



J*AUR*

(Journal of Architecture and Urbanism Research)

Available online <http://ojs.uma.ac.id/index.php/jaur>

The Urban Warming Causes and Adaptation in Tropical Cities

M. Kali Hamzah Siregar¹⁾*, Muhammad Sani Roychansyah²⁾

- 1) Magister Perencanaan Wilayah dan Kota, Fakultas Teknik, Universitas Gadjah Mada, Indonesia
2) Magister Perencanaan Wilayah dan Kota, Fakultas Teknik, Universitas Gadjah Mada, Indonesia

Diterima: Oktober 2019; Disetujui: Oktober 2019; Dipublikasi: Oktober 2019

*Corresponding Author Email: m.kaliamzahsiregar@yahoo.co.id

Abstract

Urban warming indicate that urban would be hotter than rural areas because of the urban heat island. Unfortunately, Tropical urban people are considered to be used to hot temperature. In addition, various research indicate that this condition may affect to thermal discomfort and other problems for human life. Therefore, this research will describe and explain the causes of urban warming in tropical cities and the adaptation mechanism conducted by citizen so that city government can find better solution to adapt with urban warming. To get better overview, Kuala Lumpur, Malaysia and Medan City, Indonesia become the comparison sample. The data derived from previous research result and observation using google earth satellite imagery which are analyzed descriptively and spatially. The result shows that both cities experience urban warming because of the land use and urban morphology. But, regarding with adaptation, Medan City still adapt traditionally like watering the road but in Kuala Lumpur, City government prioritize the negotiation and technological approach.

Keywords: Urban Warming, Urban Heat Island, Adaptation, Tropical Cities

How to Cite: Siregar, M.K.H, Roychansyah, M.S. (2019). The Urban Warming Causes and Adaptation in Tropical Cities. *J*AUR* (Journal of Architecture and Urbanism Research)*. 3 (1): 77-87.

INTRODUCTION

The city is a small part of the total land area of the world, only 5% of the total area of the world today. However, a small portion of the planet Earth will be inhabited by more than 65% of the total population of the earth by 2050. This is caused by an inalienable process of urbanization. The city life has attracted everyone living in the city. Therefore, to accommodate the growing urban population, various facilities and utilities are built, such as building for housings and offices, roads for transportation so that the city will be filled with buildings, increased gas emission, concrete, asphalt, lack of vegetation, and high energy consumption. Finally, they will deliver to the urban warming phenomenon.

Urban warming is a problem that cannot be separated from the current phenomenon of global warming. However, urban characteristics lead to the presence or absence of global warming, the city will always be hot. Therefore, when compared between urban temperature and rural area temperature, the urban temperature will always be higher than the rural area temperature. This phenomenon is then referred to as an urban heat island phenomenon.

Urban heat island (UHI) phenomenon explains in detail about urban warming

because by analyzing it will describe the heat distribution in urban areas in detail, the causes of heat, and the impact on humans. In addition, good adaptation, adaptation, and urban planning for urban warming will be easily carried out because the description given can not only be analyzed economically, environmentally, socially, but also spatially.

Interestingly, the urban heat island will describe heat distribution which follows the central pattern of human activity, especially in terms of land use. The urban heat island pattern will be slightly similar to urban land use patterns. The center of hotspots will be in the downtown area, followed by suburban and rural areas (Radhi, Sharples, & Assem, 2015).

The impact of urban heat island on humans is very much from various aspects, like adverse health effects (Ichinose et al, 2008) such as heat related diseases, stroke, exhaustion, cramps, and rash (Klein et al. 2017). Another impact of UHI is the increased energy consumption (Yang, Huang, and Li 2017). The use of energy for air conditioning, and ventilation is about a half of energy building (Schoetter et al. 2017). Air conditioning is the main factor causing an increase in energy use due to heat flux. This worsens biophysical and climatic risk in the city environments (Arifwidodo and Chandrasiri 2015).

Moreover, The previous survey showed that sleep disturbance is recognized to be the most significant problem caused by warming air temperature among Japanese residents. From the analysis, about 2 % more people become “poor” sleepers for each 1 degree Celsius increase in outdoor air temperature (NIES, 2003 in Ihara and Genchi 2009).

