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Bandung Urban Dense Built Environment: Its Contribution on Microclimate and Living Quality

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Abstract

Urban village (kampong) becomes the city morphology phenomenon, its growth is organic and has no land use planning adequate. The tendency of increasing local temperatures in various metropolitan cities with high density has led to urban heat island. This article is a comprehensive study aimed at describes micro-climate aspects of the urban built environment. Detailed discussion on aspects morphology of the urban village will describe its implications for the formation of the microclimate that affects residential quality. Nine locations of kampong in Bandung with was then taken into samples, namely: Sukajadi, Tamansari, Sukapada, Cigondewah Kidul, Cigondewah Rahayu, Cicendo, Babakan Ciamis, and Cihaurgeulis. Detailed and specific discussion on aspects of mass and building shape, distance between buildings, height of buildings and availability green open space provides particular information of the influence of physical aspects of morphology on the microclimate, especially the most important to the average radiation temperature (Tmrt), others, such as air temperature (Ta), humidity (RH), and wind speed (v). The quality of the living environment as indicated by the PET index (Physiologically Equivalent Temperature). The final result shows Cigondewah Rahayu with 31.2℃; 50.6%; 0,33m/s obtained PET = 35.9℃ with hot sensation. Based on the field measurement also find out that most of the nine kampongs are offering “warm” sensation living area, none of them have the “neutral,” “cool” or even “slightly cool” sensation.

Keywords: emergency medicine, instructional methods, Sudan

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1. Introduction

Based on Central Statistical Agency, Bandung is one of many cities in Indonesia with the largest population with 2,395,000 peoples [1] and Bandung in the top five cities with the largest population Tribunnews, 2018). This situation happens due to many factors, as well as population migration and high birth rates. In line with those factors, the need for decent housing is increasing. But this needs closely related to land issues and financial.

Obviously, the land is an integral part of the housing needs not likely to increase. It becomes worse with industrial development growth, which made the land for settlement is decreased. Financial also not an easy problem to deal for some people, especially people from low-middle income family. Therefore, on the grounds of land and economic efficiency, houses emerge without the support of precise mapping, concepts, and design. These houses were built with emergency funds and construction, so urban villages were formed.

Characteristics of an urban village are population based on the region, inadequate infrastructure, and poor buildings physical condition [2]. By these characteristics, it could be said that the houses are not well built; both architecturally and aesthetically. The distance between the houses is too close. So, air circulation often becomes a problem related to the health of residents. Besides the air circulation, houses that are narrow in size and poor ventilation also become a problem for the residents' health. In Indonesia, there are still 38,431 hectares of slum areas in 4,108 areas spread throughout the city/district [3]. Whereas in the city of Bandung, there were 121 villages / kelurahan, which were labeled as slum [4].

Besides, the physical condition of the house also affects the city patterns. Houses which are arranged together create density. So, that formed an irregular pattern and chaotic city. Green open space which part of healthy settlements is no longer considered. Without green open space, the microclimate in the city village could be affected. Not available green open space as a source of oxygen causes the air to exchange less pleasant and less perfect. If the houses are built by poor material which cannot absorb the heat well, it could change in temperature or temperature increase and cause urban heat island. Urban heat island is a phenomenon that usually occurs in large cities where temperatures at night are hotter than the temperature in the morning due to the reflection of heat by building materials [5].

Local diurnal temperatures in the West Bandung and North Bandung regions reach a maximum in the afternoon (at 4:00 p.m.) and higher than the morning temperatures. The difference between the afternoon and morning temperatures reached 6-11 ℃. This indicates the phenomenon of urban heat island has occurred in both regions. The increase in the average temperature of the city of Bandung also experienced a trend that has increased by 0.8 ℃ over the past 20 years [6].

Based on these, it is needed to examine the influence of buildings on microclimate in several urban villages. Changes in temperature have an impact on human health, both physically and psychologically.

2. Methodology

This study refers to the Bandung City RKP-KP database for urban villages with building density and physical environmental quality as the determination of research subjects. The city of Bandung located in $6^0$54' and $107^0$36' at 768m has a hot and humid climate with high precipitation that is an average of 223 mm a year [7]. The next step is to determine eight areas that have high levels of slums. Each research location (sub-district) will determine six measurement spots, and meteorological data will be measured from 6:00 am to 6:00 pm in 10 minutes intervals of each spot.

