THESIS

FACTORS INFLUENCING URBAN HEAT ISLAND IN SURABAYA, INDONESIA

AYU CANDRA KURNIATI
321 220 5006

ADVISORS
Dr Vilas Nitivattananon
Dr-Ing. Ir. Haryo Sulistyarso

MASTER PROGRAM
URBAN DEVELOPMENT MANAGEMENT
DEPARTMENT OF ARCHITECTURE
FACULTY OF CIVIL ENGINEERING AND PLANNING
SEPULUH NOPEMBER INSTITUTE OF TECHNOLOGY SURABAYA
2015

MASTER'S THESIS RECOMMENDATION FORM

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science (M.Sc)
at
Institut Teknologi Sepuluh Nopember

By:
AYU CANDRA KURNIATI
Student ID. 3212205006

Presentation Date : 25 November 2014
Graduation Period : March 2015

Approved by:

Advisor I	Advisor II
Dr. Vilas Nitivattananon	**Dr. Ing. Ir. Haryo Sulistyarso**
	NIP. 195504281983031001

Postgraduate Program Director,

Prof. Dr. Ir. Adi Soeprijanto, M.T.
NIP. 19640405 199002 1 001

ACKNOWLEDGMENTS

Deep sincerely and gratitude is expressed to advisor, Dr. Vilas Nitivattananon for his constructive guidance, never ending support and encouragement to always move forwards. He provided not only all the requirements for the accomplishment of the study, but also sharing knowledge, advice and point of view in both academic and practical ways. My deep appreciation is also extended to committee members, Dr. Shobhakar Dhakal and Dr. Djoen San Santoso for their helpful and insightful comments. Their support, composure and constructive comments for enhancing the quality of this thesis is indispensable. My deep gratitude is also extended to my advisor in ITS, Dr. Ing. Haryo Sulistyarso and Dr. Ir. Eko Budi Santoso, Lic.Rer.Reg for their never ending support and encouragement. Without them, this thesis work could not have been completed.

Big gratitude to Miss Jitra Luckanakpitak and Mr Sahal for kind help and support during this study. The never ending gratitude and happiness is for 2013 batch of UEM. Arya thanks for always being here with me, Binny thanks for always being my unforgettable friend, Tu` thanks for always being a real older sister, Korwnika thanks for the preferential attitude, Blue thanks for the patience and calmness, Raph thanks for being “nong”, Yin thanks for all improvement and perseverance, P` Por thanks for the inspiration, P`Kokai thanks for all sharing and knowledge, and Bahiar thanks for unique behavior. I found a new family in this international class. Indeed, we are persistent and tough people.

Special gratitude is expressed to my 2013 ITS batch, Ariyaningsih, Yusuf Muhammad Zein, Happy Aprillia, Nasa Zata Dina, Wenny Mistarika, Mega Silfiani, Wiwit Sri Werdi Pratiwi, Ardiansyah Fauzi, Tri Vicca, Ayu Cipta and Lina Inda for the unforgettable moment, caring, happiness, sadness, and dream that we share together. This one year is an amazing and incredible journey for me. Very special gratitude is for PERMITHA AIT and Phd students (Cahyono Sigit Pramudyo, Rahmadyah Trias, Petrus Sutyasadi and family, Idah Andriyani, Hafiz Lina, Intan Sofiyanti, and etc) for all support, encouragement, time and guidance.

Their supporting advice of point of view for not only academic but also in real life is indispensable.

Love and laugh is for MPK-ITS 2012 batch, Arya, Niar, Erma, Mb Evi, Retno, Rini, Maulina , Sani, Ghozali, Noha, Alen and Mirtha. My ITS friends Kiki, Andi, Fratika, Alfan, Tiko, Sakti and Dimas for their caring and support. It is been a great years in ITS, all of joy, love, laugh and blessing were spread out.

The author would like to acknowledge with appreciation for the master scholarship granted by Directorate General of Higher Education and Asian of Technology fellowship. I would like to thank all key informants from the municipality of Surabaya for providing valuable information.

Lastly, unforgettable and incredible gratitude to my family, my outstanding parents, Mr Kasbi and Mrs Jumiati, my amazing little sister Ayusta Lukita Wardani and Ikhsan, my super family, Sudarmo, Mascliha, Mishari, Edi Santoso and Qumrotin, Andi Rahmat Setiabudi and Erny Setyowati, Dian Novita Lestari and Suwito, and my adorable cousins, Sanchia, Faiqsyah, Inggid and Zasmin. Indispensable gratitude for everything, all of extravagant and immortal love, patience, concern, continuous support, advice and encouragement. Without them, author could not have been reached this point. This achievement is dedicated for them.

FACTORS INFLUENCING URBAN HEAT ISLAND IN SURABAYA, INDONESIA

By	:	Ayu Candra Kurniati
Student Identity	:	3212205006
Supervisor	:	Dr Vilas Nitivattananon
		Dr. Ing. Haryo Sulistyarso
Co Supervisor	:	Dr. Ir. Eko Budi Santoso, Lic.Rer.Reg

ABSTRACT

Increased population and urban development have raised the use of energy and effected to the urban environment. Consequently, it has resulted in the decrease of the green space while escalating the air pollution. Furthermore, it creates UHI affected to urban dwellers in many ways. This research is therefore to identify the current conditions, determine most significant factors and to enhance current strategies for address UHI in Surabaya, Indonesia. Mixed qualitative and quantitative method is used in this research. Document and statistical data related to man-made and natural factors is used for DPSIR, then determined it into most significant factors by using PLSR. Document review, stakeholders opinion and literature review were utilized to recommend strategies for addressing UHI.

The main finding of this research is the most significant factors influencing UHI, which are provision of green space, electricity consumption and use of asphalt. This research has identified that UHI is not a new issue in Indonesia, but there is an incomplete understanding to the process and address of UHI in the city level. Comprehensive approach in needed to established and implemented strategy, planning and program. Hence, is important to manage and measure the urban environmental issues. The recommendation in this research is in order to enhance the implementation of appropriate strategies to address UHI. Furthermore, the result of this research can be used as a baseline study for deeply understanding and addressing UHI in Surabaya and other cities.

Key words: electricity consumption, green space, PLS-R analysis, significant factors, UHI

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CDD	=	Cooling Degree Days
CSA	=	Central Statistical Agency
EPA	=	Environmental Protection Agency
PDA	=	Planning and Development Agency
PLSR	=	Partial Least Square Regression
UD	=	Urban Development
UP	=	Urban Planning
UP	=	Unit Pengembangan-Development Unit
UHI	=	Urban Heat Island

CHAPTER 1
INTRODUCTION

This chapter explores urban heat island, due to high rising temperature in the city that lead several impact on the human, environment and energy resource. This phenomenon like a problem circle, due to energy consumption and human activities this phenomenon occurs, while the other side due to the phenomenon, it increased the number of energy consumption and hampered of human activities. Enhance city`s strategies are the purpose instrument to reduce the Urban Heat Island (UHI). Based on that, this chapter has identified the research problem and objective, scope and limitations.

1.1 Background

Cities inhabit 2% of the earth, and nowadays urban population is growing in size and intricacy. Precisely due to urbanization and human activities take a large part for city to require large of energy (Madlener & Sunak, 2011). High energy consumption is combusted to heat and concentrated due to urban structure (high building, building material, urban structure, size of the city, urban greenhouse effect). Furthermore, it leads to heat island phenomenon that increases the temperature in densely development area (Gago & Roldan, 2013). Increase in urban temperature can occur from urban heat island and climate change (Founda, 2011). Long term temperature record not only found in large cities but also have been detected in cities with population less than 10.000 (Borbora & Das, 2013).

Gago & Roldan, 2013 said that "*High summer temperatures in the urban heat island increase energy use for cooling and accelerate the formation of smog. An analysis to discover the temperature trend over the last 100 years in various cities in the United States showed that since 1940, temperatures in urban areas had risen 0,5-3^{o}C. Accordingly, electricity demand in cities went up 2-4% for each degree Celsius of temperature increase*".

Figure 1.1 shows UHI in the various city in the United States for over 36 years due to high population and increasing activities. CRUTem3 dataset was used as an analysis tool. The red line indicates the real estimates, while the blue curve indicates the lowest population class.

Increase urban temperature from UHI, influence the environment of the people and quality of life. In addition, it brings positive impacts like continuation of plant growing season and negative impacts such as elevated consumption of energy, raised of air pollution and greenhouse gases, hamper to human health and amenities, also it can interfere water quality (Bisset, 2013).

Nevertheless, factors like policy and institution constraints in zoning, building`s form, substitute energy supply and management of transportation are an obstacle to the execution of reducing urban heat island effect. Although UHI effect becomes cities major problem, need a long time and more effort to solve, urban heat island can be solved.

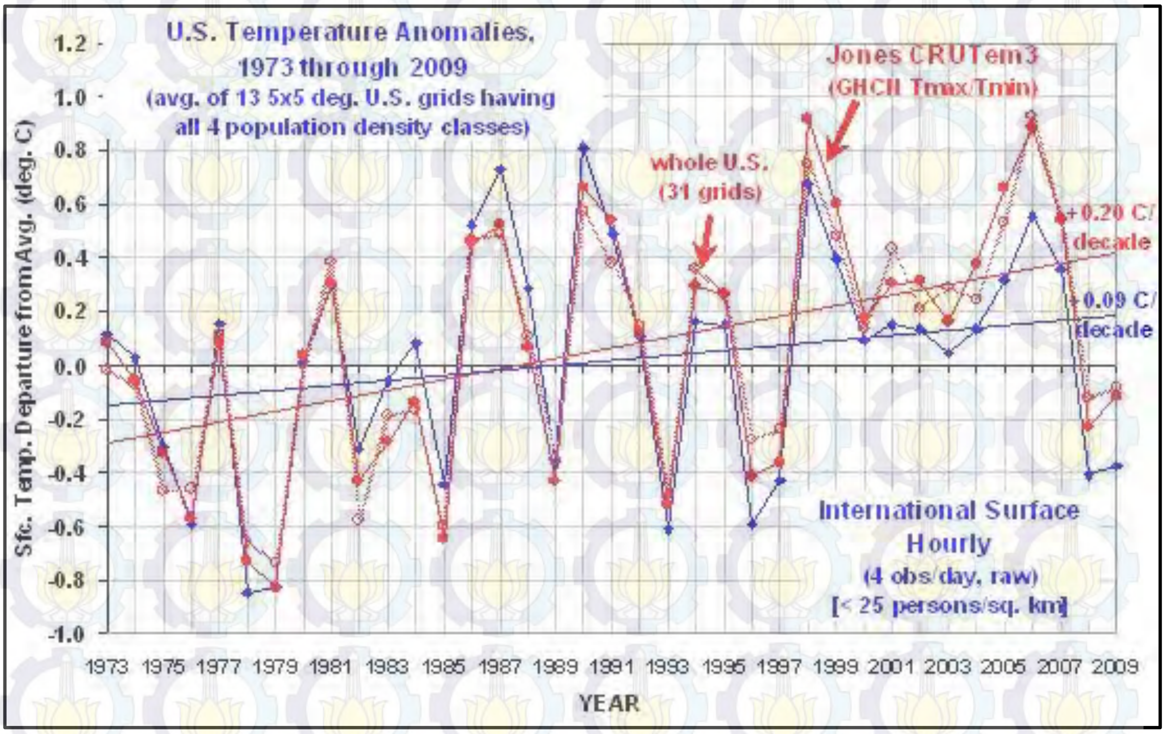


Figure 1.1 US Temperature Anomalies 1973 to 2009 (Spencer, 2010)

1.2 Rationale of Study

During summertime, urban heat island influences heat wave even. The heat wave even temperature rise maximum due to heat island phenomenon, this is make higher number of mortality. For mental health, the effect of maximum temperature was significant adjustment by cardiovascular and respiratory presentations (Williams, *et al*, 2012). Raised in temperature, declined the cooling time and increase air pollution are connecting with UHI, which influence human health by hamper human amenities, respiratory illness, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality (United States Environmental Protection Agency, 2012).

"The urban heat island effected to urban dweller in many ways, influencing their health and comfort, energy cost, air quality, and visibility levels, water availability and quality, ecological services, recreation and overall quality of life" (Prilandita, 2009). Governance and community are lack of awareness to the activities that worsening urban heat in urban live (Memon, *et al*, 2008). Therefore, most of adaptation and mitigation measures to reduce the effect are only considering on making the new technique to reduce UHI, instead of enhancing the local government`s responses and policies in terms of urban heat island in their environment. Furthermore, it is feared that some municipality are lack of understanding to reduce UHI effect. Moreover, local institutions policies and response related UHI effect need to be reviewed.

Determining significant factors also becomes the important part to reduce urban heat island, while considering that there are several factors that influence it. Several factors that influence UHI are population shift, urban and peri urban development, change in zoning, production and disposal of anthropogenic emissions and pollutants which mix with regional climate as well as in the frequency and intensity of specific weather (Prilandita, 2009). Reducing UHI on the most influencing factors based on the characteristics of a certain city is important due to effectiveness and efficiency of the purposing strategies.

1.3 Statement of Problems

Most of the past studies in terms of increasing temperature in urban area took urban heat island as the main concern (Prilandita, 2009 and Fariz, 2012). The earlier researches was tried to identify the characteristic of UHI by using one factor cause (Borbora et al, 2013; Das, et al, 2013; Lau, et al, 2004). Meanwhile several factors causes for urban heat island (Okeil, 2010; Gago, 2013; Wong, 2011; Prilandita, 2009), as well as the measures to mitigate and adapt the urban heat island (Yamamoto, 2006; Gago, 2013; Santamouris, 2013; Maula, 2009). Furthermore, the effect of urban heat island was studied by Prilandita, 2009.

Based on the references, it can be concluded that several researchers analyzed factors that influencing UHI, but not the significantly factors that influence it based on the characteristics of a certain area. Meanwhile, others analyze UHI with focusing on one factor like population or building density only. In addition, most of adaptation and mitigation measures to reduce the effect are only considering on making the new technique to reduce UHI, instead of enhancing the local government`s responses and policies in terms of urban heat island in their environment. Furthermore, ignoring significant factors that influence UHI effects will make the solution difficult to be implemented effectively, as well as it is necessary to recommend the strategies from the “stick” approach, because it is legally and basic approach.

1.4 Research Questions

Based on the background and problem of statement, it can be constructed into several research questions:

1. How is the existing condition of UHI in Surabaya?
2. What are the most significant factors that influence UHI in Surabaya?
3. How to recommend strategies for addressing UHI in Surabaya?

1.5 Research Objectives

Based on the research questions, the main objective of this research t is determine the significant factors influencing UHI, in Surabaya city. The objective should be achieved by the following specific objectives:

1. To identify the existing condition of urban heat island phenomena and effects
2. To determine the most significant factors that influencing UHI
3. To recommend strategies to address UHI based on the significant factors

1.6 Scope and Limitation of Study

There are two main types of scope in this research. They are the scope of the area and the scope of substance. All primary and secondary data have been collected in this scope area. Recommend strategies to address UHI is emphasis to strategies (policy, planning and program) implementation in municipality of Surabaya, which has been conducted from a national level and city level.

Meanwhile, the scope of substance is significant factors that influence UHI in Surabaya and strategies in terms of significant factors. The meaning of factors in this research is refers to causes and measure to address UHI in urban planning point of view which is not related to design of the city. The factors and variables in this research are changes in urban cover with area of green space, area of paving and area of asphalt variable, heat of individual emitting with electricity energy consumption variable, and greenhouse gas effect with carbon emission variable. Moreover, this research is using respondent opinion, literature review and current strategies to recommend strategies for reducing or addressing UHI. Maximum and minimum temperature in this research has been analogous to day time and night time, considering that in daily temperature record there is no time record.

In addition, the research is limited only to the most significant factors that influence UHI in Surabaya and strategies to reduce it in terms of significant factors. For enhancing the existing strategies to address the UHI, this research only focuses on endogenous factors, which come within the development of the city or man-made factors, due to limited time and difficulties on data collection. Factors that used in this research are elaboration from literature review of an existing condition. In addition, this research just using CDD and minimum-maximum temperature as measurement to identify UHI intensity in Surabaya. Furthermore, this study not included nature factors such as climate change and global warming for the causes of UHI.

This research will only discuss recommendations to enhance the current strategies that ongoing implemented. Considering the limited time and data source, assessing the current strategies will not discuss. The function of PLS-R is divided partial formulas to get the least partial which show the best equation for the formula result. Meanwhile, this research just needs to find the most significant factors that influence UHI effects, without determine the relation of each factors.

CHAPTER 2
LITERATURE REVIEW

This chapter provides several literatures in terms of urban heat island. This chapter tries to explain the concept of urban heat island phenomenon and causes effect that influencing it. The understanding of relationship between causes effect of urban heat island is needed to explore the existing of UHI`s condition and to purpose recommendation to reduce UHI effect. Figure 2.1 shows simple organization of chapter two.

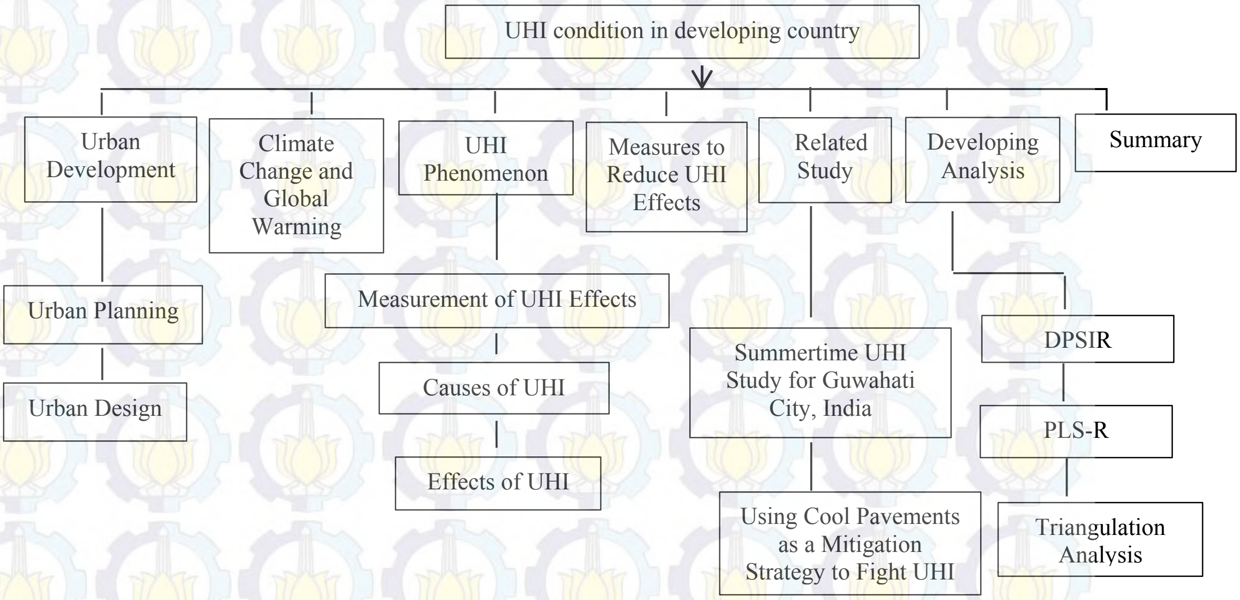


Figure 2.1 Literature Map

2.1 Urban Development

One of the most salient features that characterize human civilization during the past millennium is accelerating urbanization. United Nations stated that more than half of the population is people who prefer to live in cities, and so future global population growth. The world's population will continue to urbanize even after it stops growing around 2050, and we have entered “the century of the city” (Zhao et al, 2014).

There will be a shifting paradigm from living in rural areas in an urban one. The paradigm was predicted that in 2030, two thirds of the inhabitatnts will come and live in urban areas. It will be happen at developing countries where, each month, the people who migrate to urban areas are more than five million. In order to be close to their jobs and opportunity created by urban growth, billion of urban poor live in slums and it become a big challenge to cities in developing world. There is a tremendous pressure for rapidly growing cities to provide basic services, land, infrastructures, and affordable housing for the poor. In addition, extreme weather-related events occur with more intensity and frequency than ever, greatly increasing risk for almost a half billion urban residents living in country (Fukuda, 2013). Etymology, urban development is building usage for developing cities (Collins, 2014).

The urban inhabitants are predicted to double in 30 years from 2000 to 2030 in emerging economies, adding 2 billion more people to the cities which grow with an unprecedented speed. If urban areas are developed, it will increase 1.2 million square kilometers, nearly tripling the global urban land area in 2000. Cities produce more than 80 percent of global GDP. Urbanization can promote sustainable growth if it is organized well by increasing productivity, rising new idea with innovation, saving energy, land and natural resources. Hence, to avoid the negative impacts, urban areas has to handle the challenges by provide basic services, infrastructures, occupations, lands, and affordable housing, especially for the nearly 1 billion poor people in informal settlements. Two-thirds of the world's energy consumption is cities. In addition, more than 70 percent of global greenhouse gas emissions are consumed by urban areas (Fukuda, 2014).

Not only their exposure to climate, but also the increasing of disaster risk is found in growing cities. Coastal areas where nearly half a billion urban residents are lived have a risk from storm and sea level rise. Cities should meet the most principal needs of its people, and invert decades of economic growth particularly in small, fragile states (Fukuda, 2014).

Municipalities which are core actors in the urban development process often need to motivate urban development for starting the urban development process. To facilitate this, land-use planning is needed as one of their key tools even though it is generally geared towards restricting or controlling development (Christensen, 2014). It is easy and very efficient to supply water and sanitation in the same neighborhood. Access to health, education, and other social and cultural services is also much more readily available. Growing of the city create constraint to the environment and natural resources, while increasing the basic need cost.

"Urban growth or urban development (UD) has to be steered by a continuously provision and management vision that promotes interconnected green space, a multi-modal transit system, and mixed-use development. Various public and private partnerships should be employed to create sustainable and liveable communities that protect historic, ethnic, and environmental resources. In addition, policymakers, regulators and developers should support sustainable site planning and building techniques that reduce pollution and create a balance between built and natural systems" (Fukuda, 2014).

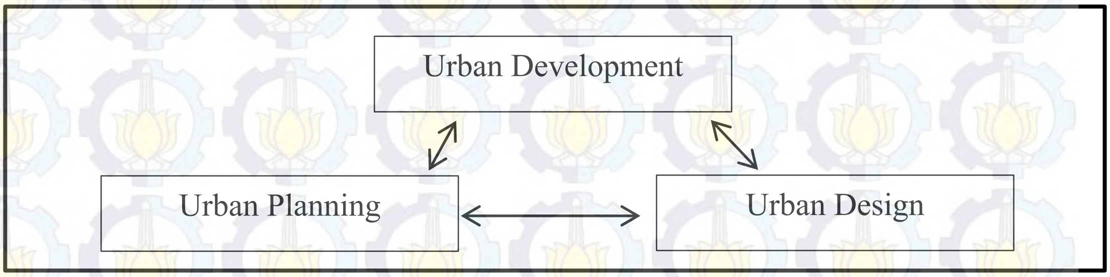


Figure 2.2 The Relationship between UD-UP-Design (Fukuda, 2014)

Figure 2.2 shows that there are connection among UD, urban planning (UP) and urban design. Three of them have a causality relationship. Furthermore, urban design is influence and influenced by urban planning and urban development, as well as urban development and urban planning relationship. Urban development as a big picture of the city development brings a lot of advantages and disadvantages for the development of the city. As well know that an urban is always growth/develop and it should be guided by urban planning and design. In addition, urban planning is the master plan and urban design is the practical to implement the urban plans. Therefore, to make a sustainable city a good urban planning and urban design are needed.

2.1.1 Urban Planning

A global phenomenon in this century is more than fifty percent of population in urban areas. From 2000 to 2030, the urban population in developing countries is predicted to double and built-up areas are projected to triple. There will be a difficult situation for cities to solve major urban challenges. It was caused by rapid demographic and spatial change, especially for developing countries. They have to cope the challenges which consist of climate change, resource shortage, slum growth and increased poverty, and safety and security concerns (World Bank, 2011).

"*Urban planning plays an important role in shaping a city. Without prior or appropriate planning, the city may grow or change in an uncontrollable way due to population and social, economic and environmental changes. Such changes are of course fundamental in planning*" (Meng, 2002).

By city planning, both new resident and established towns will have a secure, managed, and comfortable home and workplace. There are some issue in urban planning such as building locations, land use regulation, transportation, and city`s form. Not only trying to eliminate run down areas, planner also tries to maintain the development and the natural environment of the area (Khaminsky, 2014). City Planning aims to show how to develop a city. Therefore, city planning enhances the welfare of urban population by establishing suitable, equitable, healthful, efficient and interesting environments of its existing and future residents. Although most planners work in current communities, but some help develop new communities (Haris, 2014). To solve the problems such as housing areas, industrial sections, and the placement of basic facilities in current and new urban areas, architects and engineers - in partnership with their municipality - implement urban planning. Finding solutions for existing situations in cities is often more complicated than planning a new city (Khaminsky, 2014).