Speaking of human comfort, Urban warming generates discomfort and lead to some problems for inhabitants (Srivanit & Hokao, 2013) because temperature is the main aspect in providing comfort space (Boduch & Fincher, 2009). However, in various studies, people who live in tropical countries are considered accustomed to urban warming even though humans certainly have a limit on heat. The intended limit is the level of comfort.

Therefore, This study wants to explain the phenomenon of urban warming that occurs in tropical cities and adaptation plans that have been carried out by the government and the community.

RESEARCH METHODOLOGY

Method of This research is comparative descriptive with a qualitative approach. This research will compare two tropical cities to identify the similarities and differences in the characteristics of

urban warming and adaptation that have been conducted.

Comparison of adaptation carried out by tropical cities is important because tropical cities have not been considered to have an impact on urban warming because of the high adaptability of society to higher temperatures. Therefore by prioritizing the main prerequisites of comparative studies (Newton et al, 2010). Kuala Lumpur City and Medan City in Indonesia are considered the right samples of comparison because:

1. Efficiency; comparing just two cities is considered to get maximum results with a deeper analysis.
2. Relevance: comparing two cities that have the same language, character, social, culture, climate and location and history becomes important because it will indicate the comparative level of relevance. An also this two cities are neighbor although separated by strait, that is why many Malaysians live in Medan City and many Medanese live in Kuala lumpur
3. Generalization: This comparison will produce conclusions that can be implemented in various tropical cities not only Kuala Lumpur and Medan.

Data is collected through the results of previous studies, city planning

documents, and observation fields. Then, the observation is aided by google earth imagery to get a spatial description.

The data that has been collected will be analyzed descriptively and spatially. Descriptive analysis is part of statistics that study tools, techniques, or procedures which is used to describe the data set or observation results. Moreover, Spatial data analysis is spatial data processing field. In this work, it utilizes Google Earth imagery to support descriptive analysis so that the research results become more valid.

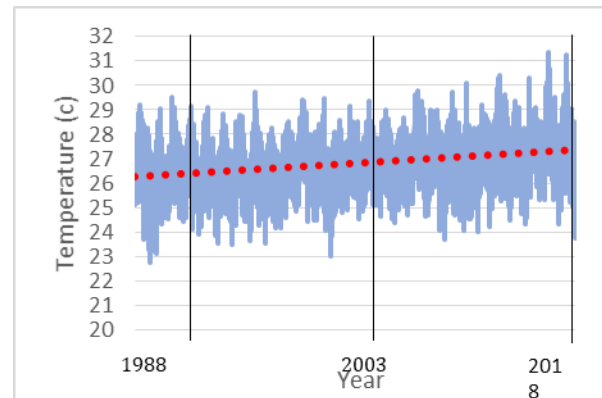
DISCUSSION

1. Urban Warming Condition and Spatial Plan in Medan City

As the fourth largest population in the world, Indonesia experienced significant progress in terms of infrastructure such as roads, buildings and also industries. This is due to increasing urbanization in the five largest cities such as Jakarta, Surabaya, Medan, Bandung and Yogyakarta. As a result, these five cities experienced urban warming phenomena. One of them is Medan city which is the third largest city in Indonesia with rapid infrastructure development.

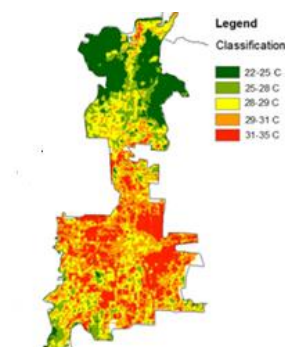
Medan City is located 3°, 27' - 3°, 47' North Latitude 98°, 35' - 98°, 44' East Longitude with a height of 2.5 - 37.5 meters above sea level. There are 2,247,425 people

living in this city in 2017. Population growth is relatively high about 0.85 % each year. Medan City faces urban warming which can be shown from temperature trend in recent years.



Picture 1. Temperature in 30 years in Medan City
Source : (Meterological, Climatological and Geophysical Agency of Medan City, 2018)

Furthermore, urban heat island map in 2018 also depicts heat distribution which spreads not only in the city center, but has also reached the suburban area. Therefore urban warming has become a problem and has an impact on almost all part of Medan City.