The aspect of physical area assessment is carried out by field measurements and through satellite map sequencing. Meteorological aspects are carried out by field measurements with two methods: fixed data is data from fixed weather stations that collect data in July - December (6 months), the second with mobile data that measures moving six spots in one city village and is repeated for three times. Figure 1 shows the study location spread in nine areas. The study was held on 6 May 2018 in Tamansari, 21 April 2018 in Sukajadi, 18 April 2018 in Cigondewah Rahayu, 2 June 2018 in Sukapada, 18 May 2018 in Cicendo, 21 April 2018 in Babakan Ciamis, 12 May at Cihaur Geulis, 1 May at Nyengseret, and 25 April in Cigondewah Kidul. The final result of this step is to analyze the pattern on the region's micro-climate map that has the potential for urban heat island formation.

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2.1. PET (Physiologically Equivalent Temperature)

PET is a standard that shows the temperature perceived by users that determines thermal comfort and microclimate in a specific area [8]. PET is calculated using the Rayman application by entering data such as air temperature (Ta), humidity (RH), and wind speed (v) [9], [10]. The microclimate as the data input to find the human perception for its biometeorology. Then, user data is also needed, such as type of activity, clothing, height, weight, and gender [11]. The range perception of PET as seen in table 1 based on the field experiment and measurement of 300 respondents in Taiwan with the climate characteristic as hot and humid [12].

3. Result and Discussion

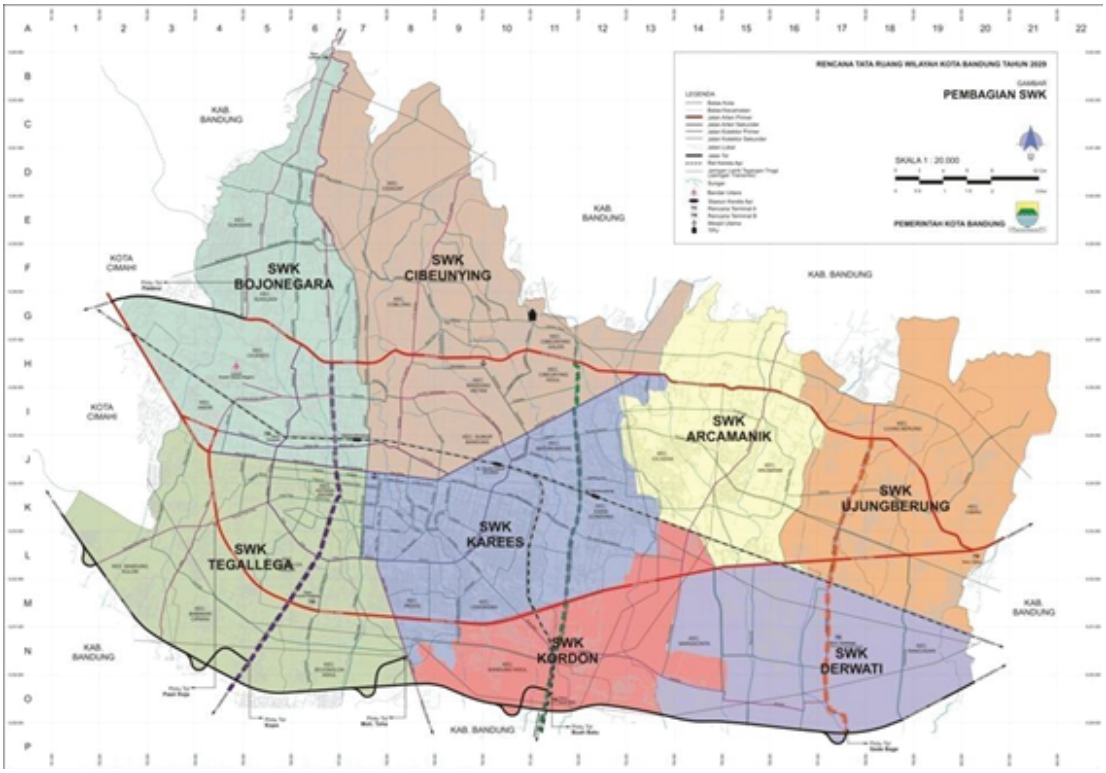

Figure 1: Area of measurement.

