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The Correlation of Urban Heat Island in Tropical Middle-Class Housing

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Abstract. A very limited number of green and sustainable construction studies have explored factors related to Urban Heat Island (UHI) in tropical middle-class housing. This paper aimed to investigate the correlation of Urban Heat Island in tropical middle-class housing in three urban housing for middle-class residents of Palembang, which were Taman Sari Kenten, TOP Jakabaring, and Talang Kelapa. Samples consisted of 125 Taman Sari Kenten housing, 27 Talang Kelapa housing, and 12 TOP Jakabaring housing. Independent variables were the resident density, socioeconomic status, house location, roof type, green area ratio, weather, time, air conditioner, pro-environment institution, and NEP scale. The Analytic method included correlation and regression. We identified that all housing had different UHI profiles where Taman Sari Kenten had the highest UHI (4.17 K), followed by Talang Kelapa (2.66 K) and TOP Jakabaring (0.66 K) against temperature in measuring station nearby, owned by BMKG (National Meteorological Station). UHI correlated with the resident density, roof type, green area ratio, weather, time, and air conditioner. The results should add to the design of ideal housing in the tropical climate for middle-class residents, focusing on its ability to mitigate Urban Heat Island.

1. INTRODUCTION

Urban development and growth have a positive effect on environmental temperatures, especially in areas with high density. This phenomenon is referred to generally as Urban Heat Island (UHI). UHI impacts on the low outdoor comfort in urban areas [1]. Human behavior becomes relatively more aggressive at warmer temperatures. At its peak, UHI is too high can result in death due to heat problems, particularly in the elderly and the vulnerable population living in urban areas [2]. In tropical areas like Indonesia, common mitigation consumes more electricity for cooling room purposes [3]. Room cooling precisely results in increased UHI outdoors due to excess heat emissions from inside the building being cooled to the outside [4]. As a result, the most vulnerable are low-income people who cannot buy and use an air conditioner.

Linearly, UHI can be stated as the sum of the contribution of surface radiation balance (R), the efficiency of convection (H), evapotranspiration (LE), heat storage (s), and anthropogenic heat (AH) [5].These sources can be physically described as radiation factors that come directly from the sun, air convection factors in the environment by roughness, the evapotranspiration factor coming from the materials present in a place, the heat-storage factors coming from man-made buildings, and anthropogenic factors released by human activities.

These physical factors are represented by variables of resident density, house location, roof type, green area to build area ratio, weather, time, and air conditioner ownership. Resident density encourages an increase in anthropogenic heat because each resident has its own energy needs that contribute to UHI. House location determines geometry and shapes, which in turn determines UHI by modifying convection, surface radiation, evapotranspiration, and heat retention. House in more open location has more degree of freedom to make extensions and other shape modification to influence local heat profile. Roof type also brings the same mechanism into effect. Green to built area ratio influencing UHI by increasing convection efficiency and evapotranspiration [6]. Weather influences heat profile environment, as well as the daily timing variation [7]. Air conditioning provides a feedback mechanism leading to the increase of heat to the environment outside the cooled area [8].

From the perspective of environmental sociology, factors that cause UHI not only from physical factors. POET Model (People, Organization, Environment, Technology) formalized by Duncan in 1959 identified the key factors causing environmental problems are population, social organization, and technology, which is also interconnected each other [9]. Canan [10] suggests that in the scope of policy impacts, it is good that POET model resolutions are developed larger to POETIC by adding Institution and Culture elements.

In the POET model, the population is the number of organisms in an ecosystem. It is clear that the increasing number of organisms, the greater the pressure this quantity is given to the environment. The social organization is how this population is structured. The general indicators used in the POET study include demographic characteristics such as socioeconomic status and power which is a political status [6]. Examples of indicators organization are income and education. Tang et.al. [11] found that socioeconomic status had an indirect impact on UHI. This happens by making changes to the physical environment that become the determinant of UHI improvement. On the other hand, UHI also gives effect to certain demographic groups such as age [2]. If UHI is applied as an Environmental component within the POET framework, then it appears that the Environment component is influential and influenced by the Organization component.