Picture 2 : Urban Heat Island in Medan City in 2018
Source : (Siregar, 2019)

The main cause of urban warming in Medan City is the same as in various

cities in the world. However, it is worsen by an unmanageable spatial system. This leads to uncontrolled development in cities in Medan City and results in land use change, housings structure unsuitability, and lack of open space area. Actually, spatial systems in Indonesia are structured starting from sub-district, city, provincial and national levels, however, spatial systems in Indonesia are often influenced by politics and the interests of those who feel disadvantaged by spatial planning. The several problems that occur in spatial planning in Indonesia are:

a. Urban Warming Adaptation done by Medan City

To mitigate urban warming, Medan City carries out various policies that are quite innovative. This is because it is difficult to control people's behavior towards the environment and in using land. Among what has been done by Medan City to overcome urban warming is the provision of green open spaces and spatial plans towards social approaches.

Table 1 : Spatial Planning Problem related Urban Warming Adaptation in Indonesia

Spatial problem	Spatial plan	Reality and effect to urban warming	Inducing sector
Housings structure unsuitability	In spatial plan, every city has building structure regulation, like building size, distance among house, distance to the road, and building type	Many house built on the different way with spatial plan that is why urban sprawl happened. There is no distance among house, building size is not similar in one neighborhood. These make bad air circulation, and environmental problem which affect to urban warming	Residential developer and citizen who against the building regulation
Land use change	There is zoning regulation which regulate function in every space on city	Many vacant land and green space area converted to be built up area like for shopping centre, industry, and housing	Private sectors who want to get more profit. They think green space area is not profitable Politician bribed by private sector

Source : Author Analysis from Data Collection, 2019

- Spatial plan towards social approach.

Without community involvement, urban warming cannot be overcome. Many people in Indonesia do watering road in front of their homes during the day. Uniquely, the community not only does watering in the yard or street of the house, but also on the house walls. This is done to reduce the temperature at home and on the road. However, the Medan City government does not yet have a program that can support the habits of these communities. The government does not yet have a program to water main roads and there is also no fire hydrant channel that can be used by the community to water the alleys and small roads.

In addition, Medan city has issued a roof garden regulation for homes that have a roof concrete. This regulation has been running for several years even though in terms of socialization, it is still not going well. In addition, the emergence of a "million tree program" is also a mitigation step towards urban warming in urban areas. Hopefully, it can increase urban canopy through vegetation on urban roads to reduce heat and absorb carbon monoxide from vehicles. In this case, the community can also be encouraged to plant trees in each house and vacant space in their respective neighborhoods

- Green space provision

Green open space is the main natural cooler in mitigating urban warming. Because vegetation that is on the green open space can provide reduce urban temperatures. The green open space is not only parks and urban forests, but also the median road, and drainage basin. Nationally, Indonesia has determined that 30% of the total area is designated as a green open space. This is also found in the document spatial plan in each local government. Government Regulation Number 38 of 2007 concerning Division of Government Affairs among the national Government, Provincial Governments, and District / City Governments states that the authority for structuring green open space is the authority of the local government. In fact, Minister of Public Works Regulation Number 5 of 2008, which is 20 m² / population is for green open space. Therefore, the national government issued a good policy about local institution for spatial planning so that every city has a Spatial Planning and Building Management Agency. This will make the green open space planning more controlled and can run optimally.

Medan City has several potential green open spaces, such as zoos in Simalingkar, mangrove areas, river borders, Polonia Airport Area, North

Sumatra University campus, Medan State University campus, parks, sports and recreation areas, and funeral locations. The availability of open green space in the city of Medan is 4211,880 Ha or 15% of the total area of Medan city. However, this is still very far from 30% of the total area for green open space (Siregar, 2012).

In addition, the city government of Medan has also purchased community lands to be used as green open spaces. However, the difficulty that must be faced by the city government of Medan is expensive land prices, so that the procurement of land for green open space takes a long time.

2. Urban Warming Condition and Spatial Plan in Kuala Lumpur

Malaysia is one of the countries with high economic growth in the world, especially in South East Asia. Similar to countries located in the tropical cities, Kuala Lumpur also experience the phenomenon of urban warming.