TABLE 1: PET range perception in a hot and humid climate region.

Thermal sensation	PET range for Hot-humid region (°C PET)
Very cold	<14
Cold	14-18
Cool	18-22
Slighty cool	22-26
Neutral	26-30
Slighty warm	30-34
Warm	34-38
Hot	38-42
Very hot	<42
Source: Lin, Matzarakis, & Hwang, 2010	

3.1. Sukajadi

Field measurement results show the same pattern between one point and another. The highest air temperature is 32 ℃ obtained from spot 1 from 10.00 to 12:00 a.m. For humidity, the graph tends to be inversely proportional to the air temperature. Humidity at 06.00 a.m. higher than humidity during the day, it reaches 82%. The calculation of PET from meteorological data in Sukajadi shown at table2.

Table 2: PET in Sukajadi.

Time	Ta (°C)	RH (%)	V (m/s)	PET(°C)	Perception
06.00	23	82	0,17	29	Neutral
09.00	29	59	0,26	34	Warm
10.00	32	56	0,10	36	Warm
13.00	27	66	0,45	30	Slightly warm
14.00	29	60	0,37	33	Slightly warm
16.00	26	74	0,22	32	Slightly warm

3.2. Tamansari

The measurements are carried out in five rounds. The highest air temperature is at spot 6, which is 31°C from 10.00 a.m and 13.00 a.m. While the humidity in the morning tends to be higher than humidity in the afternoon to late afternoon. The highest humidity is in spot 5, which is 73% at 06.00 a.m.

Table 3: PET in Tamansari.

Time	Ta(°C)	RH(%)	v(m/s)	PET(°C)	Perception
06.00	22	73	0,00	31	Slightly warm
10.00	31	45	0,24	35	Warm
11.00	30	46	0,11	34	Warm
13.00	31	44	0,29	34	Warm
14.00	30	47	0,10	34	Warm
16.00	27	61	0,10	31	Slightly warm

3.3. Sukapada

The microclimate data in Sukapada from seven rounds measurement shows air temperature reaches its peak at 1:00 p.m, which is 33 °C. While the humidity in the morning tends to be higher than the humidity in the afternoon until late afternoon. The highest humidity is at spot 4, which is 77% at 06.00.

Table 4: PET in in Sukapada.

Time	Ta(°C)	RH(%)	v(m/s)	PET(°C)	Perception
06.00	23	77	0,04	32	Slightly warm
09.00	28	62	0,54	32	Slightly warm
10.00	30	55	0,35	34	Warm
13.00	33	50	0,56	36	Warm
14.00	32	49	1,04	35	Warm
16.00	29	58	0,43	33	Warm

3.4. Cigondewah Kidul

The measurement within seven rounds collects data in Cigondewah Kidul shows that the highest air temperature is at spot 2, which is 28°C at 10.00 a.m. Meanwhile, the highest humidity is at spot 3, which is 84% at 04.00 p.m.

TABLE 5: PET in in Cigondewah Kidul.

Time	Ta(°C)	RH(%)	v(m/s)	PET(°C)	Perception
09.00	27	69	0,19	33	Slightly warm
10.00	28	65	0,35	32	Slightly warm
13.00	27	70	0,48	30	neutral
16.00	23	84	0,36	27	neutral

3.5. Cigondewah Rahayu

The measurement in Cigondewah Rahayu takes five rounds. The air temperature reaches its peak at spot 2 in 01.00 p.m with 32°C. The highest humidity is at point 3, which is 71% at 06.00.

TABLE 6: PET in in Cigondewah Rahayu.