However, these indicators only look at non-formal aspects and more on the individual characteristics of members of the population, rather than how members of the population develop more formal and targeted structures on group characteristics. These two neglected aspects can be captured by Institution and Culture concepts. An Institution is an organizational form of the organism that is formal and can work more effectively and efficiently than a combination of individuals working individually, as in indicators of demographic characteristics. Meanwhile, Culture became the largest social organization which can play an important role in a modern environment in which many individuals from different cultural backgrounds together in one population. Technology, although some people see it as a cultural element, can be separated independently as a tool used by humans to manipulate the environment.

The population, together with its social organization, including institutions and cultures, and technology, are in an environmental context. The neighborhood can be conceptualized as a proportion between the natural environment and the built environment. USDA uses 16 environmental classifications based on the proportion of the built environment on the natural environment [12]. The writer simplifies this classification into three namely the natural environment, the transitional environment (which is a transitional form between the natural environment and the built environment), and the built environment. The writer also adds a social environment, namely the social environment (the relationship between individuals or between groups of individuals) in a population.

This concept is distinguished by social organizations for the social environment is individual in an interpersonal relationship from one person to the other and not at the individual level as pure as Organization, the level of formal groups such as the Institution, and the macro-level informal groups such as Culture.

The concept of the social environment leads to a model of social contamination. The model of social contamination sees that neighbors living close together can influence each other and give cumulative effects based on majority power. Therefore, a lowly educated person may behave like a highly educated person if he or she associates with highly educated neighbors. Therefore, a lowly educated person may behave like a highly educated person if he or she associates with highly educated neighbors [10]. Pollution caused by social environment depends on time because it is observed from behavioral changes in a certain time interval [11].

The built environment is a building environment created by humans in a population. Oke [15] refers to it as a structural factor consisting of the geometry of the valley of the city, the distance from the city center, or the height-to-width ratio of the building or the road, and the cover factor which is the ratio between the built areas to the green areas. Oke [15] and [16] states a significant association of the proportion of built areas and green areas on UHI intensity. Zhao et al [5] found that the roughness of the building's surface is related to UHI. The roughness here is the aerodynamic roughness that means the material has a rough shape that provides aerodynamic resistance. For example, trees are rough because they have irregular shapes compared to glass and man-made building surfaces.

The modified environment and the natural environment are the other parts of the spectrum of human influences in their environment. The built environment is an environment completely shaped by humans, while the natural environment is not an environment completely shaped by humans. The modified environment lies between these two extremes.

McKitrick [17] justifies that sociological parameters (referred to as socioeconomic signals) can be used to predict UHI. The study involved multiple regressions on physical variables such as temperature, sea surface pressure, a proportion of dry areas, proximity to coastal, latitude, and sociological data such as Gross Domestic Product (GDP), education level, population, income, and coal utilization. However, McKitrick's study [17] is not based on a particular theoretical framework. In addition, the scope of the study is urban level with a sample of 20 cities in Canada. The above description provides an important empirical research that can be filled by this research.

2. METHODS

1.1. Location of Research

The research was conducted in the form of surveys by taking physical measurements of the physical environment and submitting questionnaires to measure aspects of the social environment, population, organization, technology, institutions, and culture. The research was conducted on three selected housing in Palembang City namely Talang Kelapa Housing, TOP Jakabaring, and Taman Sari Kenten housing.

1.2. Measurements

POETIC model is operationalized in a number of variables. Element P that reflects the population is approximated by the number of residents. The variable number of residents in this research can be included directly as independent variables are representative of the population. However, the number of residents should be standardized according to the volume of the house. Because a big house with many residents will be different from a small house with many residents. A big house with many residents does not provide heat for a small house with few residents. Therefore, we approached the population variable with the residents density, i.e. the ratio of the number of residents to the volume of the house. The population variable in this study was approximated by the ratio of the number of residents of the house to the volume of the house. The number of residents of the house was measured by a direct survey to the respondents' houses while the volume of the house was measured using a meter for length and width dimension and laser distance meter to measure the height dimension.