One of the causes of the emergence of urban warming in Malaysia is the trapping of wind circulation due to the many skyscraper buildings in Kuala Lumpur. As a result, the humid wind only reaches the suburban area and does not reach the downtown area. This is what makes the downtown area hotter than the

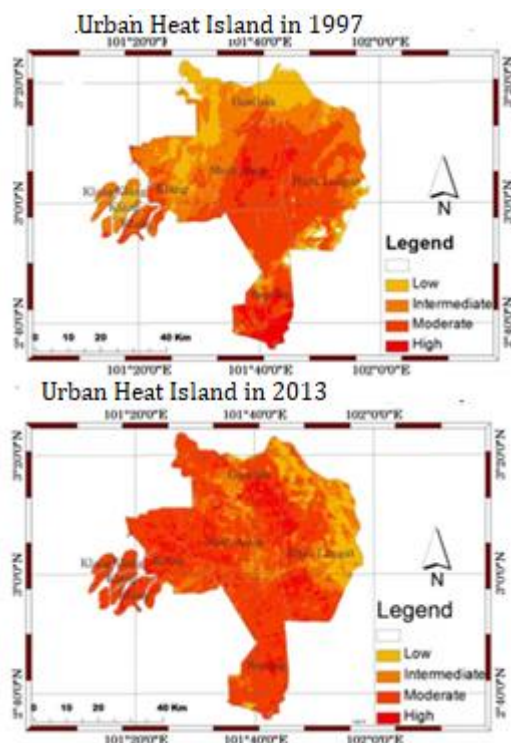
suburban area in Malaysia. (Morris, et al., 2016) concluded from his research on urban climate in Kuala Lumpur along 1999-2011 that temperatures increased by 1.66 ° C per decade, particularly in urban centers which had a temperature of 2.1 ° C higher than the suburban area. (Yusuf, Pradhan, & Idrees, 2014) also explained that the main cause of the emergence of urban warming in Kuala Lumpur is urban morphology.

Urban morphology is the process of forming housing patterns and their transformation from year to year. Formerly Kuala Lumpur was filled with housing with the formation of a social neighborhood, but in the last decade, Kuala Lumpur turned into a city filled with skyscrapers and apartment making urban temperatures rise.

In addition, in the past few years, urban canopy in Kuala Lumpur has declined dramatically even though according to research (Shahidan, et al., 2012), if kuala lumpur has a tree canopy density (LAI = 9.7) it will be able to reduce urban temperatures 2.7 ° C.

The interesting feature is research from (Morris, et al., 2016) which explains that there are significant differences between the temperatures in Kuala Lumpur at night and during the day. The temperature at night in Kuala Lumpur will

be hotter than the temperature during the day. This increase in temperature peaked at 3.1 ° C.



Picture 3 : Urban Heat Island in Kuala Lumpur in 1997 and 2013
Source : Yusuf et al, 2014

From These images above, it can be concluded that temperature in Kuala Lumpur has increased from year to year, as well as with heat distribution on the map of urban heat island in 1997 and 2013 which shows the spread of heat evenly distributed not only in downtown area, but also in suburban area. The pattern of heat distribution also follows the pattern of land use in Kuala Lumpur.

Kuala Lumpur has a structured spatial plan system from the national level to local planning. The slogan of the spatial

plan is called Vision 2020 which is planned for a period of five years.

The planning system at the local level is also divided into two, a local plan and a special area plan. This is done to distinguish several regions that have special designations such as business and government areas.

The implementation of a nationally integrated local spatial plan system will be very useful for mitigating urban warming because urban warming is also caused by poor suburban areas and rural areas in supporting urban areas.

a. Urban Warming Solution done by Kuala Lumpur City

- Spatial plan towards social approach.

Malaysia issued a comprehensive strategy to overcome urban warming. One of them is community engagement and consensus building for low carbon society. This is found in Action 3 Vision 2025 Malaysia, Low Carbon Government and Action 7 Community engagement and consensus building (LCS, 2013).