Urban planning is considering building locations, zoning, transportation, appearance and environmental aspects and slum area within the city. There are certain areas of a city for specific purposes such as housing zones, trade and service areas, and industrial sections. It is very crucial to couple them with other building locations. Comprehensive planning is needed to make a good result. The integration between building location, land use zoning, transportation accessibility and provision of public facilities are needed. Urban growth will impacted to traffic congestion and poverty (Khaminsky, 2014).

2.1.2 Urban Design

Urban designers are required for overcoming the rapid growth of problems in developing and developed countries. Urban design is required in developing countries, while the reuse of existing sites is major issues in developed cities (UC Barkeley, 2014). There is a shifting away from rural settings toward urban locations when society becomes more ethnically diverse and dense. The successful operation of the built environment more and more depends on the public and private spaces between physical structures. The relationship between individual projects and the overall fabric of the city and the region must be considered by both the private sector and public agencies.

As society becomes more ethnically diverse and dense, with population shifts to away from rural settings toward urban locations, the public and private spaces between physical structures becomes more and more critical to the successful operation of the built environment. Both the private sector and public agencies are becoming aware of the significance of the relationship between individual projects and the overall fabric of the city and the region. Urban design provides handling to both private and public elements to get innovative solutions to the relationships between building volume, public and private space, pedestrian and vehicular interaction (Urban Concept, 2006).

Arrangement and design of constructions, green and open spaces, transportation systems, services, and comfort is urban design tasks. It is the process of giving structure, shape, and character to groups of buildings, to whole neighborhoods, and the city. Furthermore, as a framework that orders the elements into a network of streets, squares, and blocks design, it blends architecture, landscape architecture, and city planning together to make urban areas functional and attractive (Duany, 2012).

Urban design as a linking part of urban planning has to work together for mitigate and adapt to climate change. Urban planning as a concept part is contain policy, regulation and strategies to manage city development, while urban design as a practical part is contain a design and concept to build a city/building to prevent climate change. In addition, urban design is needed to be implemented the strategies that have been made in urban planning. Therefore, with a batter design of the city it will make a good step to prevent and address climate change.

2.2 Climate Change and Global Warming

International effort to reduce emissions in greenhouse gases which may limit the changes needs adaptation strategies. We can avoid induced changes in future climate change by human. Global warming can causes climate change. This discussion is not limited to the global and regional level issues, but also essentially in the local and urban level issues. Urban warming occurs due to climate change or activities of human itself. Reducing global warming can be effected by manage it in the base level. Find and solve the factor that influence the urban warming is the best solution after all.

The main cause of global warming is human. Many human activities influence global warming. Burning of oil, coal and gas, has changed the temperature balance that come from Industrial society and have been done for about 200 years (Lormaneenopparat, 2002). Existing world temperature average is about 0.80 C above pre-industrial rank. The years from 2001 to 2012 rank among the warmest since record keeping began 133 years ago. The intensity of extreme weather-related events has also increased (Bisset, 2014).

Exceed of carbon dioxide (CO_2) in the air, trapped heat and accumulate the rising of temperature, is primarily a problem called global warming. CO_2 accumulates in the atmosphere for a long time, so its heat-trapping compounded over time, and it is unalterable to solve. Therefore, the emission that we polluted today is bring the negative impact to the future generation (Union of Concerned Scientists, 2011).

To reduce heat effect energy, urban cities need conservation and energy efficiency technologies that allow to consume less energy to gain equal or higher production, service and emenitis. Finally it can save energy and money (Union of Concerned Scientists, 2011). Green transportation usage for example low carbon fuels vehicles and more efficient mass transportation systems also can reduce heat effect (Li, Trappey& Hsiao, 2012). Managing forests and agriculture also ponds of water bodies can also reduce heat effect. A large tree can produce cooling effect, during a warm period, equivalent to a small air conditioning, while ponds that contain water can evaporates to air and make air cooler (Surapong, 2000).

After all, global warming is a serious problem and need continuous action to adapt and mitigate this phenomenon. Sustainable development base on environmental development has to be main priority to conduct development of the city. All actors of the city have to be involved in this action, whereas it need long term and sustainability action.

2.3 Urban Heat Island

Definition of UHI is there is the temperature differences (2-6^{0}C) in the urban area compared to the peri-urban, that influenced by urban structure and urban parameters (e.g: materials of the construction, provision of green area) have a crucial impact to the climate change (Lee, et al, 2009). UHI is occur due to heat in the urban environment that influence by the urban activities, energy consumption, and urban structure. In addition, the heat loses was decreased. (Santamouris, 2013). Urban heat is one phenomenon of urban climate modification, which varies in time, climate, location and urban characteristics (Lormaneenopparat, 2002).

Kolokotoni (2007) researched the solutions of a computational study of energy consumption and in terms of CO_2 emissions for the use of air conditioning and heater in London. The result is heating amount decline, whereas cooling amount and overheating hours increased. Kondo and Kikegawa (2003) predicted that the sensitivity of temperature to the top of electricity consumption is 6.6% in the densely populated of Tokyo. Moreover, the human activities and the condition of the environment is influencing the rising temperature. Some researches analyze that the rising of temperature can influence the local climate.

Hirano and Fujita (2012) invented a methodology to measure the UHI impacts. Their method analyzed the temporary and spatial distribution of energy consumption of commodity, services and air temperature. In addition, it's emphasis to heating, building and consumption of air conditioning in the trade and the housing sector. The result showed that UHI increase the use of cooling the building (using air conditioning) in the trading sector, while declining in the housing sector. Hence, to solve UHI issues the municipality should focus on the trading buildings, but without ignoring housing sector.

In concert with the phenomenon of global climate change, urban heat island is the primary reasons for the observed significant increase of urban temperatures. This phenomenon occurs in specific regions of the cities, presenting high density and low environmental quality and resolutions in a serious decrease of ambient thermal comfort levels and poor indoor thermal conditions.

The impact of warming in an urban environment can vary. "It can affect natural climate change and weather, public health, environmental and ecosystem disturbance. Temperature changes effect urban dweller in many ways, acting upon their health and solace, energy cost, air quality, and visibility levels, water availability and quality, ecological services, recreation and overall quality of life" (Prilandita, 2009).

2.3.1 Measurement of Urban Heat Island

Measurement to UHI can be done by assessing the effects that occur due to UHI and the parameters/condition of UHI itself. The parameters or condition how bad is the UHI is it called urban heat island intensity (UHII). In addition, UHII is temperature differences between urban and rural area and the differences between well developed and less developed in built-up area (Memon, et al, 2007).

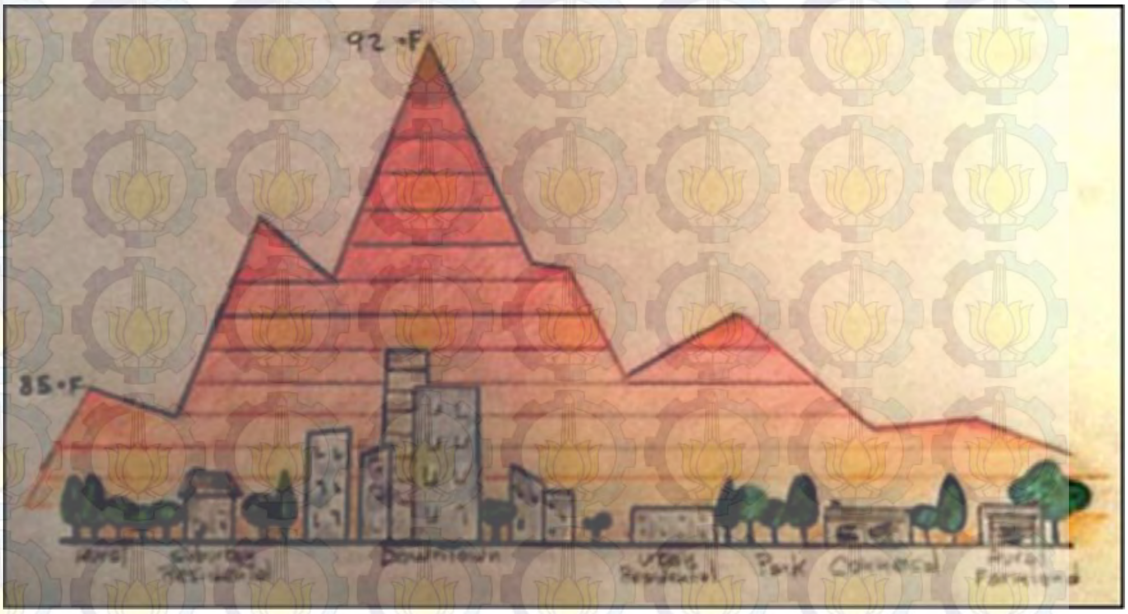


Figure 2.3 Changes in Land Cover Effects of Surface and Air Temperatures (Gago, 2013)

The temperature distribution in urban areas is extremely affected by the urban radiation balance. Solar radiation incident on urban surfaces is absorbed and then transformed to sensible heat. Most of the solar radiation impinges on roofs, and the vertical walls of the edifices, and only a comparatively small percentage extends to the ground floor. Walls, roofs and the ground emit long wave radiation to the sky. The intensity of the emitted radiation depends on the view factor of the surface regarding the sky. Under urban conditions, most of the sky dome viewed by walls and surfaces is blocked by other buildings, and thus the long wave radiation exchange does not really result in significant losses. The net balance between the solar gains and the heat loss by emitting long-wave radiation determines the thermal balance of urban areas, which are less efficient at achieving the balance and hence these areas require a higher temperature to achieve this balance. The urban heat island phenomenon may occur during day or night time periods and its patterns are strongly controlled by the unique characteristics of each urban area. Furthermore, the influence of several input climate parameters measured UHII, such as solar radiation, daytime and nighttime air temperature, and maximum daily air temperature, is investigated and analyzed separately for the day and the nighttime period (Mihalakakou, *et al*, 2004).

Ghazanfari, *et al*, 2009 studied to identify the climate factors that influence UHI intensity, such as precipitation, temperature, relative humidity, and percentage of cloudiness. In addition, the increasing temperature is influenced by anthropogenic heat that disposed from vehicles, power plants, air conditionings and others. Massive construction materials and decline of sky view factors can also influence UHI intensity (Memon, et al, 2007).

Measuring UHII is by comparing the average and maximum air temperature between urban and rural area. The comparison time period used to be a season, a month, or a year, or in some cases using few selected days (Velazquez-Lozada et al., 2006). The measurement time is in the clear and quiet night that minimize the effect of other factors in the selected area. In the other hands, UHII is the temperature change over a period time (Memon, et al, 2007).

Increasing consumption of energy can influence rising of UHII. Increasing of minimum temperature can lead the use of heating building, while the increasing of maximum temperature can increase the use of cooling building. Cooling degree days (CDD) (the gist of the divergences between the daily mean temperature and 65°F) is an approximation of the quantity of cooling needed to sustain a comfortable home environment. Cooling degree days have increased greatly over the years, contributing to rising energy demand to cool building interiors (Velazquez-Lozada et al., 2006).

Cooling degree days are values complied daily to assess how much energy may be needed to cool buildings and create comfort. In determining the cooling degree days (CDD), average temperature value is calculated for a given day. If it is greater than the standard base, the standard base value is subtracted from calculated average temperature to yield the CDD. This is compiled for daily and totaled for entire month. The CDD is calculated using formula CDD = E(ti-T). Where *ti* is daily mean temperature and T is base line temperature to use air conditioning. The rationale behind this technique is that whenever average temperature exceeds the comfort range, some cooling will be required, the requirement for cooling increases with increasing temperature (Enete, *et al*, 2012).

Based on the literature, this research will use CDD (cooling degree days) and minimum-maximum temperature as measurement to identify the UHI effects in Surabaya due to time limitation and availability of data.

2.3.2 Causes of Urban Heat Island

Many research emphasis on the UHI effect. Okeil (2010) determine the consumption of solar in the winter and the ways to mitigate it by using Residential Solar Block (RSB). It shows that RSB address the UHI through provision of green wall and roof, use of alternative energy and increased air flow between building.

Gaga (2013) analyze particular characteristic of urban climate and the causes of the heat island issue. This study was on the impact of surface albedo, evapotranspiration and the anthropogenic heating in the urban climate. He showed that green space produce suitable condition for evapotranspiration and created oases that were 2-8^0C cooler than their environment. Meanwhile, Wong (2011) stated that buildings, provision of green space and use of pavement is influencing urban temperature. Yamamoto (2006) recommend strategies to address UHI based on sustainable energy consumption, involve all stakeholders in implementing city planning, the structure and form of buildings, alternative energy use and public transportation.

There are **several causing factors** of warming in the city that has been identified. Prilandita (2009) has mentioned several general causing factors of UHI.

Population shift, urban and suburban growth, land use change, production and dispersal of anthropogenic emissions and pollutants which interact with regional climate as well as with the frequency and intensity of specific weather even (Prilandita, 2009).

From thus stated, there are two factors that influence UHI, namely factors within the activities of the city and regional climate and weather condition. Factors within in the city is factored that occur from human activities, such as land use change, anthropogenic emission and air pollution. Meanwhile, the regional climate and weather conditions is include rising temperature, clouds, and wind speed (Rosenzweig et al, 2005; Prilandita, 2009).

Lormaneenopparat (2002) said that the reasons for city to be warmer that the surrounding non-urban environment area can be considered as follows:

- Sensible heat storage:

  The materials of the urban landscape generally have low volumetric heat capacities, such as street and building materials, which means that urban surface reach a higher temperature with the absorption of a given quantity of radiation and in turn heats the overlying air faster. During the day, the urban surface absorbs heat more readily and then become a radiating source after sunset that raises night temperature

- Evapotranspiration decreasing:

  Both transpiration and evaporation process require solar energy. In the city which has limited green area, make hard surface prevent entry of water into the soil and drain it off quickly passes to the drainage system, and thereby greatly reducing the water available for evaporation. Since both evaporation and transpiration amount are decreased, the solar energy available for this process gives rise to the surface warming.

- Anthropogenic heat source:

  In areas of high activities, there is high energy consumption for the purpose of manufacturing, lighting, cooling, transportation, et cetera. These areas contain excess heat energy which is subsequently released to the atmosphere. The released energy is a form of heat waste generation, which increases urban heat.

- Air pollution and greenhouse gas effect

  Some incoming solar radiation is reflected back to space by gaseous particles, at the same time, these molecules can absorb energy and re-emitted to the air. In addition, the poor air quality can increase cloudiness, which reflects the long wave energy back to the earth.

- Wind speed

  The principle controller of heat output or heat losses from the urban atmosphere is wind speed. City is tends to have much lower wind speed at ground level than those in open areas. Therefore, heated air tends not to be flushed away as readily as it is in rural landscapes.

Form 2.4 shows, according to Yamamoto (2006), urbanization is influencing the number of population, provision of green space and expansion of living space. Those factors influencing the urban solar radiation, heat, and water that leading to the local climate. In addition, the major causes of the UHI effects are as follows:

- Increasing energy consumption that leads to anthropogenic heat release
- Less of green area and increasing construction materials can reduce evapotranspiration capacity.
- Urban form that trapped the heat due to the building's structure and urban sprawl
- The greenhouse effects of particulate air pollution in the urban atmosphere

Das and Borbora (2013) stated that urbanization is influencing UHII. Hence, the activities and physical form in the urban is effected to UHI effect. Energy consumption, greenhouse effect, anthropogenic heat, and loss of green space provision is the activities that effected UHI, while the man-made factors that represent the physical form of the city is urban structure, city size, density of population and built-up area, the width of the street and building material (Ganesan, Giridharan& Lau, 2004).

2.3.3 Effects of Urban Heat Island

The heat island phenomenon has a severe impact on the energy use of buildings, increase smog production, while leading to an increasing emission of pollutants from power plants, including sulfur dioxide, carbon monoxide, nitric oxides and suspended particulates (Mihalakakou, et al, 2004). Higher urban temperatures increase the energy consumption for cooling and raise the peak electricity demand (Santamouris*et al*, 2001, Kolokotroni*et al*, 2007, Hirano and Fujita, 2012, and Akbari 2005).

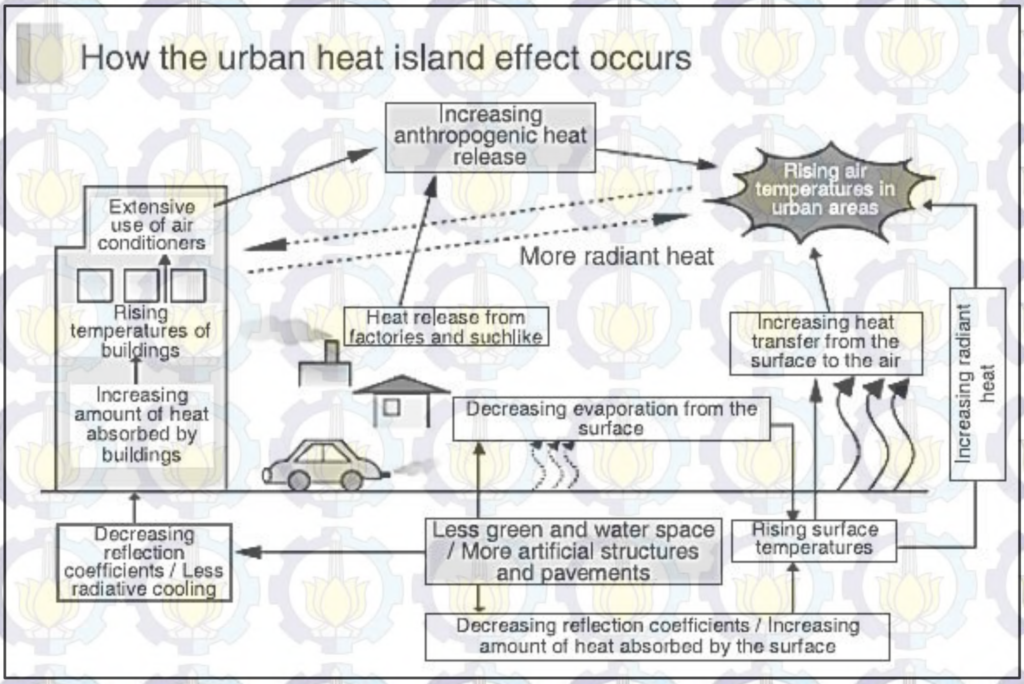


Figure 2.4 Illustration Factors of Urban Heat Island Effect (Yamamoto, 2006)

As mentioned by Santamouris et al, (2001), heat island in the city of Athens, Greece, doubles the cooling load of buildings and almost triples their peak electricity demand, while decreasing the Coefficient of Performance (COP), of mechanical cooling systems up to 25%. According to Akbari et al, (2005), for US urban centers with populations larger than 100,000 the peak electricity load will increase 1.5–2% for every 1 °F increase in temperature. The cooling energy increase is accompanied by intensification of pollution patterns in cities and increase of ozone concentrations (Sarrat et al, 2006), while the ecological footprint of the cities is increased (Santamouris et al, 2007a), the outdoor thermal comfort conditions deteriorate (Pantavou et al, 2011), the thermal stress in low income dwellings is increased, the indoor thermal comfort levels are seriously decreased and health problems are intensified (Sakka et al, 2012).

Based on those literatures, it can be reasoned that the UHI can be affected to increasing energy utilization, increasing health problem and decreasing urban dwellings comfort.

2.4 Measures to Reduce Urban Heat Island

Mitigation and adaptation can be used to address UHI effects. Those measures can be used together, due to similarity of formula and implication (Prilandita, 2009). Policy and institutional response that will be used in this study estimated covers both mitigation and adaptation measures.

2.4.1 Mitigation Measures

Gago et al, 2013 using planning strategies as approach to mitigate UHI effect, with using green space and trees, albedo and pavement as well as implementing urban design as mitigation measure. While considering that the dispersion of urban buildings and construction in a city affects the shaping of the urban heat island since this distribution can determine the absorption of solar energy and the formation of wind currents. In addition, the green space area also can mitigate the urban heat island effect (Faris, 2012; Maula, 2007)

Figure 2.5 shows that the UHI effect can be address based on characteristic of the particular area, that conducted by the local municipality. Increasing green space provision can prevent the increasing heat in the urban area, it because the green space can decrease the heat storage quantitative. Yamamoto, 2006 said that "Include the greening of building rooftops and walls, adoption of water-retentive construction materials, application of the light colored paint to exterior walls, use of reflective roofing materials, central control of building exhaust heat at the regional level, maintenance and improvement of parks and green spaces, construction of large-scale greenbelts, and reorientation of industrial/commercial facilities in light of prevailing wind direction".

In terms of transportation, pattern of urban traffic affects the efficiency of energy use and pollution in their circuit. The width of the street and lay out of the streets, including the distance between the buildings are impacted and solar utilization potential. The outcome in the smaller height to width ratio and sky view factor causes higher intensity of urban heat (Lormaneenopparat, 2002):

a) Mode of transportation

Another idea is about cluster zone of activity to limit transportation distance and energy consumption such as mixed zone of activities in central business district (CBD) zone provide direct transportation to node of city:

- Road and traffic node should make more public accessibility and reduce need of travel. Provide bicycle lane that are the most efficient of urban transport but there should be more shading by architecture and tree
- Water body can located and encourage developing with road. Some lake cannel become recreation and also reduce thermal in the traffic areas
- Using public transport as a main mode transportation. With using public transportation it can reduce the average of vehicle on the road and reduce pollution.

b) Parking lot

c) Street orientation

The mitigation measures are trying to reduce the urban heat island directly to the causes or factors that influence the phenomenon.

2.4.2 Adaptation Measures

Adaptation is adjusted in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effect or impacts. Adaptation is important in climate change matters in two ways-one relating to the appraisal of impacts and vulnerabilities, the other to the development and evaluation of response options (IPCC, 2007).

Local municipality lower the urban temperature with implementing zoning code, provided the green space and soft skill to adapt the rising temperature. Keep the building cool by using light roof that can reflect light and heat. Hence, using light pavement also reduce the heat by reflective the solar heat, help to absorb water and cool the city street. Using green space can be good ways to prevent heat. It can absorb heat, air pollution and control the water evapotranspiration. Education the public and strong integration between stakeholders can be used to reduce heat (Hoverter, 2012).

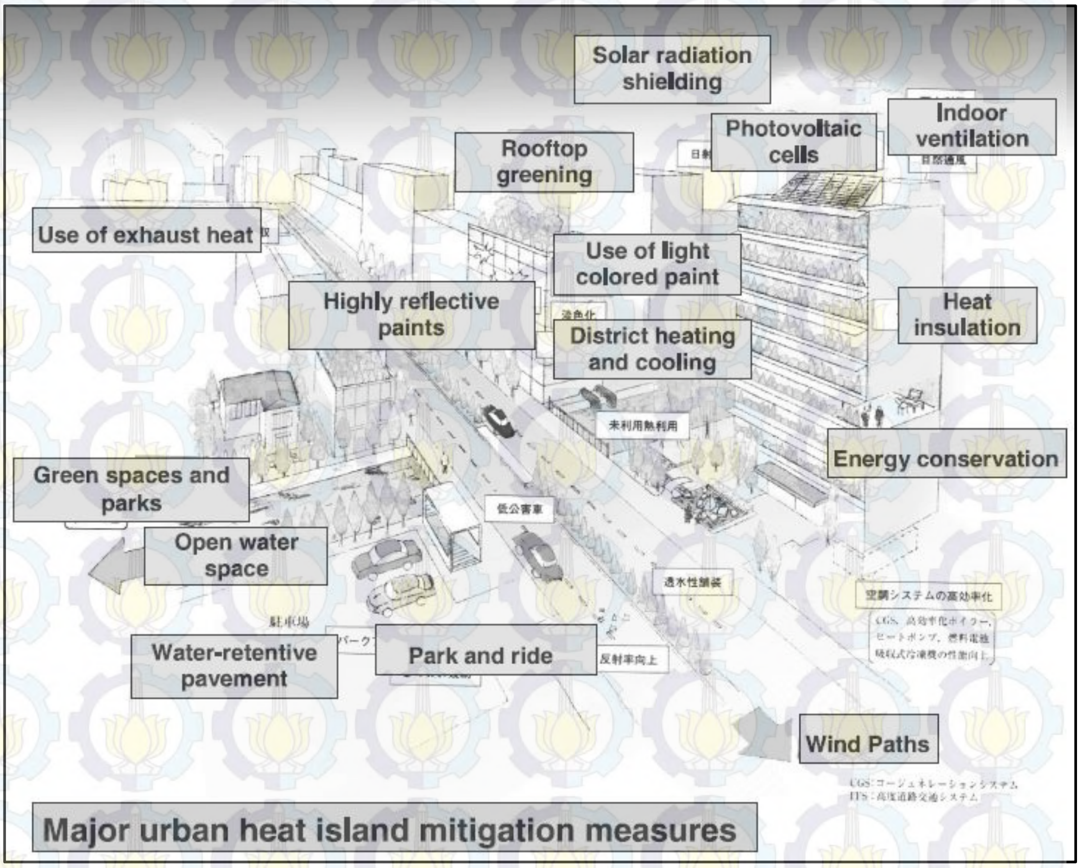


Figure 2.5 UHI Mitigation Measures Yamamoto (2006)

Mapping the disaster is needed due to the importance of address the UHI. Enhance people information and education can enhance their knowledge to address and prevent rising temperature. Others effort is by elevating the house or build a barrier in the river or water body (Prilandita, 2009). The adaptation actions in terms of urban heat island effect are mostly related to disaster preparedness, focusing to reduce the impact or effect of urban heat island.