Element O or socioeconomic status includes income and education level. In essence, socioeconomic status refers to members of society status. Income and education are declared a status, but more powerful if both are put together as a complete variable. A person with a low income but higher education has not aligned status with high income and high education. Similarly, people with high income but low education has not aligned with people with high income and high education. The complete variables should bring these two factors together. Researcher formed a new variable was the socioeconomic status variable that was multiplication between education level with individual income. A high value of this variable meant a person has a high education as well as high income as well. The value was logarithmically stated to normalize the distribution given the income can be very high (reaching tens of millions) while the highest education was only 7 (post graduate). Socioeconomic status in this study was measured by the logarithm multiplication between education levels and income levels. Both indicators were obtained by direct surveys of homeowners.

Element E included four types of environments: social, waking, transitional, and natural. On the other hand, the study [5] divided environmental factors into five factors: radiation factor (meteorological and albedo), convection factor (surface roughness), evapotranspiration factor (plant and water), heat storage factor (building), and anthropogenic factor (industry, transportation). The radiation factor would be represented by the natural environment, the convection factor represented by the built environment, the evapotranspiration factor by the transitional environment, and the anthropogenic factors by the social environment. The heat storage factor was not used because the study was conducted during the day and the heat saving effect did not appear at this time [5].

The social environment could be represented by the location of the house because the location determined how the intensity of social interaction between residents and neighbors. The location can also be independent of socioeconomic status. People do not specify location based on population and socioeconomic status. High-status people can stay in the periphery by reason of proximity to the highway and easy to mobilize. But high-status people can also choose to live in the interior for reasons of solitude and quietness from vehicle frenzy and for security reasons, at the expense of mobility. This variable was measured directly by looking at the relative position of the house in the property map.

Meanwhile, the most representative modified environment was the ratio of the green areas to the built areas [15, 16]. This variable was the most representative of the environment because it reflected the strength of the green environment that has long been considered to be significantly related to the intensity of UHI. This variable was measured in the same way as home volume measurement.

Meanwhile, for technology, the researcher used the breadth of energy factor, i.e. multiplication between ownership of air conditioner with the volume of the house. Institutions were approached with the presence of family members who work in education, health, comfort, and trade. Cultural indicators used in this study was an environmentally friendly culture, were measured using NEP scale (New Environmental Paradigm) that was commonly used to measure the orientation of pro-environment [18].

Questionnaires survey were conducted during the measurement of physical indicators. Questions included income, the number of population in the house, the level of education, ownership of air conditioning, profession and membership institutions of education, health, comfort, and trading of household members, and NEP questionnaires. NEP questionnaires conducted according to the procedures of collecting data by questionnaire in which half of the questionnaires were given a score in reverse.

1.3. Analysis of Data

Data analysis was done by bivariate correlation analysis. Bivariate correlation analysis was performed using Pearson correlation analysis to test the association between variables in POETIC components because these variables were associated with factors affecting UHI. Recently conducted regression analysis to see the effect of each factor simultaneously on UHI intensity were observed.

2. RESULTS AND DISCUSSION

2.1. Description of Data

The initial plan was collecting data from all existing houses, 125 houses in Taman Sari Kenten, 50 houses in Talang Kelapa, and 40 houses in TOP Jakabaring. However, some residents refused to fill data or filling in incomplete data, so it was difficult to meet this target. Except for residents in Taman Sari Kenten housing that filling the data completely. As a final result, the measurement was successfully performed on 215 houses, consisting of 125 houses in Taman Sari Kenten, 27 houses in Talang Kelapa, and 10 houses in TOP Jakabaring.