This concept involves various parties and stakeholders such as the people who live in Iskandar Malaysia or Kuala Lumpur. This is intended to provide benefits to the community itself. Consensus building is intended to create an agreement that covers the interests of

all stakeholders and increase public awareness of the importance of low carbon to overcome urban warming in Kuala Lumpur. In its application, a low carbon society requires a long time period because it prioritizes the negotiation process between stakeholders.

This process begins by identifying community stakeholders who have the opportunity to increase carbon production in Kuala Lumpur such as industry and society. Then, inviting all these stakeholders to discuss the impact of carbon on urban warming. From this process, comments and feedback will be obtained which will then be generalized. This process is also useful to disseminate the effects, causes, and mitigation of urban warming.

In addition, the program also routinely distributes environmental issues such as urban warming through printed newsletters, billboards, radio, television, live streaming, ranging from students to workers. Moreover, periodically, a low carbon society mobile showroom will come to neighborhoods to introduce a low carbon lifestyle, green infrastructure, and green transportation so that in the future public awareness will increase and by itself the community mitigates urban warming through campaigned steps.

Kuala Lumpur also has a program called reforestation (LCS, 2013). This program aims to run better tree management. This starts with the immediate replanting for cut-down tree areas, then the one resident one tree program. This program was issued because there was a significant reduction in the number of trees from year to year. Interestingly, the government encourages the public to report any illegal tree falling and the reporter will get a reward from the government. Another program is the tree survey which aims to record the number and condition of trees gradually.

- Provision of Green Open Space

Kuala Lumpur is also aware of the importance of the green open space to overcome urban warming. Regarding the Framework of Low carbon society and Assessment system, the green open space in each development area or neighborhood is 10% of the total area. Green open space is diverse such as gardens, parks, riverbanks, towpaths along the canals, cycle paths, designed for social interaction areas, disused trains, used and natural surfaces used for sports and recreation, burial grounds, and cemeteries (KeTTHA, 2011).

In addition, to maximize the provision of green open space, the

Malaysian government, especially the city of Kuala Lumpur, uses various technologies to carry out data collection on vacant land or space such as the use of satellite data and geographic information systems. These land or space will be occupied as green spaces. Although the vacant space or land is only 2 meters wide, the government will use it as green space by planting vegetation.

Another policy issued by the Kuala Lumpur government is the application of green roofs and green walls for each building that has strong construction for vegetation planting. Even with the increase in the green cover, it is expected that the mid-day air temperature will be reduced by 0.04 to 0.2 degree Celsius for each percent increase in canopy. Then, this policy is calculated using the Normalized Difference Vegetation Index to reduce land surface temperature to 0.07 degrees Celsius (LCS, 2013).

CONCLUSION

Similarly, these two cities involve the community to participate in adapting and mitigating urban warming from their homes and neighborhood. In addition, the causes of urban warming in Medan City and Kuala Lumpur are the same as those in other cities such as land use change, lack of vegetation, and energy consumption.

Although Medan City and Kuala Lumpur have had programs to mitigate urban warming by involving the community, there are significant differences between the two cities. Medan City tends to use traditional approaches such as watering the yard and walls of the house while Kuala Lumpur uses a negotiation and socialization approach consistently. Both are very good, traditional approaches are needed if people tend not to be able to accept the negotiation and socialization process consistently. The negotiation and socialization process is also very good for maintaining the sustainability of the program.

REFERENCES

- Aflaki, Ardalan, Mahsan Mirnezhad, Amirhosein Ghaffarianhoseini, Ali Ghaffarianhoseini, Hossein Omrany, Zhi-Hua Wang, Hashem Akbari (2017), Urban heat island mitigation strategies: A state-of-the-art review on Kuala Lumpur, Singapore and Hong Kong
- Arifwidodo, Sigit Dwinanto, Orana Chandrasiri (2015), Energy Procedia, Urban Heat Island and Household Energy Consumption in Bangkok, Thailand
- Boduch, Michael, Fincher, Warren (2009), Standards of human comfort: relative and absolute. The University of Texas at Austin.
- Gency Y., Ihara T., 2009. Environmental impact assessment of urban air temperature increase based on endpoint-type life cycle impact (part 1) – its framework, The Seventh International Conference on Urban Climate Preprints, (in press).
- Ichinose, Toshiaki, Futhoshi Matsumoto, Kumi Kataoka (2008), Counteracting Urban Heat Islands in Japan, Urban Energy Transition, DOI: 10.1016/B978-0-08-045341-5.00015-3
- Karyono, Tri. H, (2009), Eco-settlement: Permukiman Tropis Berkonsepsi Hijau Ramah Lingkungan.