2.5 Related Studies

2.5.1 Summertime Urban Heat Island Study for Guwahati City, India

Guwahati is the largest city in the state of Assam, India. The urban area is around 262 km^2 and has a population of about 12 lakh (Census of India, 2011). It located in the central area and sprawl to the peri-urban area. River Brahmaputra intersects the Guwahati into two parts with southern part comprising the urbanized core and extensions, while the northern part representing the rural areas. The general climate of the city as well as the entire region is of warm humid type. Being the gateway to the entire northeastern region of the country, the city has undergone rapid urbanization changes in the past decade. There has been considerable increase in the density of the population in the past and is projected to grow up to 21.74 lakh by 2025 (GMDA, 2009). Replacement of natural vegetated areas with dry impervious surfaces, use of building materials having high heat capacity and low surface reflectivity and increased anthropogenic heat emission into the urban atmosphere are likely to modify the thermal regime of this city.

Summertime Urban Heat Island (UHI) effect in Guwahati, is studied, by using half hourly temperature data measured at four fixed observation sites – two in the urban core and the others at the periphery, away from the city. The in situ measurements were conducted using stationary loggers from the months of May to October 2009 to study the temporal variation. Also, mobile measurements were carried out during the months of June, July and August 2013 to bring out the intra-city temperature variation. The results show existence of UHI above 2^{o}C. The highest magnitude of daytime Urban Heat Island Intensity (UHII) for the entire period of study was found to be 2.12^{o}C while highest nighttime UHII was 2.29^{o}C. Diurnal ranges of temperature (DTR) showed wide variation in each of months included in this study. Higher DTR were experienced in the month of May for all the stations– rural as well as the urban. As the summer progressed, the DTR showed declining trend through the months of June to August and started rising again in September showing the influence of monsoon in air temperature regime. Variation in the average monthly DTR within the season is low in urban stations compared to rural ones. The temperature difference, recorded in the mobile runs, between the downtown and the suburban areas, ranged from 1.23 to 0.78^{o}C.

The results proved the existence of summertime Urban Heat Island Intensity above 2^{o}C even in a relatively small city like Guwahati. With incremental decrease in green cover associated with urbanization, the phenomenon of UHI is likely to express itself in a more perceivable manner in the days to come. Increase in air temperature in a city like Guwahati, where humidity conditions are high, especially during summer, would mean substantially higher level of discomfort for dwellers. This is an important aspect that urban planners need to take into account while planning for further development of the city (Das &Borbora, 2013).

2.5.2 Cool Pavements as a Mitigation Triangulation Strategy to Against Urban Heat Island

"Heat island phenomenon rises the temperature of urban centers, increases the energy demand for cooling and deteriorates comfort conditions in the urban environment. To counteract the impact of the phenomenon, important mitigation techniques have been projected and built up. Pavements present a very high fraction of the urban regions and contribute highly to the development of heat island in cities. The use of cool pavements presenting substantially lower surface temperature and reduced sensible heat flux to the atmosphere appears to be one of the most important proposed mitigation solutions"

"Decreasing the surface temperature of pavements may contribute highly to improve the thermal conditions in the cities suffering from high urban temperatures. This can be achieved by replacement of conventional paving surfaces with new ones presenting much lower surface temperatures during the warm period, reconstruction, preservation and rehabilitation of the existing pavement to improve thermal performance and shading of the paved surfaces to decrease absorption of solar radiation. Advanced materials and surfaces, known as cool pavements, have been created and are available for use in urban environments. Cool pavements are mainly based on the use of surface presenting a high albedo to solar radiation, combined to a high thermal emissivity (reflective pavements), or are using the latent heat of water evaporation to decrease their surface and ambient temperature (water retention pavement). Both technologies are easily trained and many commercial products are available to the securities industry"

"Actual research trends to develop highly reflective pavements focus on the use of highly reflective white coatings and infrared reflective colored pigments to increase the albedo of the pavement surface, the use of reflective paints to increase the reflectance of the pavement ingredients, and also the use of color changing paints to achieve a better thermal performance all year round. Laboratory have proven that the albedo achieved can be very high and the pick surface temperature of the paved materials may fall by up to 20K. Newly developed reflective materials and techniques were tested in many demonstration and real scale projects"

"Permeability and water retentive pavements, vegetated or not, are more appropriate for rainy and humid areas where the availability of water is not a problem. Actual research targets aim mainly to involve additional agents in the multitude of the paving materials like steel bio products, fine blast furnace powder, fine texture pervious mortar, bottom and fly ash, peat moss and industrial wastelands. The aim of the research is also to improve the capillary ability of the pavements to increase the water content and the evaporation capacity of the materials. Even so, the thermal performance of the permeable and water retentive pavements depends highly on the accessibility of water" (Santamouris, 2013).

2.6 Review of Analytical Methods

2.6.1 DPSIR Analysis

DPSIR

DPSIR is "analysis tools for tracing the interactions between society and the environment produced by the European Environmental Agency (EEA). It is based on the PSR (Pressures/State/Response) model proposed by the OECD, and it has been applied to the organization of systems of indicators and statistics in relation to the policy aims" (e.g. EEA, EUROSTAT).

DPSIR consist of Driving force, Pressure, State, Impact and Response

(a) Driving Forces are the changing that both directly and directly lead pressures on the environment sector, which come from social, economic and institutional systems. The EEA defines them as "*the social, demographic and economic developments in societies and the corresponding changes in lifestyles, overall levels of uptake and production patterns*" (EEA, 2007). The driving force is effected to the social, economic, and environmental system and interaction between those sectors (Rodríguez-Labajos et al., 2009). The fundamental driving forces are the socioeconomic that influence to economic management, then the next driving force is in term of the policy. Meanwhile, the tertiary driving forces are taking more time and wider sphere of effect. The last is based driving forces, that covers crucial trends which are influenced by social elaboration in the period of time.

(b) Pressures are the factors that come from human activities that influencing environmental change (impacts). According to EEA, pressures can be identified as emission from combustion, physical and biological factors, consumption of resources utility and land use zoning.

(c) The state refers to the natural and the socioeconomic system. It can covers current condition, the particular characteristic of ecosystem, natural resources and hamper to humans. The elaboration of current state and current pressure is shows impacts.

(d) Impacts are the change in environmental function that come from social, economic and environmental dimensions. It can cover the change in environmental sectors, such as accessibility to natural and man-made resources, water and air quality, soil fertility, and health (Maxim et al., 2009). Impacts lead to responses.

(e) The response is the cities regulation and policy which are influenced by impacts and it takes to address, eliminate and tackle the impacts. The response can come from several sources, from a group of individual, public to private sectors. The response can also influencing driving force, pressure, state and impacts.

2.6.2 Triangulation Analysis

The four types of triangulation originally identified by Denzin in the 1970s: "(1) data triangulation; (2) investigator triangulation; (3) theory triangulation; and (4) methodological or method triangulation" (UNAIDS, 2010).

Data triangulation is the use of various data sources, including time, spatial and human. Determination the validity of the results can come from suitable information, that increasing the robustness and reliability of the outcome as well. This framework has implemented in many sources to strengthen the finding and prevent false interpretations.

Triangulation is a multiple methods to analyze a particular condition. The aim is to increase the validity and reliability of the outcome. Data source in triangulation is completed each others. The triangulation analysis implements for mixed use method, namely quantitative and qualitative analysis. In addition, the various of data triangulation, are accumulated by different methods as opposed to data compiled for different programmers, locations, populations

Investigator triangulation is the economic consumption of more than one investigator, interviewer, observer, researcher or data analyst in a written report. The power to confirm findings across investigators without prior discussion or collaboration between them can significantly raise the credibility of the determinations. Investigator triangulation is particularly important for decreasing bias in gathering, reporting and/or analyzing study data.

Theory triangulation is the function of multiple theories or hypotheses when examining a place or phenomenon. The estimate is to count at a situation/phenomenon from different perspectives, through different lenses, with different questions in mind. The different theories or hypotheses do not have to be similar or compatible; in fact, the more divergent they are, the more probable they are to identify different topics and/or businesses.

2.6.3 Partial Least Squares Analysis

“Partial least squares is a popular method for soft modeling in industrial applications. Partial least squares (PLS) is a method for constructing predictive models when the factors are many and highly collinear. Note that the emphasis is on predicting the responses and not necessarily on trying to understand the underlying relationship between the variables. For example, PLS is not normally appropriate for screening out factors that have a negligible effect on the answer. However, when prediction is the goal and there is no practical need to limit the number of measured factors, PLS can be a useful tool “ (Tobias, 2012).

PLS is an analysis technique that creates and elaborate from PCA and multiple regression. The objective is to determine or anlyze a set of dependent variables from set of independent variables. Lattent variable is a orthogonal factors that pulling up from the predictors that represent predictive power (Abdi, 2007). This research has used smartPLS as software for PLS analysis.

The equation of the PLS regression model can be written as:

$Y = T_h C`_h + Eh = XW_h{*}C_h + E_h = XW_h (P`_h W_h)\text{-}1\ C`_h + E_h$

Where Y is the matrix of the dependent variable, X is the matrix of the explanatory variables T_h, C_h, $W*_h$, W_h and P_h are the matrices generated by the PLS algorithm and E_h is the matrix of residuals.

Case Study (Hidayat et *al*, 2013)

Occupational safety and health is one of the important factors that can affect employees' productivity. Risk of accidents and occupational diseases often occur because the occupational safety and health program is not performing properly which can have an impact on the level of employees' productivity. The aims of the research were to determine the effect of occupational safety variable and occupational health variable on employees' productivity, and occupational safety on occupational health at installation division of PG KrebetBaru II Malang. The study was conducted at the installation division of the PG KrebetBaru II Malang using sample size of 60 people. Variables used in this study consisted of two types, i.e. latent variables and indicator variables. Data were collected using a questionnaire which was consisted of questions include all research variables and the response was measured using a Likert scale. The data then were analyzed by partial least squares method using software SmartPLSver 2. The results showed that the occupational.

Discussion and result

A. Reliability Test

Based on Table 2.1 it shows that from *Cronbach Alpha* all variables are greater than 0.60. According to Umar (2002) the instrument of the research is reliable if the coefficient of reliability r > 0.6. Therefore, it shows that questioners have given the significant measurement for the analysis.

Table 2.1 Reliability Test of The Case Study

Variable	Cronbach Alpha	Note
Work safety (X_1)	0.767	Reliable
Work health (X_2)	0.734	Reliable
Employee`s productivity (Y)	0.678	Reliable

Source: Hidayat et *al*, 2013

B. Evaluation with PLS Method

The path diagram is shows the model between structural model (inner model) and measurement model (outer model). The inner model in this research is the correlation between exogenous latent variable and endogenous latent variable. The inner model in this research is work safety (X_1) and work health (X_2) to employee`s productivities (Y). Meanwhile, the outer model has designed to reflective model. Based on Figure 2.5 it can be found that there is indicator that unacceptable to *convergent validity* terms with the value of *outer loading* is 0.448 (less than 0.5). According to Wiyono (2011), if the value of indicator less than 0.05 it should be modified the model. In addition, Figure 2.6 shows the modification model with eliminate one indicator (noise).

Next step is estimated the path by using *path estimated*. This estimated generate the value of outer loading that shows correlation between latent variable and indicators. In this research all indicators has correlation with their latent variable. In addition, the next step is criteria evaluation of *Goodness of Fit* with the results, as follows

1. Outer model

a) Convergent validity

Based on the Table 2.2 is founds that work safety, work health and productivities of the employee is valid (*outer loading*> 0.50). Therefore, it can be concluded that indicator variables are highly correlated with latent variable and it has ability to measure the latent variable.

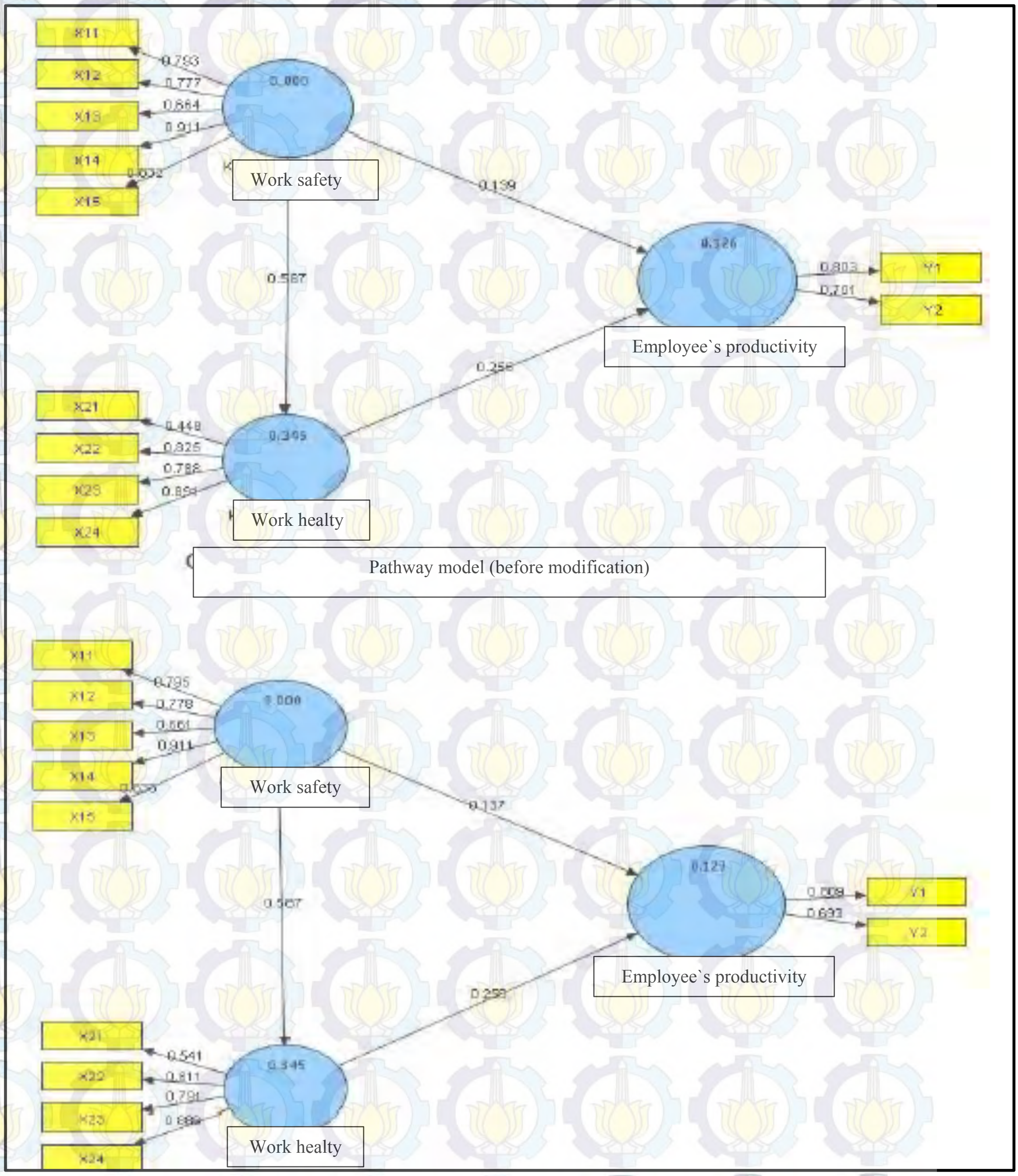


Figure 2.6 Path Diagram of Modeling Result (before and after modification) (Hidayat *et al*, 2013

b) Composite reliability

Table 2.3 shows that all latent variables (work safety, work health and productivities of employees) have higher value than 0.70. Therefore, it can be concluded that work safety, work health and productivities of employees have a high consistency. Based on Wiyono (2011), a latent variable is a reliable if the value of *composite reliability* is exceed of 0.70.

Table 2.2 *Convergent Validity* Results of The Case Study

Variable	Indicator	*Outer loading*	Note
Work safety (X_1)	Personal protective equipment (X_{11})	0.795	Valid
	Workload (X_{12})	0.778	Valid
	Work safety regulation (X_{13})	0.661	Valid
	Communication and support (X_{14})	0.911	Valid
	The importance of work safety (X_{15})	0.833	Valid
Work health (X_2)	Physically work environment (X_{21})	0.541	Valid
	Facilities and health service (X_{22})	0.811	Valid
	Recreational facilities (X_{23})	0.791	Valid
	Work health regulation (X_{24})	0.886	Valid
Employee`s productivity (Y)	Quality of work (Y_1)	0.809	Valid
	Timeliness (Y_2)	0.693	

Source: Hidayat et *al*, 2013

2. Inner model

The R-square for productivities of employee variable is 0.127. This result shows that the work safety and work health were influenced the employee`s productivities by 12.7%. Meanwhile, 87.3% the rest is influenced by the other factors that not included in the model, such as motivation, work satisfaction and organizational culture. Furthermore, work health has 0.345 for the value of R square. This is shows that work safety was influenced work health by 34.5, while 65.5% the rest is influenced by the other factors that not included in the model, such as live pattern.

Table 2.3*Composite Reliability* Result of The Case Study

Variable	Composite Reliability	Note
Work safety (X_1)	0.898	Reliable
Work health (X_2)	0.848	Reliable
Employee`s productivity (Y)	0.723	Reliable

Source: Hidayat et *al*, 2013

C. Result of hypothesis test

Hypothesis test is searching by comparing between t statistics of the case study with t Table, that shown in Tables 2.4 and 2.5. The value of t table is 2.16 (α=0.05 df= 59). The hypothesis test in this research is:

$$H_0 = \gamma i = 0 \text{ against } H_1 = \gamma i \neq 0$$

Test criteria:

If t statistic > t Table, H_0 accepted and H_1 rejected

If t statistic < t Table, H_0 rejected and H_1 accepted

1) Hypothesis between work safety to employee`s productivities

H_0: $\gamma i = 0$ = there is no significant influence between work safety and employee`s productivities

H_i: $\gamma i \neq 0$ = there is significant influence between work safety and employee`s productivities

2) Hypothesis between work health to employee`s productivities

H0: $\gamma i = 0$ = there is no significant influence between work health and employee`s productivities

Hi: $\gamma i \neq 0$ = there is significant influence between work health and employee`s productivities

3) Hypothesis between work safety to work health

H0: $\gamma i = 0$ = there is no significant influence between work safety and work health

Hi: $\gamma i \neq 0$ = there is significant influence between work safety and work health

Table 2.4 The Value of F-square

Dependent variable	Independence variable	F-square	Influence
Work safety and work health	Employee`s productivities	0.791	Low
Work safety	Work health	8.014	Middle

Source: Hidayat et *al*, 2013

Table 2.5 The Result of Hypothesis Test

Dependent variable	Independence variable	Path coefficient	t-stat	t-table	Note
Work safety	Employee`s productivities	0.137	0.791	1.671	H_0 accepted
Work health	Employee`s productivities	0.258	1.837	1.671	H_0 rejected
Work safety	Work health	0.587	8.014	1.671	H_0 rejected

Source: Hidayat et *al*, 2013

The result of this research shows that work safety variable with the value of regression coefficient is 0.137 has not significantly influence the productivities of employee. Meanwhile, work health variable with 0.258 regression coefficient is significantly influence to the productivities of employee. Furthermore, the influence between work safety and work health is 0.587 that means both variables are significantly influence.

2.7 Summary

Prevention and reducing urban heat island effect has established based on the literatures and previous researches. Furthermore, the literature review describes the effect of urban heat island that effected to livelihood and environment (Prilandita, 2009). The literatures have shown that the increasing urban temperature is depending on several factors. The factors can be endogenous factors that come from inside of the city existing in terms of manmade and also exogenous factors that come from nature. As city develop, the development of the city will be increased the urban heat island factors. In addition, it is like a cycle of problem, as human activities increase, it will lead to increasing of energy consumption, increasing built-up area, and increasing automobiles emission (GHG emission). Therefore, is generating urban heat island phenomenon, as well as this phenomenon can affect to increasing energy using, environment and health problems.

Some researches only focus on one factor to identify the UHI effect, like population or building density (Das, et al 2013; Lau, et al 2004). The other, analyzed the factors that influence UHI without further analyzing regarding to significant factors based on city`s characteristics (Okeil, 2010; Gago, 2013; Wong, 2011; Prilandita, 2009). As well as they only focused recommending strategies to reduce the effect without analyzing the significant factors that influence it (Yamamoto, 2006; Gago, 2013; Santamouris, 2013; Maula, 2009). This study tries to cover the knowledge gaps by analyzing the significant factors that influence UHI based on city characteristics with using strategies instrument to reduce or address the effect.

This research will use both microclimate and manmade causes for identify the condition of UHI effects (state). Only manmade causes will be used as a factor to determine the significant factors and determine the existing strategies. In addition, subsection 2.3.1 refers to measurement to UHI will be used as microclimate factors and subsection 2.3.2 refers to causes of UHI will be used as manmade factors. Furthermore, this research has used changes in surface cover, individual heat emitting and air pollutant that come from the number of vehicle as a manmade factor. Meanwhile, cooling degree days and maximum minimum temperature has been used as microclimate factors. This research focus in determine the most significant factors as well as focus in response option that contained in local policy or institutions to address urban heat island.

Table 2.6 shows the factors, variables and the definition that is used in this research. In addition, the reason to choose the factors and variables are as follows.

Table 2.6 Factors, Variables, Data and Definition

Factor	Variable	Data	Definition
Dependent Variables			
UHI effects (microclimate)			
Urban heat island intensity	Cooling Degree Days	Monthly mean temperature	Measurement how much and how long outside temperature was higher than a specific base temperature (standard temperature for not using air-con)
	Maximum and minimum temperature	Maximum and minimum monthly temperature	Measurement for maximum and minimum temperature in one specific area
Independent Variables			
Man-made			
Changes in surface cover	Area of green or open space	Demography data	The total area that covers with vegetation which has managed and belong to the municipality
	Area of paving	Demography data	The total area that covers with paving
	Area of asphalt	Demography data	The total area that covers with asphalt
Heat of individual emitting	Electricity energy consumption	Demography data	Number of electricity energy that people use cooling the building (use of air conditioning)
Greenhouses gases	Carbon emission	Survey record	Emission from equivalencies with the number of vehicle, that despite CO gas

a) Urban heat island intensity. This research use urban heat island intensity to measure the condition of UHI in Surabaya with using CDD and maximum-minimum temperature as the variables. Based on Velazquez-Lozada *et al* (2006) and Enete *et al* (2012), the rationale from CDD is that whenever the average temperature exceeds the comfort range, the use of air conditioning will increase and in the end it will lead to increase air temperature. Therefore, the increase of air conditioning consumption means that increase the value of CDD. Furthermore, due to availability of data and to analyze the base line data need further analysis (Lee *at all*, 2013) this research will use 65^{o}F as the base line temperature. Meanwhile, the maximum and minimum temperature in this research is refers to day time and night time temperature (Velazquez-Lozada *et al*, 2006). Based on Memon *et al* (2007), the day time and night time temperature are related to the absorption of the solar radiation. During daytime the solar radiation is influenced by anthropogenic heat and air pollution, while in night time it related to the discharge of solar radiation that being absorbed during daytime.

b) Changes in surface cover. This research is using changes in surface due to urban development effect. Surabaya as a capital and big city which has density population will increase the change of green and open space to built-up area/material cover. Therefore, this condition will increase the urban heat island in the city. According to Yamamoto (2006), Lormaneenopparat (2002) and Prilandita (2009), change in surface cover can reduce surface evapotranspiration capacity due to less of green space and increase heat storage due to construction materials such as asphalt and concentrate. Paving is use in this research due to comparison effect with asphalt which has a compact structure material. In addition, this research only uses public space that has managed and belongs to Surabaya municipality due to data availability. Based on data from Cleanness and Landscape Agency (2013), green space in Surabaya is including park, stadium/sport field, graveyard, and green line. According to Fariz (2012) and Doick and Hutching (2013) vegetation particularly tree has a key role to play in contribution to the overall temperature regulation of the cities.

c) Heat of individual emitting. This research is using heat of individual emitting refers to anthropogenic heat source. According to Yamamoto (2006) and Lormaneenopparat (2002), there is high energy consumption for the purpose of manufacturing, lighting, cooling, transportation and etcetera. Moreover, according to Lundgren and Kjellstrom (2013) , air conditioning is a common technical solution to problems of increasing temperature that increase the electricity consumption which is in the end it contribute to urban heat island effect and ambient heat exposure. Liu et al (2011) said that AC directly affects the urban heat island effect. Furthermore, based on their research found that the largest heat island intensity contributed by AC system can reach 0.70C at midday and the daily average rise is 0.53oC.