The majority of measurements were made in clear weather, while 55 houses were measured in cloudy weather. The weather at the time of measurement can be seen in Table 1.

TABLE 1. The weather at the time of measurement in three housing.

	N	Clear	Cloudy	Overcast
Taman Sari Kenten	125	121	1	3
Talang Kelapa	50	1	37	12
TOP Jakabaring	40	0	0	40
Total	215	122	38	55

Temperature measurements were conducted in the afternoon at 03:00 p.m. – 03:59 p.m. i.e. 50 measurements (23.3%). Measurements in Taman Sari Kenten housing were the most varied from 9:00 a.m. to 04:00 p.m. The most measurements were conducted at 10:00 a.m. - 10.59 a.m. as many as 48 measurements (38.4%).

Measurements in Talang Kelapa only lasted three hours are between 02:00 p.m. to 04:59 p.m. Similarly, measurements were made in the TOP Jakabaring housing.

TABLE 2. Measurement time in three housing

	N	Minimum	Maximum	Most Measurements	Number of Measurements
Taman Sari Kenten	125	09:00 a.m.	04:00 p.m.	10:00 a.m.	48
Talang Kelapa	50	04:00 p.m.	04:00 p.m.	03:00 p.m.	26
TOP Jakabaring	40	02:00 p.m	04:00 p.m.	02:00 p.m.	25
Measurement Time	215	09.00 a.m.	04:00 p.m.	03:00 p.m.	50

The average temperature difference was obtained by calculating the difference between the temperature of each house and the temperature of the measuring stations BMKG (Meteorological, Climatology and Geophysics) of Palembang at the same time and date. The measurement station of BMKG of Palembang City was a meteorological station which became the standard for the average temperature measurement whole city of Palembang. In this way obtained the difference between the housing temperature and the average temperature of Palembang. The positive difference reflected that the measured housing has had a higher temperature than the average of Palembang, indicating the occurrence of UHI phenomenon.

The difference in average temperature in Taman Sari Kenten was 4.174 ° C, while for Talang Kelapa was 2,656 ° C and Top Jakabaring was only 0.662 ° C. These results indicated that Taman Sari Kenten was a micro hot dome in suburb of Palembang. While TOP Jakabaring Housing was a micro hot pool. This was interesting because actually it was Taman Sari Kenten which was located outside of Palembang. TOP Housing Jakabaring had the lowest temperatures due to its relatively cold condition surrounding lands still in the form of swamps.

TABLE 3. Average temperature and UHI of each housing.

No	Housing	temperatures average	UHI Average	Standard Deviation UHI
1	Taman Sari	32,15	4,174	1,330
2	Talang Kelapa	31,49	2,656	1,248
3	TOP Jakabaring	27,01	0,662	0,487

The resident Density was measured by the number of people per house volume. Table 4 showed the description of the housing population of each housing.

TABLE 4. The population description of each housing.

	N	Minimum	Maximum	Mean	Std. Deviation
Taman Sari	125	2	7	4,42	1,193
Talang Kelapa	27	3	8	4,78	1,311
TOP Jakabaring	12	3	6	4,25	1,055
House Population	164	2	8	4,46	1,205

The average resident in a house was 4 people if all the houses were calculated, while if viewed per housing, housing with the densest populated housing was Talang Kelapa, close to five people per house. The fewest residents were two people who live in Taman Sari Kenten housing and three people for Talang Kelapa and TOP Jakabaring.

The resident density was the ratio between the number of residents on the house volume (length x width x height). The unit length and width were meters while the unit height was the floor. The size of the house (length x width) average was 85.96 m2 with variations ranging from the smallest was 32.8 m2 which only exist in one house to 210 m2 in two houses. The largest proportion was 21 houses with an area of 72 m2. House height is only two variations i.e. one floor (179 houses or 83.3%) and two floors (26 or 12.1%). The smallest house volume was 32.8 m2. The highest temporary floor was 384 m2. The residents density ranging from 0.013 people per m2. to 0.213 people per m2. The average of residents density was 0.0536 people per m2. As mentioned previously, the density was still under very satisfactory because it exceeds international standards, especially by entering the house as a unit level variable divider in this density.

