

ENVIRONMENTAL COMPONENTS IN POETIC MODEL: PALEMBANG URBAN HEAT ISLAND CASE STUDY

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ABSTRACT

Urbanization has opened urban thermal comfort zones thereby creating an urban island environment worldwide. Knowledge necessary to mitigate this phenomenon extend beyond knowledge on the city itself. This study sought to determine the role of environments in creating an urban heat island. A literature review was applied, to collect current knowledge on social, built, modified, and natural environment, in POETIC framework. The aim was to ascertain environmental components of urban heat island in Palembang city. The results indicated some environmental dimensions of urban heat island in Palembang. Social dimension consists of education level, people density in a house, and income level. Built dimension consists of distance between building, material albedo, material impermeability, building height, ventilations number, and ventilations area. Modified environment dimension consists of area of burning spot in open space, water pollution level, air pollution level, garden area, and green roof area. Natural environment consists of green open space area, vegetation density, and leaf area exposed to open space. Some hypotheses was developed and recommended for the further research.

Keywords: Environment, POETIC model, Urban Heat Island

Introduction

Urban Heat Island (UHI) is defined by Comarazamy et al (2006) as "a dome of high temperatures, observed in the center of the city compared to the relatively low temperatures in surrounding rural areas". UHI increasing air turbulence and reduced relative humidity. This led to a sort of global warming on a small scale. At this scale, the UHI impact felt in a number of urban meteorological changes such as the formation of clouds and fog, increasing lightning strikes, the occurrence of storms in the high frequencies, and changes in the level of rainfall, below or above normal (Elsayed, 2012). One of the UHI effect, such as the formation of clouds and fog, has quite a significant adverse impact on the economy. For example, the 1997 haze in Indonesia caused damage to US\$ 321 million in the form of outbreaks of disease, reduced productivity, residential fires, declining tourist arrivals, flight cancellations, reduced catch of fishing, the use of masks, and the cost of seeding artificial rain (Elsayed, 2012). The most familiar impact experienced by all the urban population is the increasing inconvenience of living with consequences on the increasing energy consumption of cooling technology (Tursilowati, 2008).

In Indonesia, UHI has been observed in Bandung, Semarang, and Surabaya, marked by the increasing temperature difference between the center of the city with surrounding rural

areas (Tursilowati, 2008). Meanwhile, 50.7% of Indonesia's population lives in urban areas (UN Population Division, 2012), 26.3% percent of the urban population living in slums (UN Habitat, 2013). The existence of UHI will have an impact on people living in the urban areas and particularly on people living in slum areas, where they can not afford to buy cooling technology and experiencing environmental stress manifested itself in aggressiveness to the level of a criminal act.

Palembang is one of the cities in Indonesia which experienced great development in the last decade. In the period 1999-2010 alone, Palembang has lost 14.26% swamp to turn into residential or shopping areas. If calculated from 1995, Palembang swamp has lost 73.48% in 1995 (the city government, 2010). This gives a dual effect. On the one hand, the amount of cooling land in the city has reduced drastically. On the other hand, the city heating increased sharply. This is reflected in an increase in outdoor temperature in the city of Palembang from an average of 31 ° C to 37 ° C during the day. This is in line with the decreasing availability of fresh water, increasing cases of fire, increasing public health problems, reduced productivity, and increasing people's behavior associated with an increase in temperature.

According to the POETIC model of environmental sociology by Canan (2008), environmental phenomena can be explained as the result of the interaction of six factors: Population, Organization, Environment, Technology, Institutions, and Culture.

This article will highlight the Environment component located at the center of POETIC scheme, this component is divided into four dimensions: social, built, modified, and natural. This article will then use the four dimensions of the environment to explain how each dimension influences UHI and drawing a number of hypotheses to be the provision of empirical research that would be performed in the city of Palembang.

Literature Review

Social Environment

The social environment is “. . .occupational structure, labor markets, social and economic processes, wealth, social, human, and health services, power relations, government, race relations, social inequality, cultural practices, the arts, religious institutions and practices, and beliefs about place and community” (Galea and Vlahov, 2005). Social environment is the giver of permission on a given government intervention, be it a particular policy or program. Good social environment should improve the physical and mental well-being of the individuals that compose (Campbell-Lendrum and Corvalan, 2007). Poor social environment encourages the behaviors such as gambling, drunkenness, and crime (World Bank, 2002, 2003).

Built Environment

Built environment includes structures built entirely intentiona by man to accommodate housing, mobility, sanitation, and culture (Golden, 2004). It comes as a replacement of the existing natural environment. At first, the natural vegetation removed, then engineered materials are used to transform the land, and eventually formed a new geometry (Golden, 2004). In this built environment, human in urban areas generally live and move within a nexus of architecture, engineering, and commerce (Golden, 2004).