Greenhouse gases effect. This research is using greenhouses because incoming solar radiation is reflected back to space and it trapped in the urban atmosphere due to smog that block the solar radiation to go to the higher atmosphere. In addition, greenhouses gases can increase cloudiness and smog effect Lormaneenopparat (2002). Moreover, greenhouses gases can come from transportation activities such as imperfect combustion that create carbon emission. In this research carbon emission is equivalencies from the number of vehicle. In addition, the number of vehicle can increase the air temperature, air pollution and greenhouses gas effect (Trappey et al, 2012).

CHAPTER 3
METHODOLOGY

This chapter provides explanation about the methodology of the study and research design. Conceptual framework used to create understanding for overall concept of the study. Methodology, tools, and analysis techniques used to achieve each objectives of this research, which are described in detail such as type of data needed, data collection techniques and analysis.

3.1 Research Approach

High rising temperature and high development in Surabaya is the conceptual concept in this research. Based on high rising temperature and increase development, urban heat island is estimated happen in this area (Fariz, 2013). Based on that condition, this research will be conducted. This research explores the existing situation of urban heat island by analyzing the condition of several factors in study area that leading to the significant factors which is influencing UHI in Surabaya. Emphasizing thus factors, recommendation to reduce urban heat island effect is being established by enhancing the existing strategy.

This research used a mix of qualitative and quantitative method. Thus mixed method is complete and support in every step of this research. Qualitative method will be used for exploring characteristic of urban heat island effect in Surabaya by using several factors, as well as it will be used in strategies analysis and triangulation analysis for purposed the recommendation. In the other hand, quantitative method will be used for analyze the correlation among factors and determine the significant factors, by using partial least square analysis.

3.2 Research Conceptual Framework

Based on literature review and objective of the study, a research conceptual framework of this research is has presented in Figure 3.1. This research tries to analyze UHI in two stages, the factors that influence UHI and existing strategies to address it. In this research, factors can be identified from both either the causes of UHI and the measures to address UHI. Meanwhile to identify the characteristics (condition) of UHI in Surabaya, it used UHI intensity as a measurement. Considering that based on literature review (Witlinger, 2001, Eenete *et al,* 2012, Velazquez-Lozada *et al*, 2006 and Memon *et al ,* 2007), this research will use CDD (cooling degree days) and minimum-maximum temperature as measurement to identify the UHI in Surabaya. In addition, that choice has been taken due to time limitation and availability of data. Furthermore, the CDD and max-min temperature factors is indirect factors to measure UHI effect, for the example to know the energy consumption for cooling the buildings it not only depend on CDD but also from the other factors, such as the material of the buildings, the height of the buildings, etc. Moreover, researcher can use direct measurement to measure UHI.

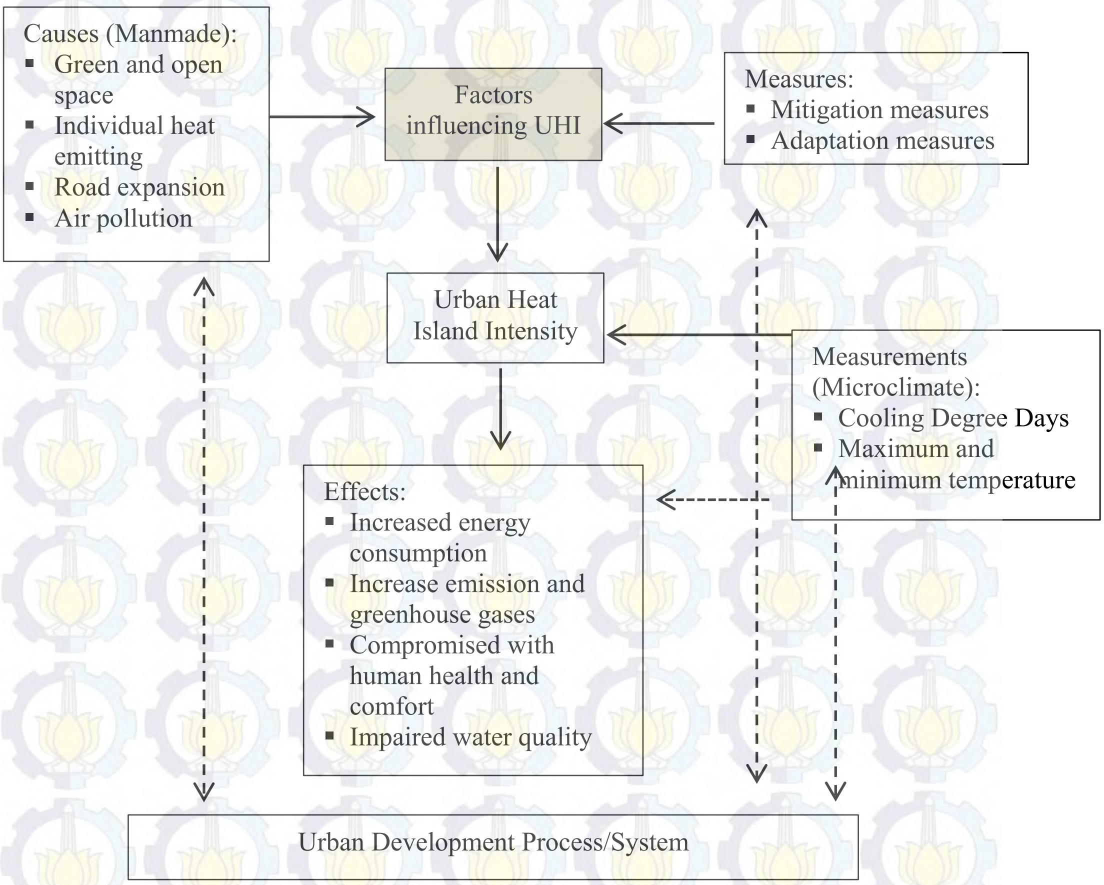


Figure 3.1 Research Conceptual Framework

Several causes of UHI can be identified as factors influencing UHI such as, change of the surface, consumption of energy heat emitting and greenhouse gases. Thus factors can create impact to the human and environment, such as health effect, increasing energy consumption, increase discomfort and decreasing of air quality. Those several factors influencing UHI intensity in Surabaya, which is in the end it will leading to the effects of UHI. In addition, this research has tried to reducing UHI effects by analyzing the existing city`s strategies condition, in terms of ongoing strategies that has implementing in Surabaya. Furthermore, the causes, measures and measurement are component of urban development process/system.

3.3 Research Methodology

Different methods have been employed in order to achieve the objectives as outlined in Chapter 1. Figure 3.2 presents the overall methodology of this research. The structures of this methodological framework for this research are, firstly identification of key problems previous studies and existing condition that covers the background and statement of problems, secondly select the study area that based on current condition, background and statement of problems, third set research question and objective that based on current condition, background and statement of problems, fourth selection of factors, indicators and variable of UHI in the literature review and preview of study, fifth set research conceptual framework and research methodology that covers research objective, and literature review, and the last is analysis steps which contain five task. Furthermore, explain the analysis step, which is divides into 5 tasks based on each objective.

Objective 1: To identify the current conditions of urban heat island in Surabaya

The objective 1 is to analysis the existing of UHI in Surabaya base on several factors (microclimate and manmade causes) that were mentioned in literature review. In addition, it uses descriptive analysis by using DPSIR to identify the UHI condition. Output of this task is identifying the characteristics of

UHI effect in Surabaya. The data collection will obtain from observation and secondary survey (document and statistical data).

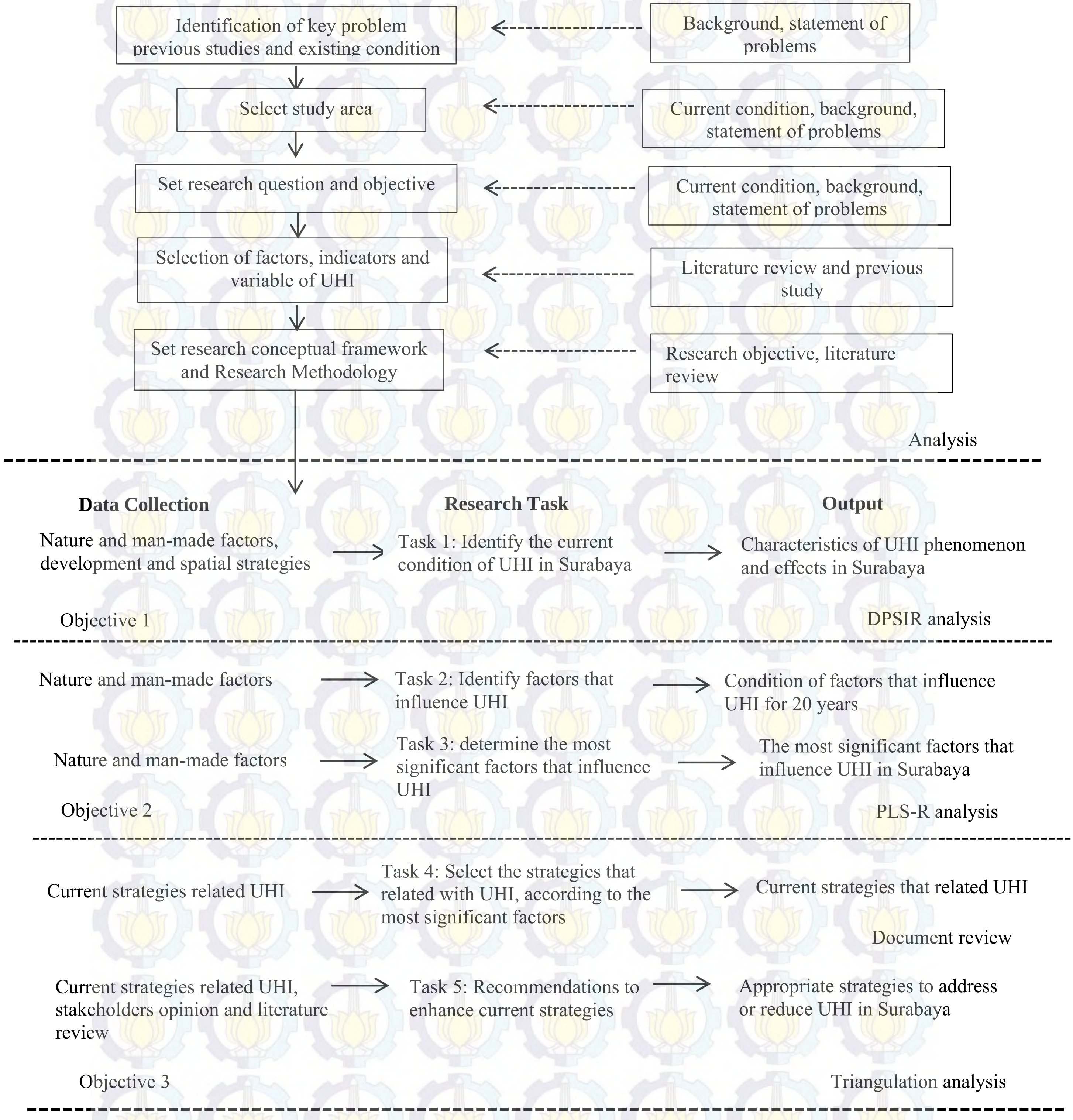


Figure 3.2 Methodological Framework

Objective 2: To determine significant factors that influencing UHI in Surabaya

To obtain the goal for objective 3, this section will be divided into two steps, as follows.

Task 2

Task two is to identify the condition of nature and manmade factors in Surabaya. The method that use in this task is statistical data review for 20 years. In addition, the statistical data that used in this task is maximum and minimum temperature data, CDD data, carbon emission data, electricity consumption, provision of green space, total area of paving and asphalt. This result can be used as a base line data in task 3

Task 3

Task two is to determine the significant factors that influence UHI effect in Surabaya. PLS-R analysis will be used as analysis method by using Smart-PLS as an analytical tool. Input data for this task is output of Task 1 and data from microclimate and man-made factors, such as demography data, area of green/open space, electricity record, transportation document, CO emission record and daily traffic average data.

Objective 3: To propose recommendations for enhancing the existing strategies to address UHI based on the significant factors

To obtain the goal for objective 3, this section will be divided into two steps, as follows.

Task 4

This step is to select several strategies related to UHI, according to the significant factors which had analyzed in objective 2. Existing strategies can be both national or city scale, such as city regulation and the national act.

Task 5

To enhance current strategies for reducing UHI effect, this task will use triangulation analysis. In addition, triangulation analysis is comparing method among three aspects named is current strategies, literature review to enhance or strengthen the current strategies and the last is respondent`s opinion/response. In addition, this recommendation is include both mitigation and adaptation to reduce/address UHI. Existing condition of UHI in Surabaya also needed as consideration. This task is used all output analysis from Tasks 1 to 4. Moreover, the first step is to select and identify the strategies related to UHI. Then, triangulation analysis will be conduct to get the best recommendation.

3.4 Selection of Study Area

The total area of Surabaya City covers land with an area of 330. 48 km^2 and marine area of 190,39 km^2. This city consists of 31 districts and 160 villages. Surabaya becomes the largest city in Southeast Asia due to the main seaport and the activities as the central of commercial in the eastern region of Indonesia. Nowadays, the population in Surabaya is reach to three million inhabitants and the peri-urban at least reached 7 million inhabitants. The administrative area of Surabaya is refers to Figure 3.3:

North Part : Madura Island and Madura strait
East Part : Java Sea
South Part : Sidoarjo Regency
West Part : Gresik Regency

Spatial pattern is a form of structural and space utilization, either planned or not. Spatial planning is the process of spatial planning, space utilization, and control of the utilization of space. Document development strategies in Surabaya divided into hierarchy tree based on spatial planning law number 26, 2007. First hierarchy is RTRWN this document covers all strategies planning for national scope. Next is RTRW, this document covers all strategies planning for overall city, then RDTRK which is detailed form from RTRW document. RDTRK document also using as reference for city governance to issuing building permit.

Surabaya in Indonesia is suitable for the objective of this research. In addition, Surabaya is facing urbanization and rapid development as well as compact city does. The quality of environment is decrease and UHI phenomenon was occurred in Surabaya (Fariz, 2009). Criteria to select this city as study area are as follows:

1. The city is located in lowland (coastal area)

2. The demographic condition of Surabaya is over-populated area
3. Traffic congestion happens due to high mobilization with insufficient road capacity
4. This city is compact city, which using mix use land use and more dense land use in the central business district
5. Administratively, Surabaya is the capital of East Java province and particularly the main activities is commercial and service in large scale
6. There is a propensity that the extreme weather events are occurred in higher density

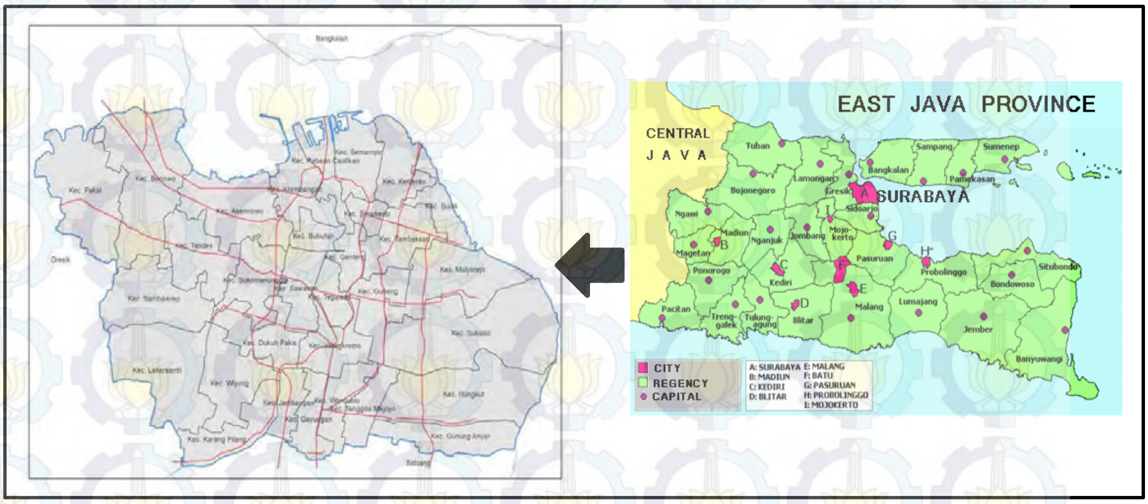


Figure 3.3 Surabaya Map (Ariyaningsih, 2012 and Surabaya Municipality, 2012)

3.5 Data Collection Methods

Data is information in raw or unorganized form (such as alphabets, numbers, or symbols) that refers or represent the conditions, ideas, or object (Prasetyo, 2005). Data collection in this research includes primary and secondary data. Primary data will obtain through observation, and semi structured interview. While secondary data will be obtained through literature review, previous study and documents from related agencies. Considering that Surabaya municipality may lack of availability on the direct strategies for addressing UHI, set up or select related strategies to address UHI is being needed. Data collection methods and techniques that used in this research was shown in Table 3.1.

3.5.1 Primary Data Collection Methods

Primary data collection done in task 1, task 2, and task 3. Primary data had gathered from observation and semi structures interview, as follows:

a) Observation is using for observing the current condition of several factors that influence UHI in Surabaya. The objects for observation are availability of green space, and daily traffic condition. The objective of this technique is documented the current condition for supporting evidence. This technique will be used for achieving goal in task 1 and task 5, to identify the current of UHI in Surabaya.
b) Response is used for triangulation analysis that is show in Appendix 3. Determined the respondents for this data collection is based on significant factors. Therefore, the respondent is municipality, expert and academicians that related with planning agencies in Surabaya. In addition, determine focus actors are chosen by using a purposive sampling or non-probability sample. Purposive sampling represents a group of different non-probability sampling techniques. As well known as judgmental, selective or subjective sampling, purposive sampling relies on the opinion of the researcher when it comes to selecting the units (e.g., people, causes/organizations, events, pieces of data) that are to be considered. Normally, the sample being investigated is quite small, particularly when compared with probability sampling techniques.

The main goal of purposive sampling is to focus on particular characteristics of a population, which is in this research the population is actors that involved in UHI effect, such as planning and development agency and department of public works,. Moreover, semi structured interview will be conducted to ask the statistical data related to the factors (causes and measurement to the effects), considering lack of document availability and the conditions of UHI in Surabaya.

Table 3.1 Data Collection Methods

Research questions	Key body of evidence	Data/information	Sources	Technique of data gathering
How is the current condition of UHI in Surabaya?	Identification of current condition regarding to several factors that influence UHI	▪ Urban temperature trends ▪ Monthly mean temperature ▪ Land use map ▪ Demography data ▪ Electricity record ▪ Air quality data ▪ Transportation document ▪ Daily traffic average data ▪ Provision of green space data	▪ Meteorology and geophysics department ▪ Statistical office ▪ Electricity office ▪ Department of public works ▪ Planning and development agency ▪ Transportation agency ▪ Environmental protection agency ▪ Cleanness and Landscape agency	▪ Observation ▪ Document review
What are the most significant factors that influence UHI in Surabaya?	Determining the most significant factors among several factors that influencing UHI effects	▪ Urban temperature trends ▪ Monthly mean temperature ▪ Land use map ▪ Demography data ▪ Electricity record ▪ Air quality data ▪ Transportation document ▪ Daily traffic average data ▪ Provision of green space data	▪ Meteorology and geophysics department ▪ Statistical office ▪ Electricity office ▪ Department of public works ▪ Planning and development agency ▪ Transportation agency ▪ Environmental protection agency ▪ Cleanness and Landscape agency	▪ Document review
How to enhance current strategies for addressing UHI in Surabaya?	Identification current strategies related to UHI and comparison among current strategies with respondent`s opinion and literature review, while considering existing condition	▪ Significant factors that influence urban heat island in study area ▪ Strategies to reduce UHI effect (city development document) ▪ Literature review ▪ Previous study ▪ Respondent`s opinion or response	▪ Department of public works ▪ Planning and development agency ▪ Experts and academics	▪ Semi-structured interview ▪ Document review (strategies in each department/agenc y)

3.5.2 Secondary Data Collection Methods

Secondary data is needed for almost all analysis in this research. Secondary data for this research includes statistical data, governance data/document, previous studies and literatures that related with UHI. Data gathering has conducted in department of public works, planning and development agency, transportation agency, statistical office, electricity office and environmental protection agency. Meanwhile, data or information that has been needed are urban temperature trends, land use map, demography data, air quality data, transportation document, city development document (RTRW and RDTRK) and strategies document to reduce/address UHI. Both the time period for manmade and nature data is 20 years.

3.6 Data Analysis Methods and Techniques

Data analysis method explored the techniques or tools that will be used to achieve the task for each objective in this research. Data analysis method and techniques that will be used in this research embraces DPSIR analysis, PLS-R analysis, and triangulation analysis.

A. DPSIR Analysis

DPSIR analysis had used in Task 1. DPSIR analysis in this research is applied to analyze the cause and effect of urban heat island in Surabaya. High rising temperature and high development in the city is the possibility driving force that causes the following impact. Several factors influencing UHI effect is the pressure in this research that has knew from literature review and previous studies, while the responses will be analyze by interview of stakeholders. Data that needed in this analysis are city development document, statistical data and strategies document.

B. Partial Least Squares Analysis

PLS regression in this research has used to determine the significant factors in several variables, divided into five independent variables and two dependent variables. PLS regression has included multivariate regression as a one part of the analysis process. PLS analysis had been chosen due to amount of dependent variables. Correlation among dependent and independent variables are being note despite of lack of concern for independent variables. PLS regression in this research has used smart-PLS for the analysis software. In additon, Kwang (2012) said that "smart PLS is a statistical Excel add-in with modern modeling tools such as Partial Least Squares (PLS) regression and Principal Component regression (PCR). These regression methods free oneself from some of the constraints of the classical linear regression (OLS or WLS) and analysis of variance, such as the non-colinearity of the explanatory variables and the minimal sample size that must be larger than the number of explanatory variables".

First step in this analysis is entering data to SPSS, both independent and dependent variable. Next step is draw/set up the model then analysis process by using PLS-regression. In addition PLS regression has last concern to kind of data, whether it distribution normal or not. This data has ignoring missing data, considerate that there are no missing data in this research`s data. Furthermore, structural model assessment procedure is assess structural model for collinearity issues, assess the significance and relevance of the structural model relationship, weight of each variables and assess the level of R^2.

C. Triangulation Analysis

Triangulation analysis has used in Task 5. To enhance the current strategies for reducing UHI, triangulation analysis is being used. In addition, triangulation analysis has compared among current strategies, stakeholders opinion and response and literatures or previous study to reduce UHI in Surabaya. To conduct triangulation analysis the first step is asking the response of stakeholders related with UHI in Surabaya, then elaborate that with literature review and current strategies. Furthermore, the results is elaboration form those three sources. The condition of UHI in Surabaya has needed as consideration. Data that needed in this analysis are combination from current city document strategies such as RDTRK and RTRW (city document strategy) with literature review including previous studies and respondents opinion regarding to response to reduce UHI effects.

"This page is additionally blank"

CHAPTER 4
OVERVIEW OF SURABAYA CITY AND CHARACTERISTICS OF UHI

This chapter tries to discuss in terms of general knowledge of Surabaya and what had been got from data collection. General knowledge of Surabaya is presents in the two section, Surabaya in the regional context and within in the city itself. Review of development and urbanization are the issues for Surabaya`s overview. Furthermore, UHI condition in Surabaya also had been presented in this chapter. Meanwhile, in the last section DPSIR analysis has been tried to discuss based on data collection.

4.1 Regional context of Surabaya

The province of the eastern Java Island is East Java province. It consists of 33 million of people occupied about 48,000 square kilometers. East Java province administratively has 29 regencies and 9 cities. Surabaya is the capital city of East Java province. In addition, East Java province is the second largest province in Indonesia, it has a lot of economic advantages, such as strategic location, cheap labor, strategic harbor, and an overall robust economic condition. Furthermore, the economic growth is mostly concentrated in Surabaya and regencies around it. Figure 4.1 shows the constellation of Surabaya to another city and regencies in East Java province.

Development of Surabaya has shown high dynamical and triggers it to the metropolitan city as well as the second biggest city in Indonesia. Surabaya has a strategic position and function in regional and national scale, as the center of commercial and service in East Java province and the center of development area in east part of Indonesia (Surabaya PDA, 2005).

Based on Government Regulation No 26/2008 in terms of national master plan of Indonesia, Surabaya city is included to Gerbangkertosusila region with the main function as a center of development in East Java province. Other ways, Surabaya is the most mainstay city in East Java province to produce fisheries, industry and tourism. Based on Regional Regulation No 05/2012 in terms of a national master plan of East Java Province 2011-2013, the main function of Surabaya city is a midpoint of growth in East Java province. Furthermore, the developing of activities in Surabaya is the center of services, commerce and services, industry, governance, education, health, transportation and tourism.