TABLE 5. The density of residents in three housing.

	N	Minimum	Maximum	Mean	Std. Deviation
Taman Sari	125	0,013	0,213	0,05279	0,026023
Talang Kelapa	27	0,016	0,111	0,05538	0,021738
TOP Jakabaring	10	0,027	0,113	0,05962	0,024182
Density	162	0,013	0,213	0,05364	0,025177

Recorded 112 respondents stated their income. The income data showed the average income was IDR 4.27 million with the largest proportion of respondents having income IDR 3 million (9.3%). The lowest income of respondents was IDR 1 million which was stated by 8 respondents (3.7%) while the highest income was IDR 30 million stated by one respondent (0.5%).

TABLE 6. Average incomes and standard deviation.

	N	Minimum	Maximum	Mean	Std. Deviation
Income	112	1,0	30,0	4,273	3,4985

The highest level of education at home most survey respondents was a high school with answering by 83 (38.6%) respondents. The lowest education was a primary school with answering from 3 (1.4%) respondents and the highest education was postgraduate which was answered by 8 (3.7%) respondents. The households with the lowest average education, elementary school, one of which has a population of 6 people in one house. This showed that many residents were children while both parents were old and from the old generation who had low education level.

TABLE 7. Residents status in three housing.

	N	Minimum	Maximum	Mean	Std. Deviation
Taman Sari	108	0,00	5,01	2,5727	0,88669
Talang Kelapa	0	0	0	0	0
TOP Jakabaring	4	1,10	2,01	1,5466	0,37519
Residents status	112	0,001	5,011	2,53604	0,893463

The house's location was encoded into two peripheral and core. A survey was only done in Taman Sari Kenten housing. 91 or 72.8% of houses were located in the core area, defined as the area surrounded by other houses in Taman Sari Kenten housing. The remaining 27.2% or 34 houses were peripheral houses located on the outskirts of the housing. There was no difference between the two types of locations based on UHI levels.

There were four types of roofing materials that were found in housing projects namely asbestos, tile roof, multi roof, and zinc. Based on contour level, each coded 3 for asbestos, 2 for tile, and 1 for metal and zinc. The majority of houses used asbestos cover (97 pieces or 45.1%). The least cover was metal and zinc, with a frequency of 12 pieces or 5.6%. It could be seen that the characteristics of Taman Sari Kenten were very different from the Talang Kelapa and TOP Jakabaring. The Taman Sari Kenten housing had tile roofs while Talang Kelapa housing and TOP Jakabaring had asbestos roofs.

TABLE 8.The three types of residential roofing.

	N	Asbestos	Tile Roof	Metal and Zinc
Taman Sari	124	34	86	4
Talang Kelapa	48	42	3	3
TOP Jakabaring	27	21	1	5
Total	199	97	90	12

The built area covered a certain proportion of the land area as well as the green area. However, the green area was not the difference between the land areas and the built areas. Because there was an open space that was not green, it was covered by cement or other ground covers. In total there were houses with a green area up to two times larger than the house areas. But on average, the green areas only reached 18.43% of the house areas. In other words, the average house in a residential sample had a ratio of green areas of the built areas around 1 to 5. The minimum value of 0 indicated fully the built areas without having green areas.

TABLE 9. The ratio of green areas to the built areas.

	N	Minimum	Maximum	Mean	Std. Deviation
Taman Sari	125	0,00	2,27	0,1415	0,37342
Talang Kelapa	0	0	0	0	0
TOP Jakabaring	30	0,03	0,86	0,3627	0,14124
Total	155	0	2,267	0,18429	0,351742

Energy data was only obtained from Taman Sari Kenten housing. In terms of use of air conditioner, 64 or 51.6% did not use air conditioner while the remaining 48% used the air conditioner. The minimum energy was 32.8 while the maximum energy was 760.0 with an average of 153.5 and a standard deviation of 111.3.