Built environment can be viewed as a metabolic system where there are inputs and outputs of materials and energy in and out form the environment (Weisz et al, 2006). The inputs and outputs can be varied, ranging from nutrition and clean water to the advanced products (Weisz and Steinberger, 2010). One important component of the input is the population itself in the form of urbanization (Golden, 2004). How the metabolic processes occur within the built environment depends on what is done by humans to achieve well-being (Craveiro et al, 2007).

For example, humans need heat to warm themselves at night and the impact on heat retention mechanism contained in the built environment (Martin, 2008). At noon, a mechanism needed is the releasing of heat, so cooling technology is applied in the built environment.

Modified Environment

Modified environment includes environmental modifications that are in a position between the natural environment and the built environment (Glaser, 2006). Modified environment changes the conditions of environment due to human intervention. These includes air pollution, waste disposal, drainage of wetlands, removal of the land, and so on (Craveiro et al, 2007). Environmental modification can be an impact of the built environment both in its purpose and in its implementation.

Modifications in the urban environment can be either positive or negative. On the positive side, it can be smoothed effort to mitigate UHI into a garden of wild plants that maximize shade by laying the proper vegetation. On the negative side, it can be the destruction of the natural function of the river and into nonproductive land through water and soil pollution.

Natural Environment

Natural environment in urban areas refer to any areas in the city that has vegetation (Gairola and Noresah, 2010). The natural environment provides a positive impact on the urban environment in general, in the form of air and water purification, micro climate regulation, encouraging social integration, provide habitat for urban wildlife, carbon sequestration, pollution mitigation, and provide spiritual, recreational, and therapeutic needs for urban communities (Gairola and Noresah, 2010). In addition, the presence of green space in the city actually increase the value of the property (Li and Saphores, 2011) because the upper classes marked socio-economic status one of them with a wider space, as provided by the green open spaces.

Hypotheses

Relationship between Social Environment and UHI

Clean, safe, sustainable, healthy, and a pollution-free environment is the environment that supports UHI control (UN ESCAP, 2011). Good social environment applied these principles in social interactions therein. For example, people who tolerate littering or polluting factories stood around him will push higher UHI by their behaviour. This is important because the people of urban communities that contribute to the UHI generally upscale communities through the establishment of a factory or a greater volume of waste from the lower and middle classes. The upper classes tend to be individualistic, with low social bond. Meanwhile, the middle class and lower class, partly supported by a large number and a small space, has a strong social bonds that have a wider social environment. Based on this reasoning, the social environment is more influenced by the upper classes would have a high UHI contribution to the environment. However, other authors consider poverty increases in urban is the cause of UHI because the poor have a social environment that is worse than the upper classes (Ramadan, 2010). Therefore it can be hypothesized:

H1a: The level of education has a positive effect on the intensity of UHI

H1b: The density of occupants in the house of a positive effect on the intensity of UHI

H1c: The level of income has a positive effect on the intensity of UHI

Built Environment

A number of aspects of the built environment can lead to UHI. These aspects include

the construction density, building height, number of windows, and the type of material (Ramadan, 2010; Shahmohamadi et al, 2011). Construction density affects the flow of air and radiative characteristics that drive UHI. Material that has low albedo and impenetrable as material for roads, roofs, walls, yards, landscaping, and parking lots, store heat and trap it so it heats the city. Tall buildings be it commercial or apartments, has a high thermal mass and produces hot valleys surrounding it which act as reservoir and impact on the flow of heat from the building to the valley (Golden, 2004). Number of windows or ventilation becomes the volume of air in and out of the building so that excess heat can be distributed and concentrated. If the window or ventilation are minimum, the building became too hot and contribute to the UHI.

From the description above it can be concluded:

H2a: The distance between buildings negatively affect the intensity of the UHI

H2b: material albedo has negative effect on the intensity of the UHI

H2C: material impermeability has positive effect on the intensity of UHI

H2D: building height has a positive effect on the intensity of UHI

H2e: The number of ventilation negatively effect on the intensity of the UHI

H2f: vents width negatively effect on the intensity of the UHI

Modified Environment

Modified environment associated with a given human pollution on the environment or on the positive modification of natural land. Both have a different impact on the intensity of the UHI. While land pollution affect many environmental problems, there is no evidence that accumulation of garbage affecting an increasing UHI. This seems to be caused by the type of waste that can be various by types and have different contribution to the increase in temperature. Nevertheless, humans tend to eliminate waste in ways that contribute to the increase in temperature, such as by burning. Sewage treatment process also contributes to the UHI. In addition, the combustion is also conducted on green plants that parts of the process to change modified environment into built environment.