Figure 4.1 East Java Province Map (Surabaya PDA, 2005-2025)

The direction for Surabaya that has stated in Surabaya Regional Planning 2005-2025 are as follows, first is enhance the quality of city`s management and infrastructure that ensure public accessibilities, second is enhance accessibilities, awareness, participation and public control in policy making and public service, third is enhance actualization and local wisdom in globalization, and the least is implement the justice as well as increase good ambience for trade and commercial.

4.2 Development of Surabaya

Surabaya is the capital city in East Java province, the second biggest city in Indonesia. It is bounded by 7° 9` - 7° 21` South latitudes and 112° 36` - 112° 57` East longitudes. Topographically, Surabaya has 0-20 meter above the mean sea level, meanwhile in the coastal area has 1-3 meter above the mean sea level rise. Most area of Surabaya city has 0-10 meter high (80, 72%) spread in east, north, south and in the middle of the city. In addition, in the west part Surabaya has high around 10-20 meter above the mean sea level rise, such as in Pakal, Lakarsantri, Sambikerep and Tandes.

The city occupies coastal terrain and lies approximately 33,048 Ha with consist of 31 sub-districts. Surabaya is the capital city of East Java Province with the most developed and most density population. Built up areas in Surabaya are almost reach 2/3 for all Surabaya area. Concentration of developing is in the down town (middle part of Surabaya) and lies to north part until south part, although nowadays it also spread from west to east part. Commonly, thus developing is concentrate on real estate building and commercial building. Up to now, the proportion of land use in Surabaya are divided into 42,00% for housing, 16,24% for paddy filed and moor, 15,20% for pond, 10,76% for commercial and services, 07,30% for industries and 05,50% for open space. The rapid development in the city of Surabaya led to the reduction of green open area that is used as a counterweight city (Fariz, 2012). As urban areas grow, changes occur in their landscape, buildings, roads, and other infrastructure replace open land and green space. Surfaces that were once permeable and moist become impermeable and dry. These changes cause urban regions to get more warmer than their rural environment, forming an "island" of higher temperatures in the landscape (Bisset, 2013).

Surabaya has divided into 12 development unit (UP) to sustain and enhance the development objectives. Thus development unit are UP Rungkut with main purposes in housing, education, conservation area and industry, UP Kertajaya with main purposes in housing, commercial, education and conservation area, UP Tambakwedi with main purposes in housing, commercial and services, recreation and conservation area, UP Darmahusada with main purposes in housing, commercial, education and health, UP Tunjungan with main purpose in commercial, housing, governance and service. UP Tanjung Perak with main purpose is port, industries and commercial-services. UP Wonokromo with main purposes in housing and commercial and services, UP Satelit with main purposes in housing and commercial-services, UP Achmad Yani with main purposes in housing and commercial-services, UP Wiyung with main purposes in housing, education, industry and conservation area, UP Tambak Oso Wilangon with main purposes in housing, commercial-services, warehousing, and conservation area. The last development area is UP Sambikerep with main purposes in housing, commercial-services and conservation area.

"Nowadays Surabaya is a rapidly growing commercial and educational substance. Some of its chief industries are shipbuilding, heavy equipment, food-processing and agriculture, electronics, home furnishings, and handcrafts. It has great universities, a popular zoo, and many recreational attractions in East Java's mountains and along its coasts. Unfortunately, the poor quality of the city's public transport system results in extensive use of private vehicles, which in turn results in constant traffic jams in the city. In response to this, the city government is preparing plans to support the implementation of a monorail/tramway mass transport network to provide high quality urban transport to its citizens. Furthermore, in the future Surabaya will build toll ring road and MRT for solving transportation problem". (Municipality of Surabaya, 2014).

The population of Surabaya city in 2012 was 2,790,533 inhabitant. The population growth in Surabaya for the last 2 decade was shown that it had declined. It shown that during 1980 to 1990 the population growth was increasing by 2.06% annually, while during 1990 to 2000 it increasing by 0.5% annually. Up to 2015 the population growth in the rural areas will be managed by 1% annually by implementing birth control and management of urbanization. In addition, to manage the population growth it also implementing decentralize in development and activities by adjusting capacity and carrying capacity in each Surabaya area (Surabaya CSA, 2013).

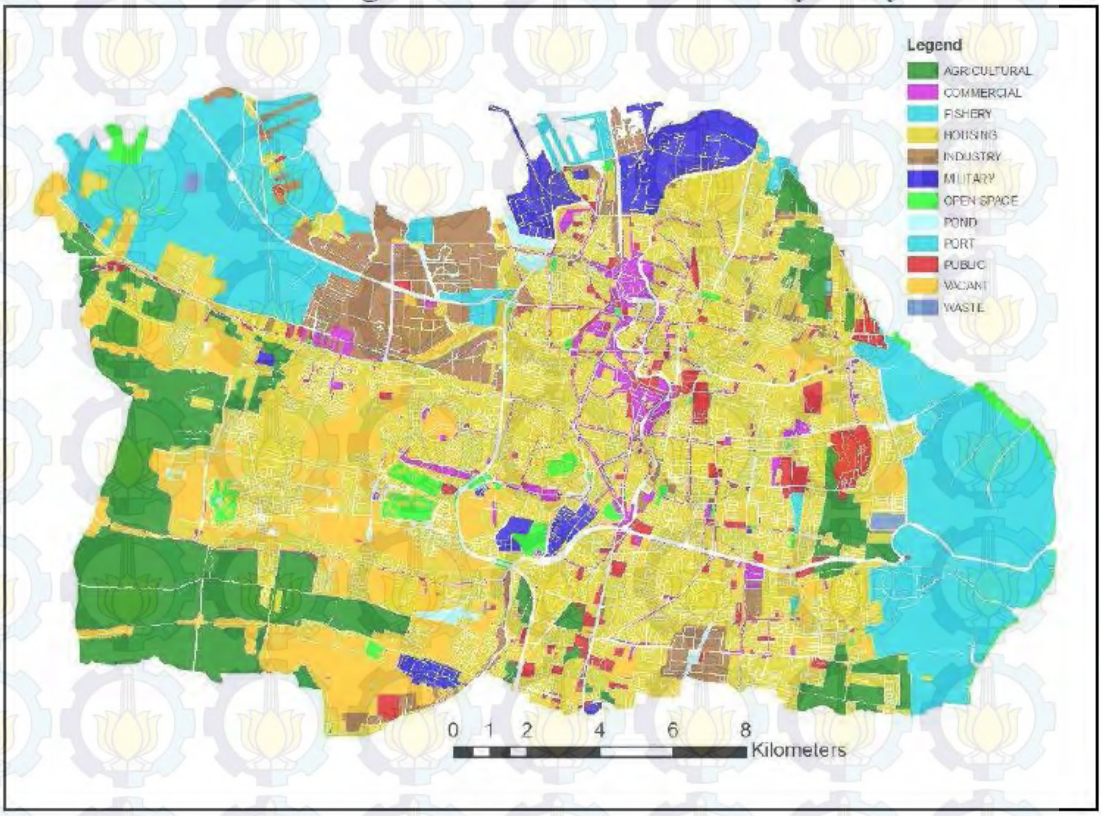


Figure 4.2 Land Use of Surabaya City in 2010 (Surabaya PDA, 2015)

Road city`s structure/pattern in Surabaya is linier, connected north part to south part of Surabaya (Tanjung Perak-Waru). Thus pattern had been built according to history of Surabaya`s development. Meanwhile, nowadays there is friction in the road`s pattern from linier to radial rectangular accordance to increasing development in West to East part of Surabaya and increasing excretion of Surabaya-Malang highway (Surabaya PDA, 2005)

The population of Surabaya city in 2012 was 2,790,533 inhabitant. The population growth in Surabaya for the last 2 decade was shown that it had declined. It shown that during 1980 to 1990 the population growth was increasing by 2.06% annually, while during 1990 to 2000 it increasing by 0.5% annually. Up to 2015 the population growth in the rural areas will be managed by 1% annually by implementing birth control and management of urbanization. In addition, to manage the population growth it also implementing decentralize in development and activities by adjusting capacity and carrying capacity in each Surabaya area (Surabaya CSA, 2013).

Road city`s structure/pattern in Surabaya is linier, connected north part to south part of Surabaya (Tanjung Perak-Waru). Thus pattern had been built according to history of Surabaya`s development. Meanwhile, nowadays there is friction in the road`s pattern from linier to radial rectangular accordance to increasing development in West to East part of Surabaya and increasing excretion of Surabaya-Malang highway (Surabaya PDA, 2005).

4.3 Climate Conditions

Surabaya, as comfortably as other city around Indonesia that lies in south equator, has two types of monsoons and has a tropical climate that features a distinct wet and a dry season. There are significant differences between dry and wet season. Wet season is comes during November to April, while dry season is comes during May to October.

Up to November to February, windy season that blows from North is increases rainfall during wet season. In addition, wind that blows from Southeast Australia brings cooler air during dry season. In wet season the average monthly humidity up to 80%, while in dry season decrease to 60%. The dry season however has close to rainy days, but not as many as the months between December and March, which sustain an norm of three measures of rain per month. Surabaya weather temperatures range between 23°C and 33°C.

Wet season

"Surabaya goes through a long wet season, from November until April. January is the wettest month of the year when the city receives about 290 mm of precipitation and only 92 hours of sunlight. Throughout the wet season the average high stands at 32°C while the low fluctuates between 23-25°C. Yet as the season progresses the level of rainfall decreases gradually as May sees only 100 mm of precipitation. In fact, threatening rainfall and relatively hot temperature make the season intolerable for the tourists" (Surabaya Municipality, 2015).

Dry season

"As Surabaya lies below the equator, the coolest, most comfortable temperatures occurs in the dry season, from May until October. It is the best season to visit Surabaya. During this season the city remains hot and humid with the average high of 30°C while the minimum stands at mid-twenties. In fact, temperature in the city hardly varies from season to season. Tourist from all over the world likes the season because it features a concentrated degree of rainfall as August and September get only 10 mm of rain" (Surabaya Municipality, 2015).

Based on Figure 4.3 it has shown that February is the highest precipitation month in Surabaya by 182 mm with 16 days of average rainfall, while the lowest precipitation month is August with no precipitation and 1 day of average rainfall. Considering that the wet season is happening during February and dry season is happening during August. In addition, average max-min temperature is shows in figure 4.4. It is shown that in Surabaya approximately the average maximum temperature reach to 35^0C meanwhile the minimum temperature is reach to 23^0C. Considering that both average max-min temperature happens during the dry season. Surabaya climatology has been described in Table 4.1.

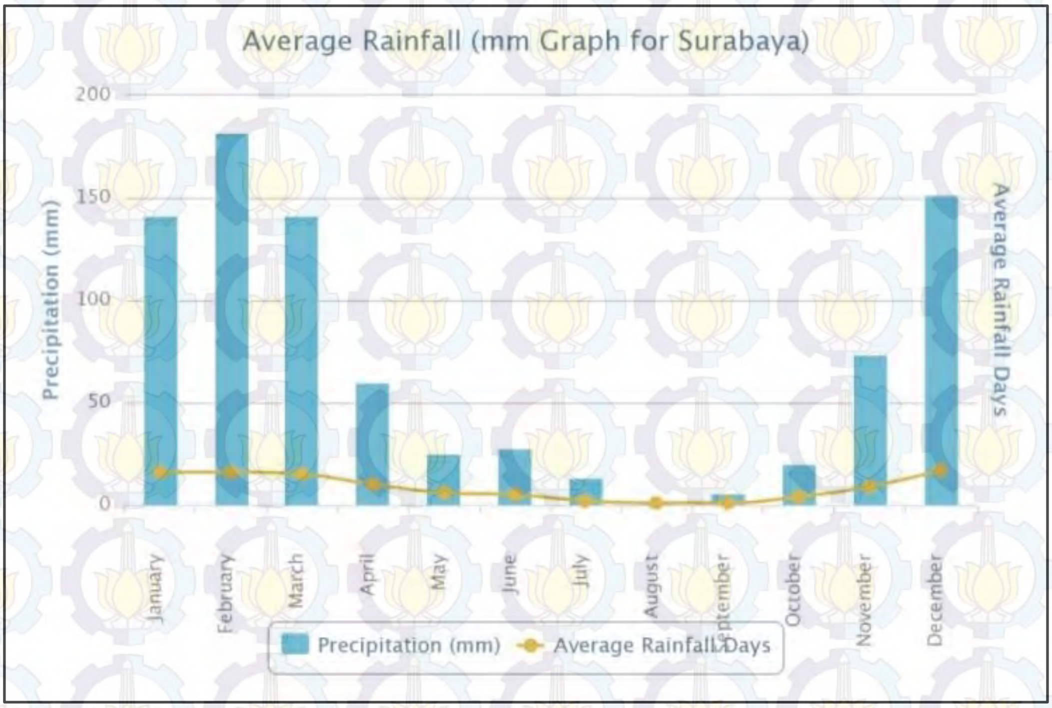


Figure 4.3 Average Rainfall of Surabaya
(http://www.worldweatheronline.com/Surabaya)

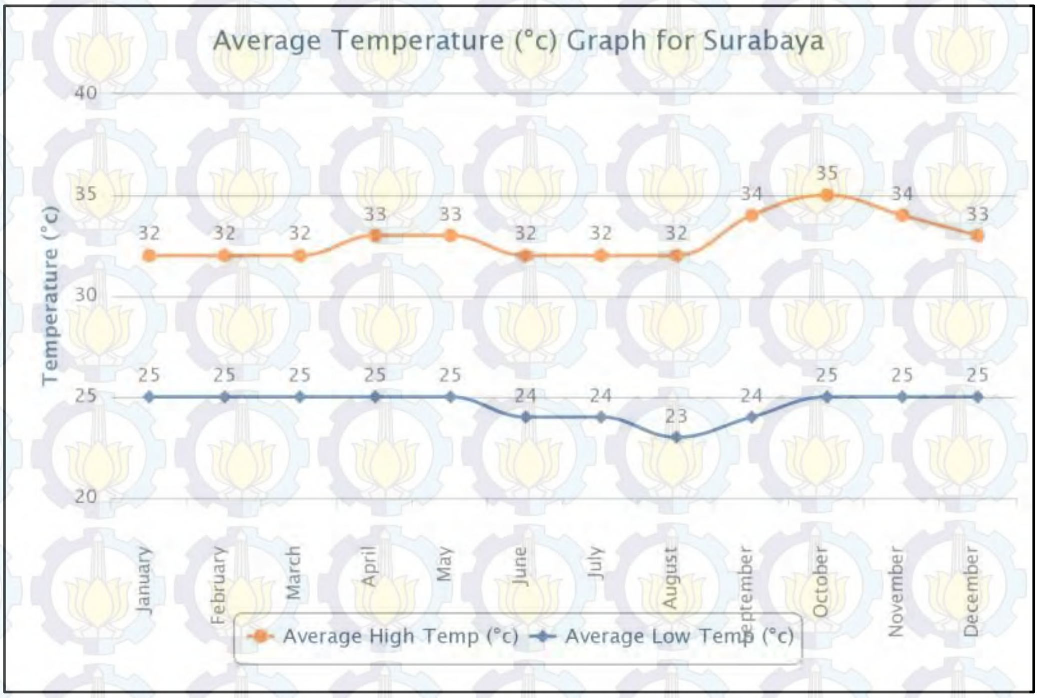


Figure 4.4 Average Maximum-Minimum Temperature of Surabaya (http://www.worldweatheronline.com/Surabaya)

Surabaya has undergone microclimate change, on 2005 the temperature in Surabaya reached 31°C and increasing up to 33°C on 2010. The temperature in the green open area reached 34,63°C while in the built-up area can reached up to 47,51°C (Fariz, 2012). Meanwhile, Figure 4.5 provides comparison between temperature in Surabaya with Malang city (the second highest development in East Java). It show that there is high rising temperature in Surabaya (orange color refers to 37.5-45°C and red color refers to 45-52.5°C)

Surabaya has three meteorology stations. Firstly, Juanda station which located in Sidoarjo district, next to Surabaya city. Secondly, Perak station 2 and Perak station 1 which is located in North of Surabaya. Those three meteorology stations covers whole Surabaya city. Figure 4.6 has shown coverage area[1] for each station. It divided into three different line. Firstly, Juanda station which is covers mostly southern part of Surabaya. Secondly, Perak station 2 which is covers mostly western and middle part of Surabaya. Least, station 1 which is covers

[1] Area that been covers in the service of station.

mostly north and east part of Surabaya. The analysis of coverage area for each station is shows in Figure 4.6. Futuremore, based on Figire 4.6 and Appendix 1 areas of each station can be used for next analysis.

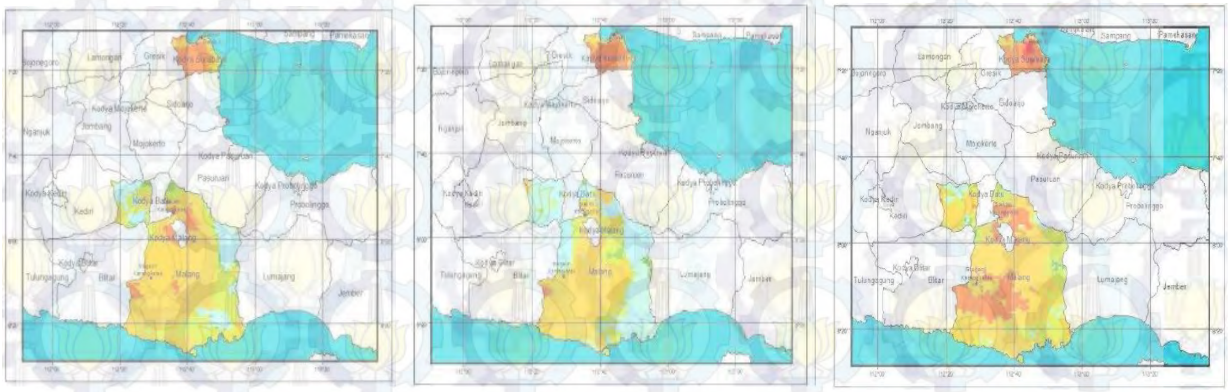


Figure 4.5 Comparison of Temperature between Surabaya City with Malang City on 2008, 2009 and 2010 Using Terra MODIS Remote Sensing (Sukojo and Arifin, 2011)

Based on existing land use map (Figure 4.2) and Surabaya Regional Planning 2005-2005, it can be shown that the coverage area of Perak 2 is the urban area which has more developed area and diversification of built-up land use, such as industry, housing, port, military, and commercial-service. Moreover, the function of coverage area in Perak 2 is the center of commercial and service, housing, industry and CBD of Surabaya. Meanwhile, the other stations named Perak 1 and Juanda station is the rural area which has less built up area and smaller coverage area compare with Perak 2.

Figure 4.7 shows the average temperature in Surabaya for the past 20 years (1993-2013) for three stations. Namely, Perak station 1, Perak station 2 and Juanda station. It shows that the highest temperature for Perak station 1 is during 2005 (29.08^{o}C). Whereas, for station 2 and Juanda station the highest temperature is during 2001 and 1998 with 29.93^{o}C and 28.38^{o}C respectively. However, the temperature has declined after 2009. The lowest temperature is during 1994 for Perak station 1 (28^{o}C), and during 2011 for Perak station 2 and Juanda station with 28.81^{o}C and 27.43^{o}C respectively.

Table 4.1 Climatology Conditions of Surabaya

No	Climatology	Stations		
		Perak 1	**Perak 2**	**Juanda**
1	Rainfall	▪ Rainfall intensity: 131mm ▪ Total days with rain 14 days ▪ Largest rainfall intensity in November-April	▪ Rainfall intensity: 215mm ▪ Total days with rain 20 days ▪ Largest rainfall intensity in November-April	▪ Rainfall intensity: 131mm ▪ Total days with rain 17 days ▪ Largest rainfall intensity in November-April
2	Humidity	▪ Average: 70% ▪ Maximum: 97% ▪ Minimum: 43%	▪ Average: 67.5% ▪ Maximum: 90% ▪ Minimum: 90%	▪ Average: 71.1% ▪ Maximum: 95.5% ▪ Minimum: 47.92%
3	Atmosphere Pressure	▪ Average: 1009.4 Mbs ▪ Maximum: 1013.1 Mbs ▪ Minimum: 1005.2 Mbs	▪ Average: 1019.8 Mbs ▪ Maximum: 1031.1 Mbs ▪ Minimum: 1008.2 Mbs	▪ Average: 1009.95 Mbs ▪ Maximum: 1012.30 Mbs ▪ Minimum: 1007.60 Mbs
4	Air Temperature	▪ Average: 28.6^{O}C ▪ Maximum: 34.1^{O}C ▪ Minimum: 23.1^{O}C	▪ Average: 28.9^{O}C ▪ Maximum: 33.0^{O}C ▪ Minimum: 24.8^{O}C	▪ Average: 28.5^{O}C ▪ Maximum: 34.4^{O}C ▪ Minimum: 21.7^{O}C
5	Solar Irradiation	73% per month	76.9% per month	67.1% per month
6	Wind Speed	Average is 6 knot, wind direction from east (April-November) and west (December-March)	Average is 5.5 knot, wind direction from east (April-November) and west (December-March)	No information*

Source: Surabaya PDA, 2007

Figure 4.8 shows that the highest temperature decreased among three stations is during 2010 to 2011 in Perak station 2 (0.7^{o}C). Meanwhile, the lowest temperature decreased is during 2000 to 2001 in Juanda station (0.1^{o}C). In addition, the highest temperature increased is during 1997 to 1998 in Perak station 1 (0.58^{o}C). Whereas, for the lowest temperature increased is during 1994 to 1995 in Perak station 1 (0.1^{o}C).

Base on Figure 4.7 it can be found that the highest average temperature is in Perak 2 station which is located in the urban area, while the other stations has a lower temperature. The reason is Perak 2 station is an urban area which has developed area and it has larger area compare with the other two stations. High developed area influence to the anthropogenic heat that released from buildings or asphalts as well as pollution and energy consumption is higher in developed area. In addition, it made the high degree of average temperature.

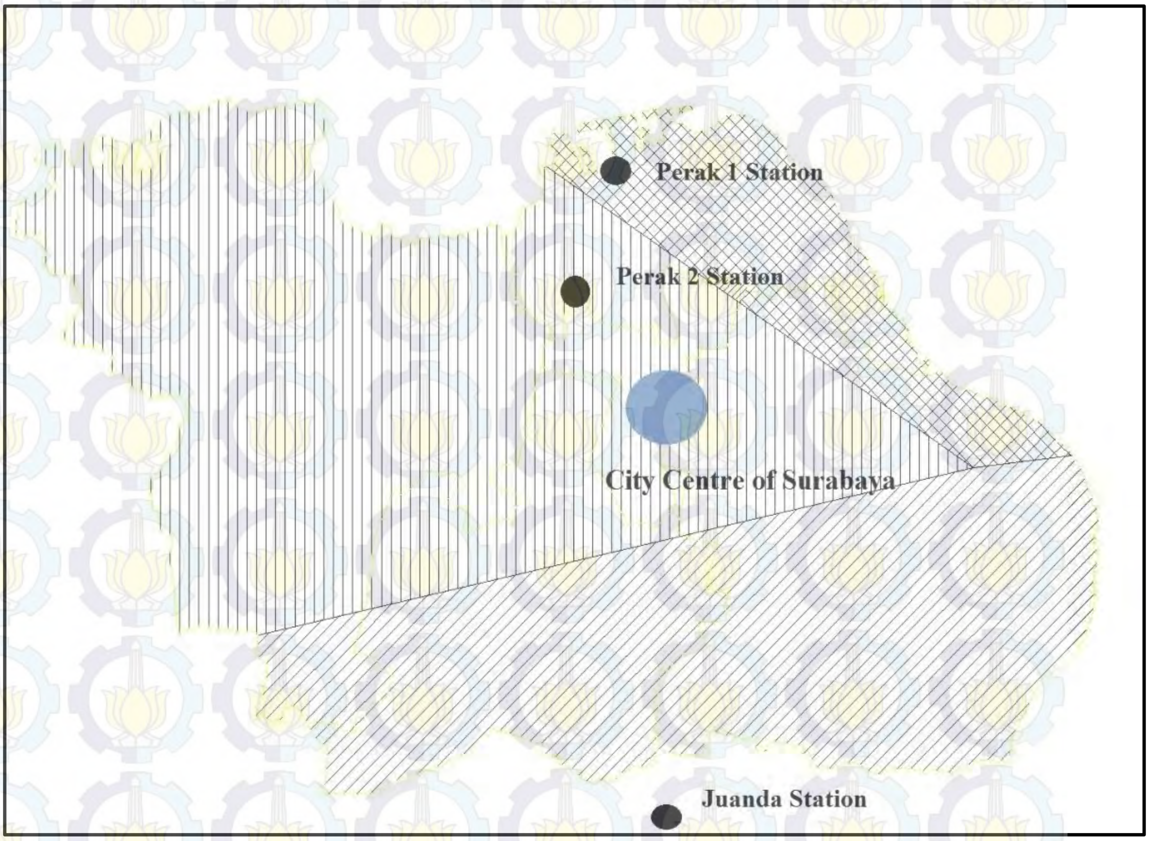


Figure 4.6 Coverage Areas of each Meteorology Stations in Surabaya

From the Figure 4.8, it can be prove that the average temperature in Surabaya tend to increase in the first 10 years but then decline in the last 10 years. The maximum average temperature is in 1998 at 29.1^{o}C, while the minimum is in 2011 at 28.17^{o}C. In addition, there was a significant increase in average temperature of Surabaya from 1997 to 1998 (0.43^{o}C) and significant decrease from 1998 to 1999 (0.46^{o}C). Furthermore, the maximum and minimum temperature needed to be analyzed due to significantly felt by people in particular area.