Questions of the institutions were yes and no options. For educational institutions, 17 (7.9%) respondents claimed to be active in education, either as teachers, lecturers, or instructors/tutors. Health institutions were 8 (3.7%) respondents. 4 (1.9%) respondents worked in the field of comfort. The largest proportion was in the field of trade which was 79 or 36.7% respondents. The minimum institutional value was 0.5 indicating that family members had only trade institution. The maximum value was 4 in two families. One of them had family members who worked in health as well as comfort, while others had family members worked in health and education.

The culture in this research was measured by NEP scale questionnaires. There were 129 valid answers from respondents. The minimum value was 13, maximum 36, and an average of 21.99. The Standard deviation of respondents' answers were 4.58. Almost all of the answers came from Taman Sari Kenten. There were only 5 answers given by respondents from TOP Jakabaring housing.

2.2. Correlation Analysis

Researcher tested the correlation on all independent variables by controlling two variables, weather and time. This was conducted because both types of variables were natural environmental variables whose variations would not theoretically depend on the other independent variables.

Table 10 showed the calculation of first order partial correlations by controlling weather factors.

TABLE 10. Calculation of correlation between POETIC variables with weather and time control (X6 and X7).

Var	X1	X2	X3	X4	X5	X8	X9
X1	1						
X2	-0,270**	1					
X3	-0,044	0,104	1				
X4	0,292**	-0,233*	-0,122	1			
X5	0,439***	-0,089	0,276**	-0,127	1		
X8	-0,560***	0,448***	-0,002	-0,329**	-0,201	1	
X9	-0,028	0,128	-0,071	-0,063	-0,107	-0,016	1
X10	0,210**	-0,180**	0,036	-0,007	0,096	-0,155	-0,193

Description:
X1 = resident density
X2 = socio-economic status
X3 = house location
X4 = roof type
X5 = ratio of green area to the built area
X8 = air conditioner
X9 = pro-environment institution
X10 = environmental paradigm (NEP scale)

Table 10 showed that there were several independent variables which were linear combinations with each other. Each pair of these variables included:

1. The socioeconomic status was correlated with residents density.
2. The smaller the resident density, the greater the socioeconomic status of the resident. This result was reasonable because people with high socioeconomic status could achieve that status without a financial burden of life dependents. This correlation in its greatest form could be seen in the differences between developed and developing countries. In developed countries, small population density while developing countries with a dense population.
3. Type of roof correlates with resident density and socioeconomic status
4. Houses with large populations tended to use rough roofing materials (asbestos) while people with high status tended to use smooth roofs. This result was reasonable considering the price of rough roofing materials tended to be cheaper than smooth roof.
5. The Green Area Ratio to the Built Area correlates with the residents density
6. The higher the resident density, the higher the ratio of green areas to the built area. This result could be explained by the inability of low socioeconomic residents to convert their green areas into the built areas. In fact it could be said they make the green areas

abandoned to expand green areas. This result confirmed the view that actually the most socioeconomic populations who contributed to UHI as it tended to convert the green areas into the built areas.

7. Green Area Ratio to Built Area correlates with House Location
8. Among geographic factors, house location was the variable most likely to be representative because it was independent of population and organization, shown in the correlation results above. People did not specify location based on population and socio-economic status. High-status people could live in the periphery by reason of proximity to the highway and easy to mobilize. But high-status people could also choose to live in the interior for reasons of solitude and quietness from vehicle frenzy and for security reasons, at the expense of mobility. However, location variables correlated with the ratio of green areas to positively built areas. The more in peripherals, the greater the green area of the residents. These results indicated that more trees were on the periphery of housing rather than in the middle of the housing.
9. The air conditioner correlates with the resident density
10. The smaller the resident density, the greater the use of cooling. This could be explained also by the high socio-economic to buy coolers to cool large houses. We would not be surprised if technology was also positively correlated with the organization.
11. The air conditioner correlates with the socioeconomic status
12. The higher the socioeconomic status the greater the use of cooling. It has been described above that this was a logical consequence of the negative correlation between technology and population, since houses with small populations were houses with high socioeconomic.
13. The air conditioner correlates with the type of roof
14. Houses with cooling technology tended to use smooth roof. In line with the residents' financial to buy smooth roof that was more expensive than roof rough.
15. The environmental paradigm correlates with resident density and socioeconomic status.