Time	Ta(°C)	RH(%)	v(m/s)	PET(°C)	Perception
06.00	25	71	0,25	31	Slightly warm
09.00	30	56	0,21	35	Warm
10.00	31	51	0,33	36	Warm
13.00	32	54	0,91	34	Warm
14.00	30	52	1,40	32	Slightly warm

3.6. Cicendo

The measurement collects the data within four rounds in Cicendo. The highest air temperature was at spot 1, which was 32°C at 02.00 p.m. While the humidity in the morning tends to be lower than humidity in the afternoon to late afternoon. The highest humidity is at spot 4, which is 82% at 04.00 p.m.

3.7. Nyengseret

Nyengseret got the meteorological data from four rounds measurement. The highest air temperature is at spot 6 with 33°C at 02:00 p.m. While the humidity in the morning

Table 7: PET in Cicendo.

Time	Ta(˚C)	RH(%)	v(m/s)	PET(˚C)	Perception
06.00	24	76	0,40	29	Neutral
09.00	31	53	0,36	35	Warm
10.00	30	54	0,66	32	Slightly warm
11.00	30	53	0,26	33	Slightly warm
13.00	29	70	0,09	34	Warm
14.00	32	54	0,48	36	Warm
16.00	25	82	0,17	31	Slightly warm

tends to be higher than humidity in the afternoon to late afternoon. The highest humidity is at spot 5, which is 74% at 03:00 p.m.

Table 8: PET in Nyengseret.

Time	Ta(˚C)	RH(%)	v(m/s)	PET(˚C)	Perception
6:00	24	79	0,12	28	Neutral
8:00	30	65	0,15	32	Slightly warm
11:00	30	61	0,44	34	Warm
15:00	31	65	0,28	34	Warm

3.8. Babakan Ciamis

The measurement in Babakan Ciamis takes five rounds. The highest air temperature is 30˚C from 10:00 a.m. to 02:00 p.m. While the humidity in the morning tends to be lower than humidity in the afternoon to late afternoon. The highest humidity is in spot 5, which is 75% at from 06.00 until 09.00 a.m.

Table 9: PET in Babakan Ciamis.

Time	Ta(˚C)	RH(%)	**v**(m/s)	PET(˚C)	Perception
6:00	24	75	0,03	32	Slightly warm
10:00	30	54	0,18	35	Warm
11:00	30	52	0,19	35	Warm
14:00	30	58	0,17	34	Warm
16:00	28	68	0,21	34	Warm

3.9. Cihaur Geulis

The measurements in Cihaur Geulis collect data in five rounds. The highest air temperature is at spot 6, which is ˚C at 11.00 a.m. While the humidity during the day tends to have similar value from 09.00 a.m. to 11.00 a.m. The humidity in the morning and

afternoon are higher than humidity in the day. The highest humidity is in spot 5, which is 74% at 05.00 p.m.

TABLE 10: Calculation Data in Cihaur Geulis.

Time	Ta(°C)	RH(%)	v(m/s)	PET(°C)	Perception
06.00	24	62	0,00	32	Slightly warm
09.00	30	59	0,39	34	Warm
10.00	30	58	0,53	33	Warm
11.00	33	59	0,23	37	Warm
17.00	26	74	0,32	31	Warm

4. Conclusion

Study on the urban dense built environment in Bandung gives the understanding of microclimate and living quality. Overall, from a total of 54 PET data, 9% of PET offers “neutral” perception, 37% of PET offers slightly warm and finally, 54% of PET offers “warm” perception. The results confirm that most of the nine areas are offering “warm” sensation of living area; none of them have the “cool” or even “slightly cool” sensation. The built environment impact on microclimate more significant compared with the atmospheric condition based on geographical location. The hilly area with altitude 687masl and average temperature 28 ℃ does not become significant enough to offer “slightly cool” or “neutral” perception. It is also found that the highest PET value is 37℃ at 11.a.m.

This study describes the microclimate in several areas showing a similar pattern. In general, the diurnal of humidity in the morning tends to be higher than in the afternoon and late afternoon. The afternoon air temperature shows a higher value than the morning air temperature that contributes to urban heat island phenomena in the urban area.

Compared to the previous study in 2013, where the peak dry season in Bandung was from July to August, there were significant changes in the weather. Solar radiation from the temperature of the black ball, in previous studies, shows that the main factor that increases Tmrt (average radiation temperature). In this study, high humidity is a significant factor that increases the perception of PET.

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