Figure 4.9 has shown that the maximum and minimum temperature in Surabaya is increasing from last 20 years. Furthermore, the increasing and decreasing temperature was happened but not too significant. For maximum temperature it increases by 0.5-1°C, while minimum temperature is increase by 0.6-1.06°C. That trend has presented that during 20 years people felt increasing temperature by 1°C. One degree differences may sound like a small amount, but it's an unusual event in our planet's recent history. Earth's climate record, preserved in tree rings, ice cores, and coral reefs (national aeronautics and space administration, 2012), shows that the global average temperature is stable over long periods of time. Furthermore, small changes in temperature correspond to enormous changes in the environment. Based on IPCC (2007) it stated that with increasing 1°C temperature it can effect to decreasing freshwater availability by 2050s, coastal areas will be at risk due to increased flooding, death rate from disease associated with floods and droughts.

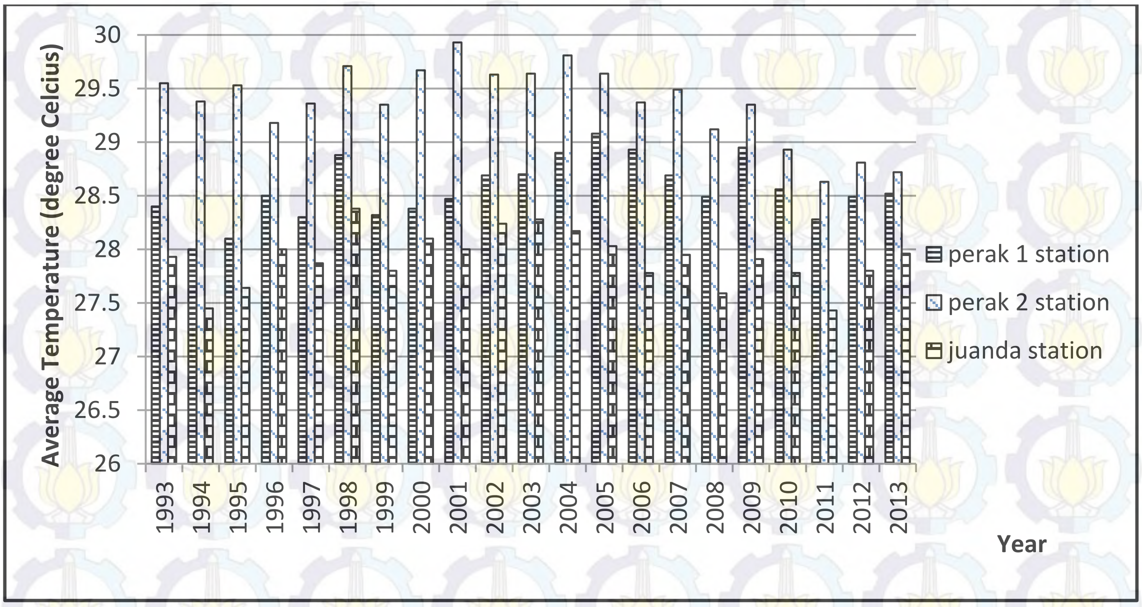


Figure 4.7 Average Temperature in Three Meteorology Stations of Surabaya, 1993-2013 (www.tuitempo.net)

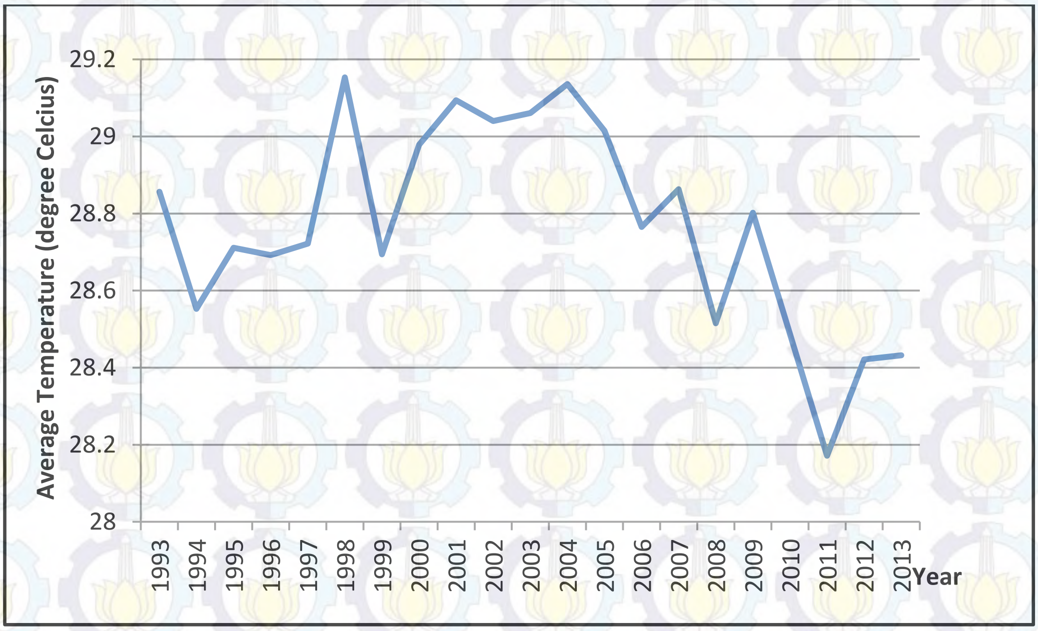


Figure 4.8 Average Temperature in Surabaya, 1993-2013 (www.tuitempo.net)

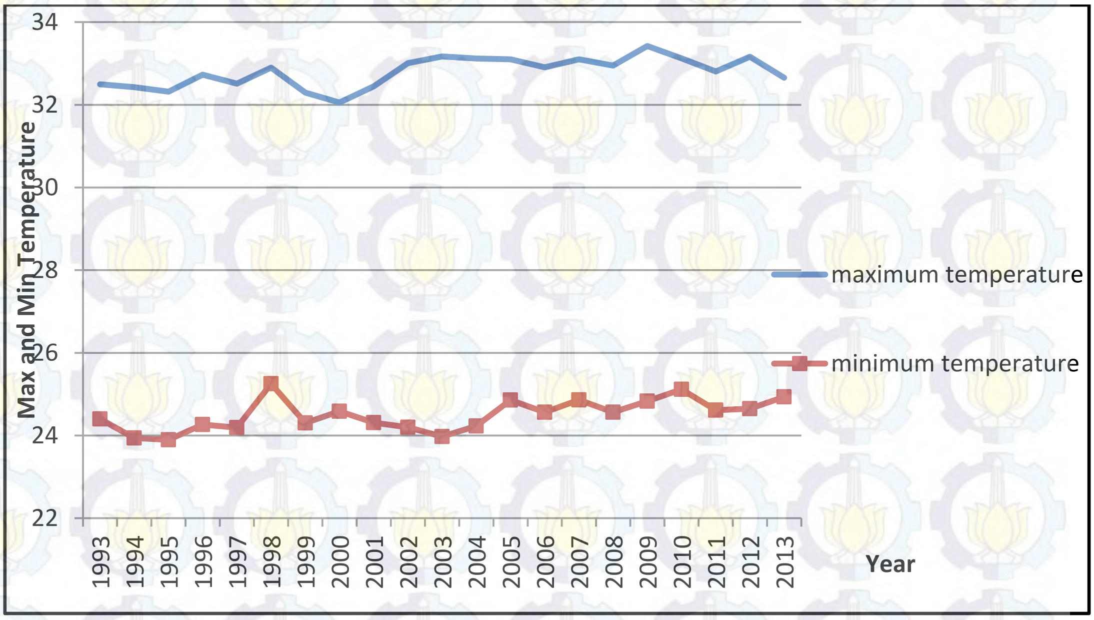


Figure 4.9 Maximum and Minimum Temperature in Surabaya, 1993-2013 (www.tuitempo.net)

4.4 UHI Phenomenon in Surabaya

The composition and structure of urban area together with the urban parameters (e.g. Building materials, vegetation cover) have a significant force on local climate: the urban areas are 2-6°C warmer than the surrounding countryside known as urban heat island (Lee, et al, 2009). Meanwhile, according to EPA the annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its environment. In increase, over the past 100 years, Tokyo's average temperature has increased by almost three degrees Celsius, and that of Osaka has increased by two degrees Celsius (^{O}C). Since it is said that global warming has put up the Japan's average temperature by almost one degree C, the temperature increase due to the UHI effect is probably close to two degrees in Tokyo and about one degree in Osaka.

Although, the UHI has been delineated as the temperature difference between urban and rural areas, it has likewise been reported as the temperature change over time. In one of such studies UHI was determined in Tokyo as the temperature change from 1930 to 1990 (Mochida et al., 1997). Furthermore, this research using the temperature difference between urban and rural also as well as the change of temperature over last 20 years.

UHI phenomenon can be identified with measuring the intensity of UHI by using two microclimate factors, named CDD and maximum-minimum temperature. In the other hand, UHI effects can also be measured by CDD and maximum minimum temperature. "Cooling degree days", or "CDD", are a measure of how much (in degrees), and for how long (in days), outside air temperature was higher than a specific base temperature. They are employed for calculations relating to the energy use required to cool buildings. UHI effected to using of energy, with assumption increasing energy consumption will increasing UHI and vice versa.

4.4.1 Maximum and Minimum Temperature

The UHII determined by comparing the mean and maximum temperature between urban and rural areas are denoted to as the mean and maximum UHII respectively. The proportion time period used to be a season, a month, or a year, or in some cases using few selected days (Velazquez-Lozada et al., 2006).

The reason to put maximum temperature values for analysis UHI in Surabaya is due to significantly differences of temperature between three meteorology stations. In addition, it because of the higher value of anthropogenic heat that comes from buildings (built up area) and the function of each coverage area. Moreover, high number of pollution and energy use enhances the greenhouse effect that contributes to the trap of short-wave radiation in the urban canyon.

Figure 4.9 shows the maximum temperature in Surabaya for the past 20 years (1993-2013) for three stations. Namely, Perak station 1, Perak station 2 and Juanda station. It shows that the highest maximum temperature is during 2005 for Perak station 1 (33.53^{o}C). Whereas, for station 2 and Juanda station during 2012 and 1996 with 33.78^{o}C and 32.86^{o}C respectively. However, the temperature has increased after 2000. The lowest temperature was during 1994 and 1995 for Perak station 1 (32.2^{o}C) and 2000 for Perak station 2 (32.1^{o}C) and 2011 for Juanda station (31.78^{o}C).

Figure 4.10 shows that the highest maximum temperature decreased among three stations is during 1998 to 1999 in Perak station 2 (0.72^{o}C). Meanwhile, the lowest temperature decreased is during 2004 to 2005 in Juanda station (0.03^{o}C). Furthermore, the highest temperature increased is during 1996 to 1997 in Perak station 2 (0.67^{o}C). Whereas, for the lowest temperature increased is during 1996 to 1997 in Perak station 1 (0.1^{o}C).

There is difference temperature among three stations, considerate in the previous analysis (section 4.3) that coverage area of Perak 2 station is the urban area which has the largest area (0.54% for the total area of Surabaya) and most developed area with has diversity of land use. Based on thus result (Appendix 2), it can be shown that there is 0.92^{o}C difference between Perak 2 and Juanda station. Meanwhile, there is 0.09^{o}C difference between Perak 2 and Perak 1 station. The other result that has been found in the last 20 years is the maximum temperature in Surabaya has gone up approximately by 1^{o}C. In addition, it can be concluded that the area with highly developed is increasing temperature rapidly.

The reason to put the minimum temperature which is called night time temperature for analysis UHI in Surabaya is because during calm and clear nights the minimum temperature in rural area is lower than in urban area. Furthermore, during night time the measurement of UHI will be more significant because at night time there is low solar radiation intervention which is influence the measurement of surface temperature (anthropogenic heat) and during night time is the time to cool the surface.

Figure 4.11 shows the minimum temperature in Surabaya for the past 20 years (1993-2013) for three stations. Namely, Perak station 1, Perak station 2 and Juanda station. It shows that the highest minimum temperature for Perak station 1 and Perak station 2 is during 1998 with 25.2°C and 25.83 respectively. Meanwhile, the highest minimum temperature in Juanda station is 24.47°C on 1998 and 2010. Furthermore, the lowest temperature happened during 1994 for Perak station 1 (23.9°C), during 2003 for Perak station 2 (24.1°C) and 1994 for Juanda station (22.56°C).

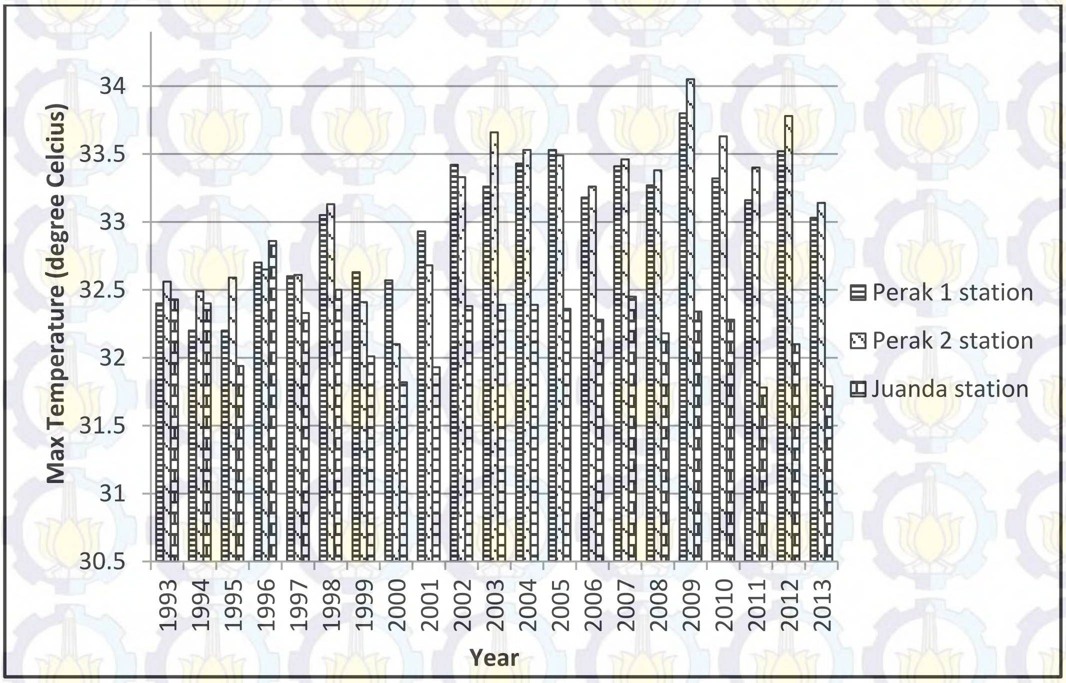


Figure 4.10 Maximum Temperature in Three Meteorology Stations of Surabaya, 1993-2013 (www.tuitempo.net)

Figure 4.11 shows that the highest minimum temperature decreased among three stations is in Perak station 2 and Juanda station, both during 1998 to 1999 with 0.95°C. Meanwhile, the lowest temperature decreased is during 1996 to 1997 in Perak station 2 (0.04°C). Furthermore, the highest temperature increased is during 1997 to 1998 in Juanda station (1.43°C). Whereas, the lowest temperature increased is during 1995 to 1996 in Perak station 1 (0.01°C).

There is temperature difference among three stations. Based on thus result (Appendix 2), it can be shown that there is 1.4°C difference between Perak 2 as an urban area and Juanda station as a rural area. Meanwhile, there is 0.51°C difference between Perak 2 and Perak 1 station. The other result that has been found in the last 20 years is the minimum temperature in Surabaya has gone up approximately by 1°C. In addition, it can be concluded that in the least developed area the temperature is cooler that the developed area.

Sum up, based on maximum and minimum temperature variable, it can be concluded that UHI was happening in Surabaya. There is temperature difference among three stations, Perak 2 station that represent urban area while the other two, Perak 1 station and Juanda station is represent rural area. This result in accordance with Fariz (2012), said that accordance to maximum and minimum temperature on 2013, the main area of UHI in Surabaya is UP Tunjungan and UP Dharmawangsa, which is include in coverage area of Perak 2 station.

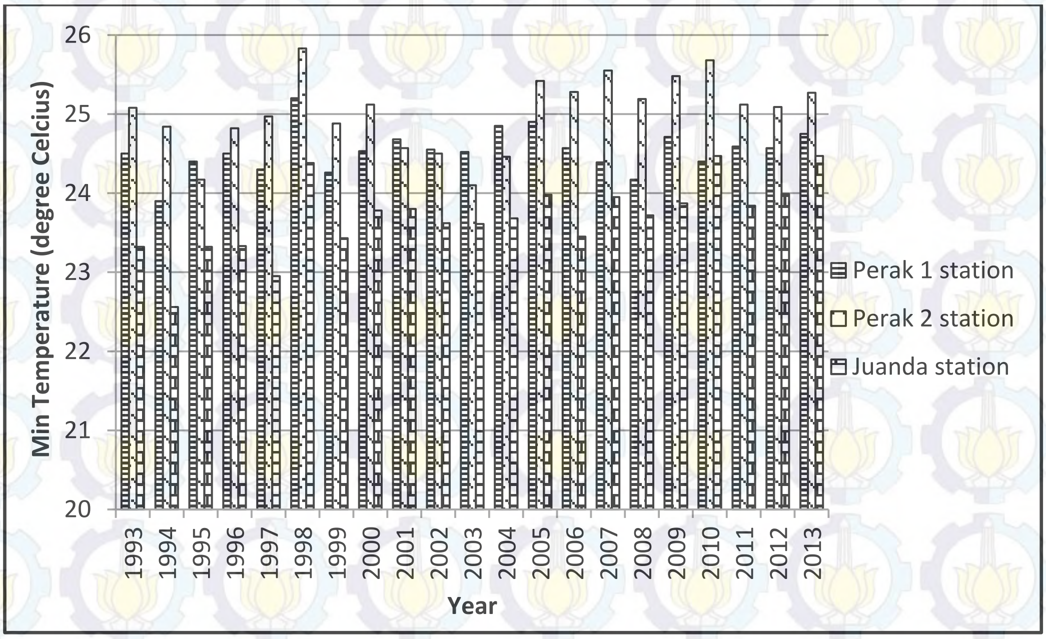


Figure 4.11 Minimum Temperature in Three Meteorology Stations of Surabaya in 1993-2013 (www.tuitempo.net)

4.4.2 Cooling Degree Days (CDD)

The reason to put cooling degree days for analysis UHI in Surabaya is because it can help to estimate the using of electricity energy consumption in Surabaya and also to estimate air quality impact related with energy use of cooling down buildings. In CDD analysis it used the daily average of maximum and minimum temperature in Surabaya for the last 20 years. This analysis has used 65^{o}F as the baseline degree for calculate CDD, considering the similarities of room temperature to use air conditioning (65^{0}F).

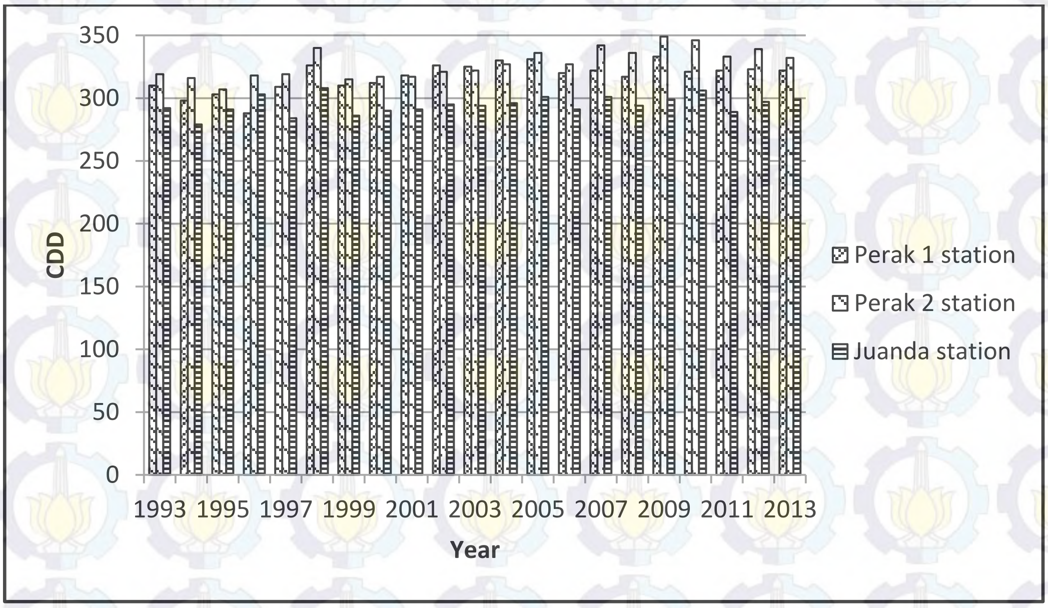


Figure 4.12 CDD in Three Meteorology Stations of Surabaya, 1993-2013 (www.tutiempo.ne)t

Figure 4.12 shows that among the three weather stations in Surabaya the highest number of CDD is Perak 2 at 344. Meanwhile, Perak 1 at 333 cooling degree days and the lowest is Juanda station at 309 cooling degree days (Appendix 2). In addition, it can be concluded that the rural area which is represented by Juanda station has the highest comfort to live due to less use of cooling energy and has the lowest UHI intensity. Meanwhile, the urban area which has more developed area is has the highest value of CDD which is mean that Perak 2 needs a heavier usage of existing air conditioning. Higher in CDD level also mean that it higher in degree of temperature.

4.5 DPSIR Analysis of UHI

4.5.1 Driving Forces of UHI

Surabaya nowadays is facing increasing population with the number of population is 2,803,049 people in 2013. It is well-known that the progressive replacement of natural surfaces by built surfaces, through urbanization will lead to population increase that constitutes the main cause of UHI formation. Furthermore, high number of population will decrease the natural surface. Meanwhile, natural surfaces are frequently composed of vegetation and moisture-trapping soils. Thus, they employ a relatively large ratio of the absorbed radiation in the evapotranspiration process and release water vapor that contributes to cooling the air in their neck of the woods. In contrast, built surfaces are composed of a high percentage of non-reflective and water-resistant construction materials. As a result, they tend to take up a substantial dimension of the incident radiation, which is liberated as high temperature.

Figure 4.13 shows the trend of urbanization, death and birth activities in 31 sub-districts. That figure can identified the source of population contribution in Surabaya. Furthermore, it has shown that during 2010 the highest source for number of population in Surabaya is come from "urbanization" activities (people migrate to Surabaya). Meanwhile the birth activity is the lowest source for population. In addition, it can be concluded that urbanization take the largest contribution to contribute the amount of population in Surabaya.

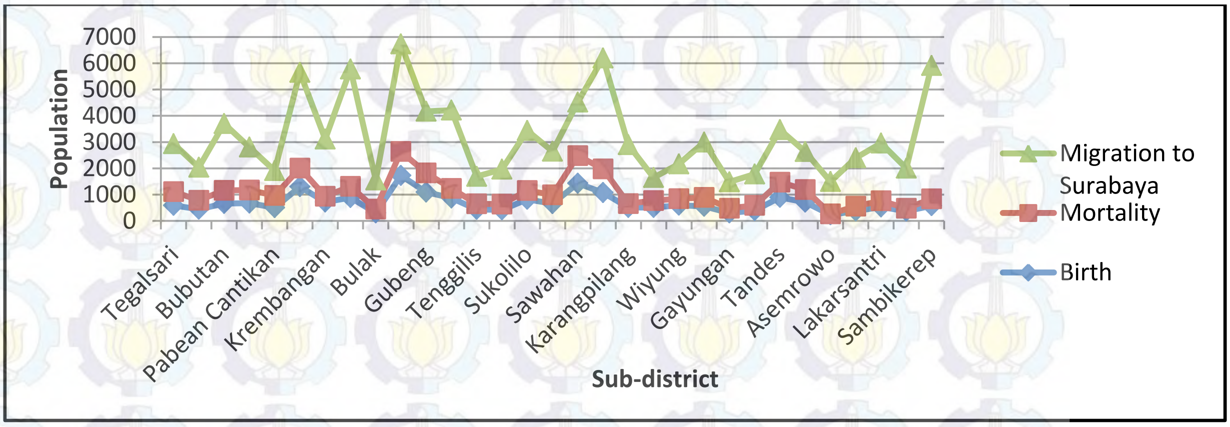


Figure 4.13 Source of Population in Surabaya on 2010 (Laksono, 2012)

Through the increasing of population, it will shift the soil covers and it will contribute to loss of green space, while the vegetation intercepts radiation and produces shade that also contributes to reduce urban heat release. The reduction and fragmentation of large vegetated areas such as parklands, not only reduces these benefits, but also inhibits atmospheric cooling due to horizontal air circulation generated by the temperature gradient between vegetated and urbanized countries (i.e. Advection), which is experienced as the park cool island effect. In increase, increasing population in Surabaya will burdens the city capacity, which will implement to the narrow arrangement of buildings along the city's streets form urban canyons that inhibit the leakage of the reflected radiation from most of the three-dimensional urban surface to space. This radiation is finally occupied by the building walls (i.e. reduced sky view factor), therefore enhancing the urban heat release.