The more people followed the pro environmental paradigm, the more they had residents density, but on the other hand, the more they were in low socioeconomic status. This confirmed that the most environmentally conscious population was the middle to lower class population. However, their economic characteristic became the constraint of realizing this paradigm into behavior. It could be seen from the resident density positive correlation with pro-environmental paradigm. It could be interpreted if the lower middle-class economy had a desire to live in a healthy and comfortable environment, but in reality, they lived in the opposite situation.

2.3. Regression Analysis

Furthermore, a regression analysis was conducted to look at what variables were associated with UHI intensity in the research sample. The following table showed the results of the research regression analysis.

TABLE 11. UHI POETIC Factors that affect the intensity of UHI

Simbol	Variables	Beta	Sig
X1	Residents density	24,525	***
X2	Sosioeconomi status	-0,089	0,587
X3	House location	0,1	0,745
X4	Roof type	-0,613	*
X5	Greean area ratio to the biult area	-0,749	*
X6	Weather	-1,408	***
X7	Time	0,916	***
X8	Air conditioner	0,003	*
X9	Pro-environtment institution	0,106	0,595

X10	Environtment paradigm	0,009	0,33
	R^2	0,659	
	Adjusted R^2	0,612	
	F	13,874	***
	N	125	
	Standard error	1,194	

The results showed that the elements of Population (X1), Environment (X3, X4, X5, X6, and X7), and Technology (X8) influenced UHI while Organization (X2), Institutions (X9), and Culture (X10) did not significantly influence. Theoretically, the findings of this study showed that from six elements of POETIC, only elements P, E, and T were related to the housing environment.

This element seems to be related to the development of Palembang as an industrial city in developing countries. In agrarian times, the environment was entirely linked to the human population (PE) because humans did not have yet found technology that was meaningful enough to change the environment on a large scale. The industrial era introduced technologies that in turn raised the role of technology in changing the environment. The development of Air Conditioning technology, for example, allowing people to buy more and more this technology along with the income of some members of the community increases and the need to get a comfortable microclimate.

Therefore, at this stage, PE had turned into PET. In developed countries, human social organizations such as education and other socioeconomic status began to go because of income stratification due to the industrial revolution. Different social levels provided different relationships to the environment and hence, go elements of Organizations in PET model to POET. The presence of element O in this research was actually facilitated because the population (P) allowed for both status and culture as well, according to the results of correlation analysis. However, their relationship was not direct, in contrast to the population, technology, and environment that was relatively direct in influencing UHI.

Based on results and explanations that Organization, Institutions, and Culture did not significantly influence which reflected the unavailability of Palembang at a stage that allows the social elements to play a role in UHI. Socioeconomic status of society was not sufficiently different that gave meaning to environmental change. Likewise, the institutions in the society did not have awareness for sustainability nor exploiting the environment unsustainably. Meanwhile, an environmentally conscious culture have had not yet been established. This culture was also not very exploitative, possibly because of the standard collective consciousness to not leave a too big impact on the environment.

Furthermore, the results confirmed the importance of PET to be developed into POETIC in order to produce an optimum influence on the decline of UHI. Regression results reflected that Palembang have had not been optimal in directing social elements in efforts to mitigate UHI. Pro-environmental institutions have not focused on the reduction of UHI, as well as cultural and socioeconomic status. Meanwhile, population and technology have had positive effects on UHI, meaning that these variables have had negative effects on UHI mitigation.