Water pollution have an impact on the UHI in three ways. First, it brings poison to aquatic biota and damage aquatic life including green plants that give disturbance to the natural environment which contribute negatively to UHI. Second, it create a buildup of waste water pollution that interferes with the flow of water so that the water does not have enough space to move and produce flooding. Third, water pollution interfere the nutrients that plants obtain from water from river or stream flow.

Air pollution is the biggest giver UHI impact in terms of environmental modification. Air pollution contributes to the UHI in two ways. First, air pollution produces heat from motor vehicle transport and trading activities. Second, air pollution produces particles that block the flow of air and if it has a low albedo, can absorb heat, thus contributing to UHI.

On the positive side, the modified environment affects UHI negatively with garden arrangement that supports UHI mitigation. This is for example shown by increasing the number of green plants on the natural land that help circulate air and water for urban communities. In addition, the use of green roofs, in the sense of building a hydroponic farm on the roof of the

house, is able to mitigate the UHI.

Based on the above arguments, then the next hypotheses are:

H3: modified environment affects the UHI intensity

H3a: Burning in the open space positively influence the intensity of UHI

H3b: Water pollution has a positive effect on the intensity of UHI

H3c: Air pollution has a positive effect on the intensity of UHI

H3d: The existence of park negatively affect the intensity of UHI

H3e: The presence of a green roof plants negatively affect the intensity of the UHI.

Natural Environment

Natural environment is an ancient environment of a city. He became remaining part of the pre-urban environment and will continue to diminish as the city grow. As part of an ancient environment, natural environment have characteristics more similar to the rural environment that tends to lead to a negative impact on the intensity of the UHI. Natural environment is a factor that lowers UHI by preventing the buildup of heat and heat partition (Emmanuel, 2010). This influence then depending on the season, climate, size, type of growing medium (whether grown in target locations such as asphalt and concrete with low plant density or in natural ground locations with high plant density), and the amount of leaves (Shashua-Bar, 2000) . Factors relevant to the season and a single climate means the size of the green open land, growing medium, and leaf area. Hence the hypotheses that can be drawn are:

H4a: The area of green open negative effect on the intensity of the UHI

H4b: plant density negatively affect the intensity of the UHI

H4c: Leaf area negatively affect the intensity of the UHI

Research Method

The research was carried out following research steps. Stages beginning with the discovery of a problem as it has done in the beginning of this article. After that process, then I will performed the determination of variables and data collection. Once those two things are done, the next stages are measurement and data analysis. From the analysis of the data it will be found what environmental factors influence the UHI in the city of Palembang. These factors have different strengths. Factor with the greatest power will be prioritized for repair (if it has a positive effect on the intensity of UHI) or enlarged (if negatively effect on the intensity of the UHI). This repair is done by giving building tax cues, levy taxes, and sanctions. Output of this research is a recommendation required for the city of Palembang to improve the existing conditions so that the UHI rate can be reduced and the public feel more comfortable to live in this city.

Each of these variables are measured in different ways. UHI, the built environment, natural environment, and modified environment measured by observation while data for the social environmental was measured by survey. Measurements performed on residential location on the outskirts of town. Residential location on the outskirts of the city chosen because it provides minimum limits for UHI happened. If even in this region, the influence of the factors of the UHI has been very large, UHI in the center of the city will even larger. Therefore measurements on the outskirts of the city will determine the critical point for UHI mitigation needs in the city of Palembang.

According to the hypothesis, the factors measured through survey methods include education level, household density, and income levels. The factors measured by the method of observation covers a distance of buildings, albedo materials, materials impermeability, building height, number of ventilation, ventilation width, frequency, intensity, and duration of

burning in open fields, the level of water pollution, air pollution levels, the existence of the park, the existence of green roof plants, green open land area, the density of plants in open fields, leaves areas in open land, and the temperature difference between the outdoor temperature in the urban and rural areas. The unit of analysis is the house. Taman Sari Kenten housing is used as a place of research. It have 211 housing units so that the unit of analysis consisted of 211 units.

Analysis was performed using structural equation modeling with 19 independent variables and one dependent variable (UHI intensity). The first stage is the principal component analysis is to reduce the factors then the next step is regression factors for the independent variables.

Conclusions

The study dealing with the environmental factors that influence the UHI in the city of Palembang. This is a case study that tries to portray how the various types of environment interact with each other and form a warming effect on the city. The research findings are expected to be input for policy makers to determine the issue of new building regulations, levy taxes, and sanctions for violators. By knowing the factors that influence the intensity of UHI, measures to strengthen the factors that can reduce the intensity of UHI and debilitating factors that can increase the intensity of the UHI can be done.

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