Additional components that come from increasing population, such as the scattered and emitted radiation from atmospheric pollutants in the urban area, the production of waste heat from air conditioning and refrigeration systems, as well as from industrial processes and motorized vehicular traffic (i.e. anthropogenic heat), and the obstruction of rural air flows by the windward face of the built-up surfaces, have been recognized as additional causes of the UHI effect.

4.5.2 Pressure of UHI

Presses can be determined as the direct forms of stress caused due to increase in the anthropogenic activities and their direct interference into the natural surroundings. In addition, the direct intervention in this research is a urbanization that leads to population increase. Urbanization makes high development of built-up area which is influential to the supplying of green space as well as increase the air pollution (carbon emission). This research is embracing to energy use of goods and services and the number of vehicles for causes of air contamination.

4.5.2.1 Provision of Green Space

The number of population that linearly increase for last 20 years has made changed in land cover from open space to build up area. It addition, it is important to preserve area of green space and open space to balance the air temperature, absorb air pollution, and to reduce anthropogenic heat. In this research the scope of green space is covers graveyard, stadium, and park/green that manage by the municipality.

Increasing population in Surabaya is parallel with increasing development which is change green space to built-up area. Table 4.2 shows area of green space in 2009, that will compared with table 4.3 that shows area of green space in 2013. This table below will show the provision of green space in Surabaya.

Table 4.2 Area of Green Space in Surabaya in 2009

Kind of green space	Area (ha)
Park /green line	1,314,888
Stadium/sport field	1,304,170
Graveyard	1,296,155
Verification of green space to municipality	-
Total Amount	3,915,213.00

Source: Municipality of Surabaya, 2009

Table 4.3 Area of Green Space in Surabaya n 2013

Kind of green space	Place-sub district	Area (ha)
Park /green line	Middle of Surabaya	167,710.78
	North of Surabaya	81,699.98
	South of Surabaya	134,705.43
	East of Surabaya	485,703.75
	West of Surabaya	166,426.66
Stadium/sport field	Surabaya	383,200
Graveyard	Surabaya	1,575,100
Verification of green space to municipality	Surabaya	1,172,700
Total Amount		4,167,246.60

Source: Cleanness and Landscape Agency, 2013

Based on Table 4.2, the number of green space in Surabaya is 3,915,213 ha, while in 2013 the number of green space is 4,167,246.6 ha. It can be concluded that up to now the area of green space in Surabaya is increasing. This condition is occurs due to management of green space. In addition, during 2013

Surabaya`s municipality has implemented strategy to provide more green space with changing open space/abundant land to green space, optimize and develop parks, using area of gas station for tree planting, et cetera. Moreover, this strategy is accordance to the vision of Surabaya to make Surabaya city more livable.

The National Act No 26/2007 on Spatial Planning states that every city/region should provide minimum 30% of green space from the total area in the city/regency. Furthermore, the 30% total is divided into 10% for private green space and 20% for public green space. In addition, up to 2013 the area of public green space in Surabaya is 4,167 ha while the standard is 6,609.6 ha for open space, considering that the total area of Surabaya is 33,048 ha. Therefore, up to now the provision of green space in Surabaya needed to be increased.

4.5.2.2 Increased Carbon Emissions of Air Pollutants

Urban heat islands raise demand for electricity energy in summer. Companies that supply electricity typically rely on fossil fuel power plants to fill much of this demand, which in turn contributes to an increase in air pollutant and greenhouse gas discharges. The main pollutants from power plants include sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), and mercury (Hg). These pollutants are harmful to human health and also contribute to complex air quality problems such as the formation of ground-level ozone (smog), fine particulate matter, and acid rain. Increased use of fossil-fuel-powered plants also increases emissions of greenhouse gases, such as carbon dioxide (CO_2), which contribute to global climate change. This research is use carbon emission from electricity energy consumption and fossil fuel that used for vehicle. In addition, the electricity energy consumption in this sub-section is embracing to energy consumption for manufacturing, lighting, cooling building, etcetera.

Surabaya is facing the rising of electricity energy consumption and fossil fuel as well as rising in the number of vehicles that will lead to increasing air pollutant and greenhouse gas emission. Furthermore, this condition will lead to increasing the urban heat island in Surabaya. This table below will show the number of carbon those equivalencies from electricity energy consumption and the number of vehicles for the last 20 years.

This research used greenhouses gas equivalencies calculator to translating energy and emission data to carbon (greenhouse gases) emission. The greenhouse gas equivalents calculator can translate abstract measurements in concrete terms that easier to understand, such as "equivalent to avoiding the carbon dioxide emissions of 183,000 cars annually". "*This calculator may be useful in communicating greenhouse gas reduction strategy, reduction targets, or other initiatives aimed at reducing greenhouse gas emissions*". (Environmental Protection Agency, 2014).

Table 4.4 shows that there is increasing carbon emission as well as increasing in electrical energy consumption and number of vehicles in Surabaya. For the last 20 years the increasing of carbon from electrical energy consumption is 4,146,358 metric tons of carbon while from number of vehicles is 10,889,529 metric tons of carbon. In summation, to their impact on vitality-associated emissions, elevated temperatures can directly increase the rate of ground-level ozone formation. Basis-level ozone is formed when NOx and volatile organic compounds (VOCs) react in the presence of sun and hot conditions. If all other variables are equal, such as the level of precursor emissions in the aviation and wind speed and focal point, more earth-level ozone will form as the environment becomes sunnier and hotter.

The burning of fossil fuel has increased the concentration of atmospheric carbon dioxide (CO_2). This occur due to oil combustion that released carbon combine with the oxygen in the air to make CO_2. CO_2 is the major causes for greenhouse gases. Increasing the carbon emission in the air will trapped the solar radiation within in the city. It block the heat to the atmospheric layer, make it trapped and higher the temperature in the city. Moreover, this condition influences the UHI intensity in Surabaya.

Table 4.4 Increased Emissions of Air Pollution in Surabaya

Year	Total electricity energy consumption (kWh)	Equivalencies to Carbon emissions	Total number of vehicles	Equivalencies to Carbon emissions
1993	2,099,777,000	1,447,903	849,114	4,033,292
1994	3,252,384,000	2,242,685	857,688	4,074,018
1995	3,490,127,000	2,406,621	866,262	4,114,745
1996	3,662,436,000	2,525,436	874,836	4,155,471
1997	2,658,217,000	1,832,976	883,409	4,196,193
1998	2,358,349,000	1,626,202	891,983	4,236,919
1999	4,247,970,000	2,929,192	900,557	4,277,646
2000	4,633,039,000	3,194,717	909,131	4,318,372
2001	4,829,039,000	3,329,869	909,131	4,318,372
2002	5,031,179,000	3,469,255	918,662	4,363,645
2003	4,881,332,000	3,365,927	918,662	4,363,645
2004	5,546,500,000	3,824,595	923,143	4,384,929
2005	5,962,378,000	4,111,364	1,379,147	6,550,948
2006	6,004,348,000	4,140,304	1,371,631	6,515,247
2007	6,375,034,600	4,395,911	1,364,116	6,479,551
2008	6,664,679,500	4,595,636	1,356,601	6,443,855
2009	6,954,324,300	4,795,361	1,349,085	6,408,154
2010	7,243,969,200	4,995,086	1,341,570	6,372,458
2011	7,533,614,100	5,194,811	4,047,015	19,223,321
2012	8,003,958,000	5,519,137	2,840,173	13,490,822
2013	8,112,903,800	5,594,261	3,141,647	14,922,821

Source: modified from statistical office and http://www.epa.gov/cleanenergy/energy-resources/calculator.html

4.5.3 State – Current Condition of UHI

Current situation of UHI effects in Surabaya can be known from maximum and minimum temperature and cooling degree days in the recently year, which is occurring in Surabaya nowadays.

4.5.3.1 Maximum and Minimum Temperature

Maximum and minimum temperature measurement in Surabaya is divided into three stations, which had been assumption that Perak 2 as the urban area while Perak 1 and Juanda station as the rural area. Considering that Perak 2 is more built up area and embracing to the result in section 4.3. In addition, this table shows the maximum and minimum temperature in Surabaya nowadays.

Table 4.5 shows that there are significantly differences among three stations. Furthermore, the maximum temperature in Perak 2 station which is the urban area has 0.11°C difference with Perak 1 station, while has 1.35°C difference with Juanda station. Meanwhile, for minimum temperature it has 0.51°C difference between Perak 2 and Perak 1, while it has 0.80°C difference between Perak 2 and Juanda station. According to the result, it can be concluded that UHI effects has occur in Surabaya embracing to temperature difference between urban and rural area at 1°C. In addition, Figure 4.13 shows the trend of maximum minimum temperature in the three weather stations.

Table 4.5 Maximum and Minimum Temperature in Surabaya n 2013

Month	Perak 1		Perak 2		Juanda	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
January	32.8	24.8	33.1	25.2	32.3	24.6
February	33	25.1	33	25.5	32.2	25
March	33.5	25	33.7	25.5	32.3	24.7
April	33.1	25.4	33.2	25.8	31.9	25.3
May	33.2	25.4	33.3	25.8	31.5	25.5
June	32.7	25.3	32.8	25.3	30.9	24.8
July	32	24	32.2	24.4	30.7	23.7
August	32.4	22.9	32.9	23.9	30.9	22.5
September	33.4	23.9	33.5	24.6	31.8	23.1
October	35.2	25.3	34.5	26.1	33.4	24.8
November	33.5	25.3	33.6	25.9	32.4	25
December	31.6	24.7	31.9	25.2	31.2	24.6
Total	396.4	297.1	397.7	303.2	381.5	293.6
Average	33.03	24.76	33.14	25.27	31.79	24.47

Source: Tutiempo.net

Based on Figure 4.14, it can be seen that for three meteorology station, namely Perak station 1, Perak station 2 and Juanda station have the same month for decreasing and increasing temperature. For maximum temperature it has decrease during April to August and increase during August to October, with the highest peak in October. Meanwhile, for minimum temperature it has decrease during May to August and increase during September to October, with the highest peak is in October. It can be concluded that during that time for highest temperature is in dry season and the lowest ones is in wet season.

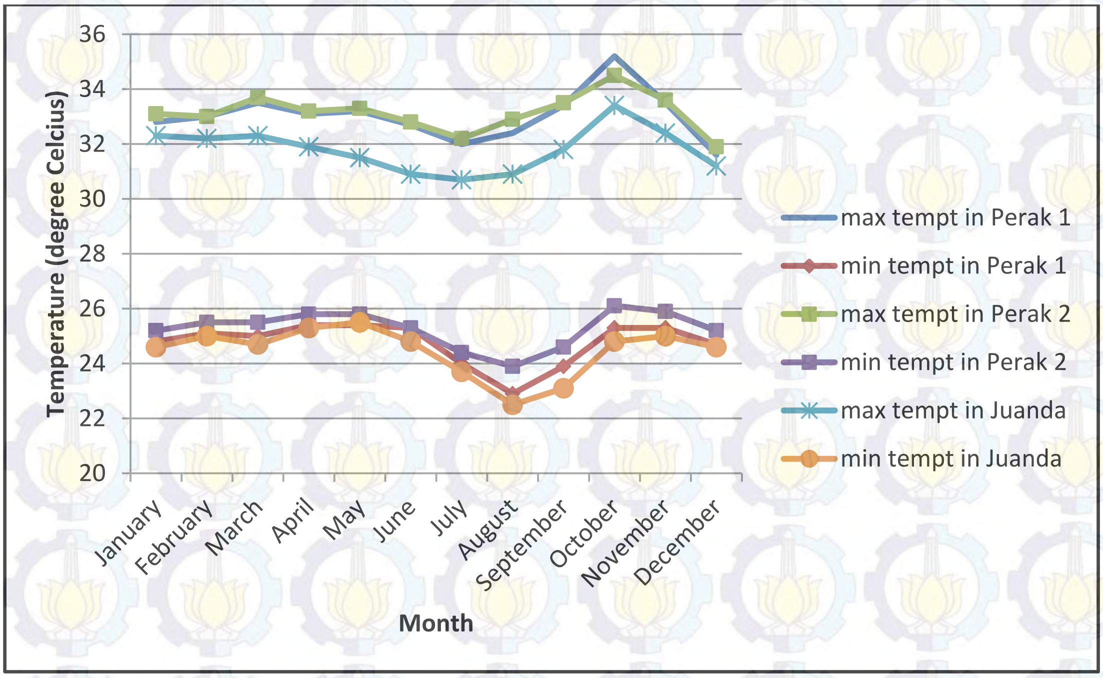


Figure 4.14 Maximum and Minimum Temperature in Three Meteorology Stations of Surabaya on 2013 (www.tutiempo.net)

4.5.3.2 Cooling Degree Days (CDD)

The current situation for cooling degree days in Surabaya will be represented the monthly record based on daily record in secondary data. Cooling degree days will embrace to energy consumption to cooling the building that refers to anthropogenic heat, even there are other indicators to identify thus both variables.

Table 4.6 shows that in 2013 Perak 2 station has the highest average number of CDD at 332, while Perak 1 and Juanda station at 322 and 299 CDD. It can be concluded that the most comfort place to live is in scope area of Juanda station which has the lowest amount of CDD. Furthermore, Juanda station (rural area) also indicates that the energy consumption and degree of UHI is quite low rather than in the urban area. Further away from the urban area will decrease the level of energy consumption for cooling the building as well as decreases the level of anthropogenic heat, which in turn will reduce the intensity of UHI effects. Moreover, it can be indicated that Surabaya`s municipality has to provide approximately 953 cooling degree days for cooling the building. In addition, Figure 4.14 shows the trend of cooling degree days in Surabaya during 2013.

Table 4.6 Average Cooling Degree Days in Surabaya on 2013

Month	Perak 1	Perak 2	Juanda
January	326	336	315
February	301	307	288
March	339	351	317
April	328	336	309
May	342	349	316
June	321	322	287
July	301	310	277
August	291	313	261
September	309	322	275
October	371	371	334
November	332	344	313
December	306	318	297
Total	3867	3979	3589
Average	322	332	299

Source: www.tutiempo.net

Based on Figure 4.14 it can be concluded that there are same pattern in three stations in Surabaya, which show that the lowest number of CDD is during August while the highest number of CDD is in October. Both of that month is in dry season. In this section, it can be concluded that the max-min temperature is influence the number of CDD.

4.5.4 Impacts of UHI

Impacts are the ill effects on the socio- economic environment as well as the natural environment brought in by the changes in the state of an important resource that influences the overall environment in one or another. For the impact for UHI effects in Surabaya are related with using of energy and elevated emission of air pollutants and greenhouse gases that always increasing in the last 20 years.

Energy use in Surabaya is increasing for last 20 years which is influencing by the rising of temperature, although there are several other factors that influence the rising of energy consumption, such as building type, building height, the preference of each person in the use of energy and so forth. In this research the meaning of energy use is the consumption of energy to cool the buildings. The formula that has used to determine the energy use in Surabaya is using the simple calculation from total energy consumption and cooling degree days.

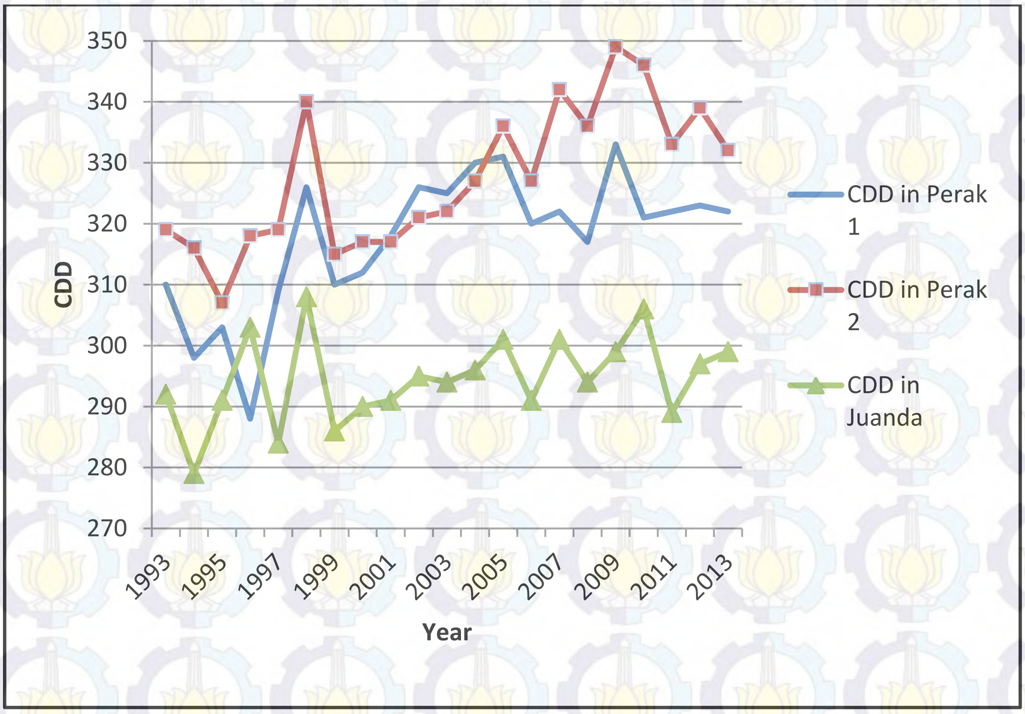


Figure 4.14 Cooling Degree Days in Three Meteorology Stations of Surabaya in 2013 (www.tutiempo.net)

Table 4.7 shows how to monitoring and targeting of energy consumption in Surabaya based on cooling degree days. The method is to find total and normalized energy consumption for cooling buildings in Surabaya over a 20-year period. The normalized energy consumption for a specific year (in kWh) was calculated as follows (US EPA, 2014):

$$normalized\ kWh = \frac{Total\ kWh}{Total\ cooling\ degree\ days} \times 3777\ days$$

*Where: 3777 = average total cooling degree days in Surabaya for 20 years

Normalized kWh is needed to normalize the data by using cooling degree days. The result is to analyze the total energy to cooling the building.

Based on Table 4.7 it can be concluded that the energy situation was actually getting more inefficient over the last 20 years. It was increasing by 5.86 B kWh since 1993 to 2013. In addition, in 2013, the government of Surabaya had to provide approximately 8 B kWh to cool its buildings. Finally, the increasing number of cooling degree days would mean increasing energy use, which will lead to increasing UHI effects in Surabaya.

Table 4.7 Energy Consumption for Cooling the Building in Surabaya

Years	Total electricity energy consumption (billion kWh/year)	Total cooling degree days/year	Billion kWh per degree day	Normalized billion kWh/year for cooling the building
1993	2.10	3,704	$6x10^{-4}$	2.14
1994	3.25	3,609	$9\ x10^{-4}$	3.40
1995	3.49	3,613	$10\ x10^{-4}$	3.65
1996	3.66	3,713	$10\ x10^{-4}$	3.73
1997	2.66	3,669	$7\ x10^{-4}$	2.74
1998	2.36	3,930	$6\ x10^{-4}$	2.27
1999	4.25	3,650	$12\ x10^{-4}$	4.40
2000	4.63	3,683	$13\ x10^{-4}$	4.75
2001	4.83	3,697	$13\ x10^{-4}$	4.93
2002	5.03	3,743	$14\ x10^{-4}$	5.08
2003	4.88	3,747	$13\ x10^{-4}$	4.92
2004	5.55	3,797	$15\ x10^{-4}$	5.52
2005	5.96	3,881	$15\ x10^{-4}$	5.80
2006	6.00	3,738	$16\ x10^{-4}$	6.07
2007	6.38	3,904	$16\ x10^{-4}$	6.17
2008	6.66	3,830	$17\ x10^{-4}$	6.57
2009	6.95	3,952	$17\ x10^{-4}$	6.65
2010	7.24	3,950	$18\ x10^{-4}$	6.93
2011	7.53	3,800	$20\ x10^{-4}$	7.49
2012	8.00	3,872	$20\ x10^{-4}$	7.81
2013	8.11	3,830	$21\ x10^{-4}$	8.00

Source: Surabaya CSA, 1993-2013

4.5.5 Response to UHI

The response is limited by the anthropogenic actions that are needed in order to bring modifications into the driving forces, to lessen down the pressure, to restore the land, and to alleviate the impacts. Response in this research is related with mitigation and adaptation action to reduce UHI effects in Surabaya. Considering that there is no direct response to address UHI, the related existing strategies will include as a response. Nowadays, Surabaya has implemented several strategies such as policy, city regulation and national act to address UHI effects, as follows:

1. Greening program

   Increasing the number of green space in Surabaya will be through by restoration of green space function as a city`s lung with prohibited the development or extend the lease for gas station and made it become green space. Up to know there are several gas stations that had changed to green space like in Dr Soetomo road, Raya Gubeng, Ahmad Yani, and Ngangel Jaya Tengah. In addition, the other action is One Million Trees Program. In Surabaya to implement this program is by giving one three for one birth as well as people who migrate to Surabaya and this program irreplaceable with amount of money. Moreover, this program has not included poor community (Environmental Protection Agency, 2013)

2. Reducing CO_2 emission in transportation sector

   Based on Regional Regulation No 6/2002 it stated that it needed to examine motor vehicle to made suitable with standard vehicle emission (Transportation agency, 2005).

3. City Regulation in terms of Tree Protection

   This is the first regulation in Indonesia that Surabaya has implemented. This regulation stated that tree replacement will be implemented for tree deforestation and tree destruction with at least 10 trees with same characteristics and planted near the area of tree destruction. Furthermore, billboard assembly in the tree is prohibited (Cleanliness and Landscape Agency, 2010).

   Zoning codes

   The regulations generally dictate function for an arena, building height and mass, population density, and parking requirements. Zoning codes can ecorage heat island mitigation in different ways, such as through parking lot shading requirements (Planning and Development Agency, 2005).

4. Green building standards

   This standard is a rule/regulation to build new building to green building (Department of Public Work, 2005).

5. Building codes

   Building codes establish standards for structure, alteration, and repair of buildings and other constructions. For instance, local governments can include cool roofing in their building codes as an energy saving measure (Planning and Development Agency, 2005).

6. Procurement

   Local governments procure cool technologies, such as cool roofs for a construction. This procurement has implemented in governance offices, education places, and public facilities (Department of Public Works, 2010).

“This page is additionally blank

CHAPTER 5
DETERMINING SIGNIFICANT FACTORS

This chapter is referred to research methodology chapter for determining the significant factors that influence UHI effects in Surabaya, which is the main objective in this research. The data that has used in this chapter was collected from municipality and agencies that related with UHI phenomenon. In addition, PLS-regression has used to determine the significant factors. Furthermore, results of this chapter are going to use for addressing UHI effects that will discuss in the next chapter.

5.1 Identification of Key Factors that Influence UHI in Surabaya

This chapter tries to identify the key factors related to UHI in Surabaya with considering the condition of UHI in Surabaya that was analyzed in the chapter 5. In addition, there are several factors that influence UHI in Surabaya. Those factors have divided into independent variables and dependent variables. Dependent variables include maximum and minimum temperature which will be integrated into the mean temperature and cooling degree days that will be represented in the annual data. Meanwhile, independent variables include area of green space, area of paving, area of asphalt, energy consumption and carbon emission.

5.1.1 Dependent Variables

Independents variables in this research are related with a micro climate that influences UHI effects, such as maximum and minimum temperature and cooling degree days. Both of thus variables had been collected from secondary data.

A. Maximum and minimum temperature

Maximum and minimum temperature for quantitative analysis is based on the data from 1993 to 2013. In addition, mean temperature will be used for represent maximum and minimum temperature. The definition of the mean temperature here is the average of the maximum and minimum temperature in monthly measurement that used for yearly information.

Based on the Table 5.1 it can be shown that the mean temperature in Surabaya is mostly in 28^{o}C while the rising temperature happened in 2009 and 2010 by 1^{o}C but then decreasing again in 2011. In addition, for last 20 years the mean temperature in Surabaya is increasing by 0.45^{o}C.