In the global era, researcher viewed POET as insufficient and it should include elements of institutions and cultures in addition because societies with different cultures and institutions put different environmental pressures. Therefore, POET model developed into POETIC. In Palembang case, however, the environmental model is still at PET level and will soon become POETIC as environmental awareness and sustainable development are growing. However, cultural diversity is still very small since the community generally comes from Palembang itself with its own perspective on the environment, as evaluated using the NEP questionnaire.

The final POETIC model successfully formulated as a model for explanation of UHI phenomena. In this research reflected the three main factors that affected the UHI namely population, technology, and the environment. These results reflected the lack of representation of Organizational, institution, and Cultural components. However, the researcher did not see this was a theoretical weakness, but as a situation that should be improved by society and government. In other words, the POETIC model was a normative model in which the ideal living environment should be related by every POETIC element that encourages the environment for the better. If the OIC has not been significantly related, then this meant that society needed to be encouraged to optimize these elements, rather than blaming Duncan and his successors as the creators of the wrong frame of mind. Their theory was too general that anything could be included as an indicator of each element and someone will find a significant relationship with a particular phenomenon.

The above results identify a number of methods to improve the situation of the Urban Hot Dome in Palembang. In addition to confirming the effect of population and technological factors, this research confirmed that roof level contours were important for UHI. Development should pay close attention to the problem of roof selection. The preferred roofing material was a contoured roof. The best consideration fell on the green roof, which was a decrease UHI intervention that provided the greatest side benefit. In addition, interventions at the level of housing were suggested in the form of construction of water bodies, either moving or silent.

Green roof interventions were physical interventions that had an effect on psychosocial considers. The immediate effect of a decrease UHI was a feeling of comfort. Other effects included increasing social attachment and decreasing aggressiveness. It has not yet taken into account the economic increase for residents, developers, or the government in the form of increased value or otherwise, cost savings.

Meanwhile, the developer must also provide water bodies in the residential area. This water body could be linearly flowing like a river or radial static like a lake. Green roofs along with artificial water bodies would decrease UHI simultaneously while increasing the economic value and replacing the loss of vegetation and swamps due to the construction of house clusters.

3. CONCLUSIONS

Recently, scientists have stated that 2016 was the warmest year in the last 115 thousand years, beating the record set in 2015, the year which also beat 2014 [16]. By consensus, this increase was attributed to human behavior. Its impact has been clearly observed with increasing frequency of floods, droughts, storms, and forest and land fires.

It would be more problematic for Palembang where UHI occurred at an alarming level. Moreover, the dry season brought an increase in UHI through the strengthening of smoke haze in Palembang. As a result, as UHI rise, the risk of higher heat waves, higher aggressiveness, lower population productivity, and lower public health status.

The physical intervention was also affecting on psychosocial considers. The immediate effect of a decrease UHI was a feeling of comfort. Other effects included increasing social attachment and decreasing aggressiveness. It did not take into account the economic increase for residents, developers, or the government in the form of increased value or vice versa, cost savings. Developers should build houses with relatively flat roofs that allowed plants to be planted on the roof of the house as green roofs. If the roof should be sloped, then the house should be designed with terraced so that the upper terrace could be used to be a green roof. Meanwhile, the developer must also provide water bodies in the residential area. This water body could be linearly flowing like a river or radial static like a lake. Green roofs along with artificial water bodies would decrease UHI simultaneously while increasing the economic value and replacing the loss of vegetation and swamps due to the construction of house clusters.

In line with the above, local governments needed to issue new regulations that fix problems Building Permit and Eligible Certificate Award Function today, so that interventions could be established and could be applied to all new buildings in Palembang. This new regulation added an index of levy calculation with a roofing material index. The new regulations should also provide development terms by using a green roof at least 10% of flat roof area. In addition, housing should be required to have a water body with a certain area, either in the form of flowing or calm, with the purpose of cooling residential complex.

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