- Karyono, Tri. H, (2011) Thermal comfort in the tropical south east asiacountry, Architecture Science Review.
- Karyono, Tri. H, (2015) Predicting Comfort Temperature in Indonesia, an Initial Step to Reduce Cooling Energy Consumption.
- Klein, Joyce, Rob Crauderueff, Urban Heat, Island Mitigation, Can Improve, New York, and Citable Link. 2017. "Urban Heat Island Mitigation Can Improve New York City's Environment: Research on the Impacts of Mitigation Strategies on the Urban Environment."
- KeTTHA – Ministry of Energy Green Technology and Water of Malaysia, 2011
- Lin, C., W. Chen, P. Chang, and Y. Sheng, 2011: Impact of the Urban Heat Island Effect on Precipitation over a Complex Geographic Environment in Northern Taiwan. *J. Appl. Meteor. Climatol.*, 50, 339–353, <https://doi.org/10.1175/2010JAMC2504.1>
- LCS, Low Carbon Society Blueprint for Iskandar Malaysia 2025 (2013)
- Meteorological, Climatological, and Geophysical Agency. 2017. "Medan City in Number."
- Morris, K. I., Chan, A., Salleh, S. A., et al. (2016). Numerical study on the urbanization of Putrajaya and its interaction with the local climate, over a decade. *Urban Climate*, 16, 1e24. Available at <http://www.sciencedirect.com/science/article/pii/S2212095516300062>.
- Newton, Kenneth, Jan W Van Deth (2010), Foundations of Comparative Politics, Second Edition, Cambridge University Press.
- Paatero, J, 2018, Renewables in Urban Environment, Aalto University
- Radhi, Hassan, Sharples, Stephen and Assem, Essam (2015) Impact of urban heat islands on the thermal comfort and cooling energy demand of artificial islands-A case study of AMWAJ Islands in Bahrain. *SUSTAINABLE CITIES AND SOCIETY*, 19. 310 - 318.
- Schoetter et al. (2017), Parametrisation of the variety of human behaviour related to building energy consumption in the Town Energy Balance (SURFEX-TEB v. 8.2).
- Shahidan, M.F., Shariff, M.K.S, Jones, P., Salleh, E., Abdullah, A.M., A comparison of *Mesua ferrea* L. and *Hura crepitans* L. for shade creation and radiation modification in improving thermal comfort. *Landscape and Urban Planning*, 97, 168-181 2010.
- Shahid, Shamsuddin, Sahar Hadipor, Xiaojun Wang, (2017), Impacts and adaptation to climate change in Malaysian real estate.
- Siregar,M.K.H. 2019, Adapstasion towards The Increased Urban Temperature : Case Study of Medan City, Indonesia *Thesis*. Keio University, Japan.
- Siregar,M.K.H. 2012, Penyediaan Ruang Terbuka Hijau di Kota Medan *Skripsi*. Institut Pemerintahan Dalam Negeri.
- Srivanit, Manaf, Kazunori Hokao, Pawinee Lamtrakul (2014), Classifying Thermal Climate Zones to Support Urban Environmental Planning and Management in the Bangkok Metropolitan Area <https://www.sciencefriday.com/educational-resources/the-albedo-effect-urban-heat-islands-and-cooling-down-your-playground/>
- Yang, Qiquan, Xin Huang, and JiayiLi. 2017. "Assessing the Relationship between Surface Urban Heat Islands and Landscape Patterns across Climatic Zones in China." *Scientific Reports*, no. April. Springer US:1–11. <https://doi.org/10.1038/s41598-017-09628-w>.
- Yusuf, Ahmed, Mohammed Oludare Idrees, Biswajeet Pradhan (2014), Spatio-temporal Assessment of Urban Heat Island Effects in Kuala Lumpur Metropolitan City Using Landsat Images. *Journal of the Indian Society of Remote Sensing*