can easily change function and layout to accommodate different activities [10], and this applies to the outdoor spaces of urban villages. It can be said that the physical layout of their outdoor spaces does not depend on other physical elements such as benches, vegetation, kiosks, and others. This is in accordance with Gandarum's [1] statement about local wisdom which describes how humans behave and act in responding to situations that are typical in the scope of their physical and cultural environment. The characteristics of people in urban villages have an impact on the assessment of the comfort of their outdoor spaces. The findings of this study are consistent with previous research indicating that over 75% of users preferred shaded areas [35].

In high-density environments such as urban villages, it is recommended that building layouts be carefully planned according to the specific climate zone. A comprehensive study of urban street canyons is crucial to understand the unique bioclimatic thermal conditions shaped by elements such as width, height, orientation, regional context, and urban density. Among the factors influencing quantitative heat stress, shading emerges as the most significant, followed by modifications in wind speed. Therefore, the role of the height-to-width (H/D) ratio is essential not only for generating shading but also for influencing airflow. Additionally, simulations on wind speed and shading patterns indicate that adequate shading can significantly enhance thermal comfort, particularly when the Physiologically Equivalent Temperature (PET) exceeds 35 °C. Enhancing outdoor thermal comfort is a key strategy in promoting the sustainability of urban form and design. [36].

4. Conclusion

This study explores the physical factors that form outdoor spaces that affect the physiological comfort of outdoor spaces in densely populated urban settlements, especially in the Kampung Kota Petamburan area, Central Jakarta. The main objective of this study is to identify the elements or physical factors that form outdoor spaces that affect the physiological comfort of outdoor spaces in urban villages. The most significant physical elements of outdoor spaces that affect the physiological comfort of space are the height-to-width (D/H) ratio followed by the roof cover area. The characteristics of urban village communities also affect their assessment of the physiological comfort of their outdoor spaces. This shows that for urban village communities, the completeness of the physical elements that form outdoor spaces is not a dominant factor for people in using their outdoor spaces. Through linear regression analysis using SPSS 26, it was found that two main variables that significantly affect physiological comfort (PET) are the height-to-width ratio between buildings (D/H) and the percentage of roof cover area (% roof). The results show that a higher D/H ratio and a larger percentage of shaded areas contribute to increased comfort of urban village outdoor spaces. The D/H ratio plays an important role in creating shade and reducing direct exposure to sunlight, which helps reduce heat and increase outdoor comfort. Furthermore, user preference for shaded areas supports these findings, with more than 75% of respondents indicating a tendency to choose and spend more time in areas protected from direct sunlight. This preference underscores the importance of shade in the design of outdoor spaces in dense areas. These findings are in line with previous studies that emphasize the importance of physical spatial elements, such as shade from canopies or buildings, in creating more comfortable thermal conditions. In the context of a dense urban environment such as Kampung Kota, strategic building arrangements, taking into account the D/H ratio and roof area, can foster a more comfortable environment that supports sustainability and improves the quality of life of residents. In conclusion, the physiological comfort of Kampung Kota outdoor spaces is significantly influenced by two main factors: the height-to-width ratio between buildings and the percentage of roof covering. Optimal management of these two variables can create comfortable shaded areas that encourage social activities in dense settlements. This study provides practical recommendations for planners and architects in designing more climate-responsive communal spaces and improving comfort in densely populated urban environments.

5. Acknowledgements

I gratefully acknowledge Universitas Trisakti for their support and resources

6. Conflict of Interest

The authors confirm that there are no conflicts of interest in relation to the publication of this manuscript.

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