Table 5.1 Temperature in Surabaya, 1993-2013

Years	Maximum temperature (^{o}C)	Minimum temperature (^{o}C)	Mean temperature (^{o}C)
1993	32.50	24.40	28.45
1994	32.43	23.94	28.19
1995	32.32	23.90	28.11
1996	32.73	24.26	28.50
1997	32.51	24.19	28.35
1998	32.90	25.25	29.08
1999	32.29	24.30	28.30
2000	32.05	24.59	28.32
2001	32.45	24.31	28.38
2002	33.01	24.20	28.61
2003	33.17	23.97	28.57
2004	33.12	24.23	28.68
2005	33.10	24.86	28.98
2006	32.91	24.56	28.74
2007	33.10	24.86	28.98
2008	32.95	24.56	28.76
2009	33.42	24.83	29.13
2010	33.12	25.12	29.12
2011	32.81	24.61	28.71
2012	33.16	24.65	28.91
2013	32.66	24.93	28.80

Source: www.tuitempo.net, 2013

B. Cooling degree days

Cooling degree days that will be used in the quantitative analysis is the result from subtraction the mean temperature to standard temperature (65^{o}F). The data will be presented in annual data from daily temperature measurement.

Based on Table 5.2 it is found that the average CDD for last 20 years was increasing, with annual average is 330.62 CDD. In addition, during 20 years cooling degree days was increasing by 10.79 cooling degree days.

Table 5.2 Annual Average of CDD in Surabaya, 1993-2013

Years	Average CDD
1993	308.56
1994	301.07
1995	300.96
1996	309.45
1997	305.65
1998	327.26
1999	304.30
2000	307.00
2001	308.01
2002	312.45
2003	312.53
2004	316.48
2005	323.20
2006	313.63
2007	325.45
2008	319.21
2009	329.74
2010	329.25
2011	316.39
2012	322.54
2013	319.35
Total	**6612.48**
Average	**330.62**

Source: www.tuitempo.net, 2013

5.1.2 Independent Variables

Independent variables in this research are related with manmade factors. The definition for manmade factors is the factors that occur due to human activities. Independents variable in this research are factors that influence urban heat island in Surabaya, such as area of green space, electronic energy consumption, area of paving, area of asphalt and carbon emission that come from vehicle fossil fuel.

A. Area of Green Space

Area of green space is embracing to change in surface covers factor. Area of green space is influence to reducing surface evapotranspiration capacity. Evapotranspiration process requires solar energy, meanwhile since both evaporation and transpiration amount are decreased, the solar energy that involved in this process will rise to the surface heating. In addition, the temperature in green space is slightly different with in the built up area. In this research area of green space is embracing to area of green space that manage by municipality, such as park, tomb, median road, pedestrian and stadium.

Table 5.3 Total Area of Green Space in Surabaya, 1993-2013

Years	Area of green space (km^2)
1993	0.37
1994	0.46
1995	0.65
1996	0.84
1997	1.03
1998	1.22
1999	1.42
2000	1.61
2001	1.80
2002	2.18
2003	2.26
2004	2.41
2005	2.62
2006	2.64
2007	2.70
2008	2.73
2009	3.08
2010	3.92
2011	4.00
2012	4.15
2013	4.18

Source: Cleanness and Landscape Agency, 2013

Based on Table 5.3 it has shown that the number or green space in Surabaya has increased 91.14% the last 20 years. The total area of green space in 2013 is 4.18 km2.

B. Area of Paving

Area of paving variable is embracing to change in surface covers factor. Both area of paving and asphalt are effects to the heat storage on non-reflective construction material. In addition, non-reflective construction will absorb heat, keep it and become radiating after sunset that raises night temperature. In this research the assumption is increasing use in paving will lead to increasing the heat. Based on Table 5.4 it has shown that the total area of paving in Surabaya has increased 99% for the last 20 years. The total area of paving in 2013 is 874.52 km2.

Table 5.4 Total Area of Paving in Surabaya, 1993-2013

Years	Area of paving (km^2)
1993	6.12
1994	12.51
1995	19.16
1996	26.08
1997	33.26
1998	40.83
1999	48.79
2000	57.14
2001	65.88
2002	75.01
2003	84.53
2004	94.44
2005	104.74
2006	115.43
2007	126.51
2008	137.98
2009	196.58
2010	338.69
2011	481.06
2012	677.79
2013	874.52

Source: Transportation Agency, 2013

C. Area of Asphalt

Area of asphalt variable is embracing to change in surface covers factor. Both area of paving and asphalt are effects to the heat storage on non-reflective construction material. In this research the assumption is increasing use in asphalt will lead to increasing the heat. Based on Table 5.5, shows that the expansion of asphalt is always increase. The total area of asphalt in 2013 is 37,013.99 km2 which is linearly used with the urban development. The increasing for the last 20 years is 97.69%. In addition, asphalt road construction is used for highways or primary road, while the others are used for paving and concrete.

Table 5.5 Total Area of Asphalt in Surabaya, 1993-2013

Years	Area of asphalt (km^2)
1993	861.45
1994	2,556.10
1995	4,293.68
1996	6,176.86
1997	8,205.63
1998	10,234.40
1999	12,263.17
2000	14,291.94
2001	16,320.71
2002	18,348.87
2003	20,376.41
2004	22,403.34
2005	24,429.66
2006	26,455.37
2007	28,480.46
2008	30,504.94
2009	31,339.94
2010	32,623.98
2011	33,908.26
2012	35,336.01
2013	37,013.99

Source: Transportation Agency, 2013

D. Electricity Energy Consumption

Electricity energy consumption variable is embracing to individual heat emitting. In addition, in Surabaya the increasing in energy consumption for the purpose of cooling, industry, household, lighting, business, et cetera will excess heat energy which is subsequently released to the atmosphere. The released energy is increase urban heat. Electricity energy for cooling the building is used in this research.

Based on Table 5.6, there were increasing number of energy consumption, except declining in 1997 and 1998. In addition, for the last 20 years municipality of Surabaya has to provide 104,917,558.50 Mwh for cooling the building.

Table 5.6 Electricity Energy Consumption in Surabaya, 1993-2013

Years	Electricity energy consumption (Mwh)
1993	1,855,188.26
1994	2,239,407.85
1995	2,572,808.57
1996	2,829,815.10
1997	2,427,471.19
1998	2,554,865.68
1999	4,396,366.28
2000	4,750,873.75
2001	4,933,441.97
2002	4,925,790.62
2003	5,071,000.52
2004	5,517,110.47
2005	5,803,290.70
2006	6,067,334.55
2007	6,174,341.17
2008	6,443,733.20
2009	6,312,208.44
2010	6,676,630.80
2011	7,361,073.61
2012	7,873,960.99
2013	8,130,562.03
Total	104,917,275.7

Source: Surabaya CSA, 1993-2013

E. Carbon Emission

Carbon emission variable is embracing to air pollution factor. Air pollution factor in this research had taken from transportation sector only and due of data limitation, hence the number of vehicle on the road will be used as baseline data. In addition, the result of carbon emission is from equivalence the number of vehicle on the several main roads that had been taken by transportation department in Surabaya.

Based on Table 5.7 it has shown that the increasing number of vehicle will increase the number of carbon emission in the air. In addition, for last 20 years the total carbon emission in Surabaya is 137,244,424 metrics ton of carbon while the number of vehicles is 28,893,563. Furthermore, it can be concluded that the number of carbon emission in Surabaya has increased 72.97% for the last 20 years.

Table 5.7 Carbon Emissions (CO) in Surabaya, 1993-2013

Years	Total number of vehicles	Carbon emission (metrics ton of carbon)
1993	849,114	4,033,292
1994	857,688	4,074,018
1995	866,262	4,114,745
1996	874,836	4,155,471
1997	883,409	4,196,193
1998	891,983	4,236,919
1999	900,557	4,277,646
2000	909,131	4,318,372
2001	909,131	4,318,372
2002	918,662	4,363,645
2003	918,662	4,363,645
2004	923,143	4,384,929
2005	1,379,147	6,550,948
2006	1,371,631	6,515,247
2007	1,364,116	6,479,551
2008	1,356,601	6,443,855
2009	1,349,085	6,408,154
2010	1,341,570	6,372,458
2011	4,047,015	19,223,321
2012	2,840,173	13,490,822
2013	3,141,647	14,922,821
Total	28,893,563	137,244,424

Source: Transportation Agency, 2013

5.2 Results and Discussions of Statistical Analysis

PLS-regression analysis has used to determine the significant factors with using two dependent variables and five independent variables. Time period that used is 20 years since 1993 to 2013. Furthermore, smart PLS has been used as software to analyze it. The dependent variables are maximum and minimum temperature that represented by mean temperature and cooling degree days. Meanwhile, the independent variables are area of green space, area of paving, area of asphalt, electricity energy consumption and carbon emission. The kind of regression that has been used is multivariate regression which has several independent variables (x). PLS has been chosen for this analysis due to the number of dependence variables (y). Moreover, PLS is named the independent variable as a latent variable and the dependent variable as an indicator variable.

Smart-PLS software has applied for this research. Firstly, data were manually typed into Microsoft Excel and saved as *.xlxs*. Secondly, since Smart-PLS takes native Excel format directly, the data set has to be converted into *.csv* (comma delimited) as the file format type. Set up the modeling structural equation base on PLS, the first step is developing two specification models that are the *structural model* (inner model) and the *measurement model* (outer model). The inner model in this research is the connection between dependent and independent variable. The inner model in this research is UHI effects and man-made factors. Meanwhile, the outer model is the connection between indicator and latent variable. There are two types of number:

1. Number in the circle: These show how much the variance of the latent variable is being explained by the other latent variables.
2. Number on the arrow: These are called the path coefficients. They explain how strong the effect of one variable is on another variable. The weight of different path coefficients enables to rank the relative statistical importance, which is used to determine the significant factors that influence UHI in Surabaya.

The PLS path modeling estimation for determine the significant factors that influence UHI in Surabaya shown in Figure 5.1, that included two number, number in the circle and number on the arrow. In addition by looking the diagram, the following preliminary results are (Appendix 4):

a) Explanation of target endogenous variable variance

The coefficient of determination, R^2 is 0.407 for the factors endogenous latent variable. This means that the “factors” latent variable, which is contain of carbon emission, area of asphalt, area of paving, area of green space and energy consumption are explaining 40.7% of the variance in UHI. Meanwhile, 59.3% remaining is explaining by other factors that excluded in this research, such as wind speed, water body, urban structure and the others. Therefore, the small value of variance indicates that the data points tend to be close to mean and hence to each other.

Figure 5.1 Path Diagram of Modeling Result

b) Inner model path coefficient sizes and significance

The inner model shows that factors variable (carbon emission, area of asphalt, area of paving, area of green space and energy consumption) have 0.638 effects on UHI. Meanwhile, 0.362 remaining is affected by other factors that excluded in this research, such as wind speed, water body, urban structure and the others. Based on Kwong and W ong (2012), the effect size assesses the magnitude or strength or relationship between latent variables. Moreover, the effect size helps researchers to assess the overall contribution of a research.

c) Indicator reliability

Table 5.8 shows the various reliability and validity items that should be checked and reported. Reliability and validity are needed to check the data that used in this research, whether it is valid (trustworthy) and consistent.

Based on the reliability and validity checking, this research shows that all the data and the result is valid and reliable.

Table 5.8 Reliability and Validity Checking

Check list	Smart-PLS	Analysis
	Reliability	
Indicator Reliability	"Outer loadings" numbers	It can be shows that based on outer loadings number, each of variables has a higher value than 0.70. Therefore, the higher is preferred (Wiyono, 2011). In addition, it can be concluded that indicator variables are highly correlated with latent variable and it has ability to measure latent variable.
Internal Consistency Reliability	"Cronbachs Alpha"	Umar (2002) said that an instrument of the research is reliable if the coefficient of reliability, r>0.6. In addition, based on Cronbachs Alpha factors variable is exceedingly than 0.6. therefore, it shows that data has given the significant and consistency of the measurement
	Validity	
Convergent Validity	"AVE" numbers	Kwong and Wong (2013) said that the AVE numbers should be higher than 0.5. Based on this research it is found that AVE values are greater (0.861 for factors and 0.995 for UHI variable) than the acceptable threshold of 0.5. Therefore, convergent validity is confirmed.

d) Outer model loadings

Outer model loadings is to view the correlations between latent variable and the indicators in its outer model. In this research, outer model loadings will be used for identify the most significant factors that influence UHI in Surabaya. Table 5.9 shows the weight of each indicator that influences the equation. In addition, the weight of each indicator assesses the magnitude or strength of indicators to the latent variable.

Based on Table 5.9, it can be found that the most significant factors are area of asphalt (0.970), energy consumption (0.988) and area of green space

(0.971) respectively. In addition, in Surabaya the most significant factors that influence UHI are the change of land cover such as use of asphalt and provision of green space as well as the electricity energy consumption. Furthermore, the provision of green space in this research is embracing to provide park and plant trees, considering that according to Hutchings and Doick (2013) said that vegetation, in particular trees can be very effective as it delivers several mechanisms of cooling simultaneously and in a complementary manner. In Surabaya the area provision for green space is simultaneously increase in accordance with the Surabaya`s regulatory to provide more trees.

Table 5.9 Significance of Factors

Indicators	UHI	Factors
CDD	0.998	
Mean temperature	0.998	
Carbon emission		0.827
Area of asphalt		0.970
Area of green space		0.988
Area of paving		0.872
Energy consumption		0.971

Source: Smart-PLS, 2014

This research is limiting for only determining the significant factors without excluding the linier relationship among the latent and indicator variables. Therefore, whereas the latent has a linier or inversely relation, it will not excluded and could be in the further research.

The change of the surface will increase the sensible heat storage and decrease the evapotranspiration. The heat will trap in the materials like street (asphalt) during day time then it will become radiating source after sunset that rises night temperature. Meanwhile, evapotranspiration is needs solar energy to do the process, while when the area of green space is limited it will make difficulties to absorb the water that will lead to decrease the amount of evapotranspiration and in the end of the day it will rise the amount of solar energy that rising the surface heating. Furthermore, electricity energy consumption is embracing to use of air conditioning for cooling the buildings. Whereas, cooling the building increase a building`s energy consumption and associated carbon emission.

e) Checking structural path significance in bootstrapping

Bootstrapping checking result in Smart-PLS can generate t-statistic for significance testing of both the inner and outer model. In this procedure, a large number of subsamples (e.g., 5000) are taken from the original sample with replacement to give bootstrap standard errors, which in turn gives approximate t-value for significance testing of the structural path. The bootstrap results approximately the normality of data (Kwong and Wong, 2013).

Using a two-tailed t-test with significant level of 5% the path coefficient will be significant if the t-*statistic* is larger than 2.093 ($\alpha = 0.05$, degree of freedom is 19) that can be shown in Appendix 6. Furthermore, Table 5.10 shows the checking result.

Table 5.10 Bootstrapping Checking Result

	Original sample	Sample mean (M)	Standard error (STERR)	t statistic	P values
Factors	0.638	0.653	0.124	5.165	0.000

As presented in Table 5.10, the t-statistic[1] is 5.165 which are larger than t-value[2] 2.093. Therefore, it can be concluded that the model loadings are highly significant and there is influence between manmade factors which are carbon emission, area of asphalt, area of green space, area of paving, and electricity "energy use with UHI (Yamamoto, 2006; Lormaneenopparat, 2003; Prilandita, 2009 and Gago, 2003).

[1] The result of PLSR analysis

[2] The result of t-table

"This page is additionally blank"

CHAPTER 6
STRATEGIES FOR ADDRESSING UHI

This chapter refers to the conceptual framework to enhance the existing city`s strategies for addressing UHI in Surabaya. In addition, it has tried to set up and identify the strategies that related to UHI and give the recommendation to enhance the strategies for addressing it. Semi structured question was conducted to collect and analyze the current strategies in each department or agencies. Respondents were being determined in the previous chapter. Furthermore, triangulation analysis has been conducted to elaborate the strategies that come from three different sources, namely literature review, stakeholders response and current strategies related to UHI in Surabaya.

6.1 Identification Strategies in Reaction to Significant Factors Influencing UHI in Surabaya

This chapter tries to achieve the objective three, which is to propose recommendation for enhancing current strategies to address UHI. Hence, to achieve that objective, this sub-section tries to select and identify the related strategies that address or reduce UHI in Surabaya. In addition, these strategies are come from document review and stakeholders response. Furthermore, the strategies in this research are embracing to on-going strategies implemented by municipality of Surabaya. Strategies that will be used in this research are related to the most significant factors that have been discussed in the previous chapter and strategies that reduce/address UHI.

The most significant factors are change on land covers and electricity energy consumption with embracing in area of green space, area of asphalt and consumption of air conditioning. The existing mitigation and adaptation strategies that related to those three factors are as follows.

1. Change in surface cover (open space to built-up area)
   a) Pavement

More than a quarter of the urban areas are generally covered by streets. Development of the city was needed for expansion of the road. Mainly, type of pavement for main road is asphalt (dark pavement). In gain, like conventional dark roofs, dark pavements get hot in the sun because absorbing 80-95% of sunlight (Douglas et al, 2004). Hot pavements aggravate urban heat island by warming the local air and contribute to planetary warming by radiating heat into the air.

Asphalt is used primarily as pavement of the road in Surabaya. Therefore, this condition increasing the urban heat island effects in Surabaya (based on chapter five). Nevertheless there is no significant policy or strategy to embrace the kind of pavement for the street. In addition, use of pavement in Surabaya still using conventional dark pavement (asphalt) as the main pavement for the road.

b) Green space

Provision of more vegetation (green space) in the city is one of mitigation and adaptation measures that can be practiced to cope with UHI effects. Research stated that the temperature in the green area is cooler than in built-up area (Fariz, 2012, Gago et al, 2013). In addition, this is because trees can absorb excessive heat from building, hard surface (asphalt) and other sources. Based on regulation by Interior Ministry No 1/2007 the green area can be provided through park (city park, recreational park, community park), city forest, conservation forest, city zoo, field and stadium, grave yard, paddy field, buffer zone, green roof, green building, open parking, riparian, and green line.

In Indonesia, the green and open space in cities is regulated by The National Act No 26/2007 on Spatial Planning. The policy stated that every city/regency should provide 30% of the city`s area for green and open space. From the total 20% should be provided for public green and open space, while 10% should be provided for private. Parallel with this policy, the Surabaya municipality has tried to increase the amount of green space in Surabaya. Revitalize and optimize open space to green space, and also verification some area to green space. In addition, many of gas stations in

Surabaya are lack of permit to build and occupied the open and green space function. Therefore, Surabaya municipality tries to rehabilitate the function back. Regardless, that strategy seems still need a lot of effort to fulfill 20% of public space requirement.

Another action is city regulation to protect the tree. This is the first regulation in Indonesia that Surabaya has implemented. This regulation stated that tree replacement will be implemented for tree deforestation and tree destruction with at least 10 trees with the same characteristics and planted near the area of tree destruction. Furthermore, billboard assembly in the tree is prohibited.

Strategies to greening the city is the One Million Trees Program. This program was established by the National Government as mitigation measures to reduce global warming and its effects. This program requires every city/regency to provide or plant at least one million trees each year. They were given freedom how to conduct the program. In Surabaya, one of the measurements taken is involving the private and public sector to optimize greenery program. They have to plant or provide trees as an action in one million trees program. Every school, public service, office and industry has taken a part in this program.

2. Electricity energy consumption (individual heat emitting)

Surabaya has implemented indirect strategy to reduce the air conditioning consumption. Green building awards is being used for controlling the land use zoning, reducing energy use, recycling waste and be in accordance with surrounding environment. In addition, in green building award, citizen is given the opportunity to do self-assessment. There are several points in green building that should be considered, such as land ecological enhancement, movement and connectivity, material cycle management, community wellbeing strategies, building and infrastructure. Moreover, the self-appraisal is included appropriates site development, energy efficiency and conservation, water preservation, material resources and cycle, indoor health and solace, and building environmental management. Furthermore, there is several difference of building that can be assessed, such as new building, existing building and interior space.

6.2 Enhancing Strategies for Addressing UHI in Surabaya

Enhancing the current strategies were developed to enhance and create new strategies for addressing the UHI with using triangulation analysis. There are three variables, namely provision of green space, use of asphalt and electricity energy consumption. This analysis method is considering among three sources, which are stakeholders opinion, current strategy and also literature review. Furthermore, thus three sources will be elaborate for getting appropriate strategy to address UHI in Surabaya. In addition, the elaboration process of triangulation analysis can be shown in Appendix 5. The recommendation on enhancing current strategies for addressing or reducing UHI in Surabaya can be implemented, as follows.

A. Provision of green space

Provision of green space should considering the suitable tree, tree location, and tree density. Suitable tree is needed due to function and morphology of the tree that suitable to decrease high temperature. In addition, tree location is needed to plant the tree that suitable with the location. For example, industry and high density housing area need a lot of tree with high density compare with low density community. Furthermore, tree density is associated with tree canopy tend to cast more shade and deliver greater rainwater management and biodiversity benefits than smaller ornamental species. Meanwhile, to enhance the implementation of protect the tree regulation and one million trees program is strictness and involves of all city`s stakeholders with complete understanding the importance of green space to the city. Moreover, good publication with provide city website and other media that easy accessible is needed.

B. Electricity energy consumption

Considering that green building is a new program and up to now there is no city regulation that control the use of green building, municipality should enhancing it with considering Surabaya own characteristic, such as the characteristic of the people, building materials, environment and etcetera. In addition, green building has to elaborate all aspect, start from roof, building, design, use of energy, materials, the environment surrounding it, even waste and garbage disposal also being considerate. Integration with other city`s strategies is needed due to overlapping and discrepancy with other city regulations. Moreover strict and honest assessment to evaluate and implement the building is needed.

Public knowledgeable should be increase related to green building. Furthermore, to clarify the regulation further, the plan should be more practical, like discussion related to green roof, considering that green roofs are an significant element in an overall scheme to offset the negative impacts of UHIs and enhance the value of green building practices for occupants and surrounding citizens. It possesses the ability to improve air quality, reduce combined sewer overflows, provide functional spaces for building residents, support biodiversity, reduce noise, and extend waterproofing longevity. When green roofs are combined with other measures, such as urban forests and reflective roofs and paving, in green building, environmental benefits associated with investing in UHI reduction. Moreover, in green roof the kind albedo should be maintained. Albedo is a unit less measure with possible values ranging from 0 to 1. Objects that reflect lots of light have a high albedo approaching 1, while a stark black body would have an albedo of 0.

C. Use of asphalt

Enhance the strategies and address UHI with using cool and reflective pavement and elaborate with other strategies, such as provision of vegetation along the road and use green building to reduce other sources that influence UHI intensity in Surabaya. The construction of asphalt is needed to be considerate, due to quality and it also can reduce heat. The night construction is cooler that in the day time. Day time construction can increase the air temperature. Furthermore, using light albedo for asphalt can decrease the solar absorption. Moreover, using cool pavement can also decrease the city`s air temperature.

6.3 Discussions

Recommendation to enhance the current strategies can be done in both ways adaptation and mitigation measure. In enhancing Surabaya`s current strategies, literature review, existing condition and stakeholders opinion are being used. In addition, Surabaya indirectly has implemented strategies to reduce UHI, although up to now there is no direct measure to reduce it. Furthermore, in environmental management measures the usage of comprehensive strategy (policy, planning and program) was being needed to make appropriate solution. The usage of regulator or in this case it called strategy, can be used as “stick” to guide the implementation of urban development system (Nitivattannanon, 2013). The integrated aspect mainly in urban planning, design and policy can be applied by municipality and citizen to reduce UHI. For the example, in construct green building people should considering not only the building it-self (material, design, facilities) but also the environment (suitable site plan-zooning, renewable energy, waste disposal, and etcetera).

Other city strategies can also become additional references to reduce UHI in Surabaya as long as it has characteristic similarity. For the example, Jakarta which has similarity with Surabaya, is a metropolitan city, has high density populated and the capital city of Indonesia. Therefore, the Jakarta`s strategies or policy can be implemented in Surabaya (city policy DKI Jakarta No 38/2012 related to Green Building).

Next, the lesson learned to enhance the current strategies is by clarifying and focusing to the objective. For the example, first is provision of green space for reducing UHI not only embracing to esthetic, function or the number of park, but also considering the tree selection, density and place. Second is selection of pavement and the way to construct is important to reduce urban heat. Choose the cool pavement with high albedo and constructed in the night time is much better to reduce heat. In the end, increasing people knowledge and awareness is important to reduce UHI.

UHI is not a new issue of the city, actually in Indonesia particularly in Jakarta already known urban heat island phenomenon and the effect that occur because of it. Although, when it comes to the local level (in this research

Surabaya is the study case) many people doesn't understand about it. Unfortunately municipality recognizes UHI as a high temperature in the city, whereas it has different and complex meaning than high rise temperature (Prilandita, 2009). Furthermore, up to now there is no direct measurement to measure UHI in Surabaya. Moreover, this research is using CDD and maximum-minimum temperature to measure UHI condition. In addition, this condition influences the way to implement and establish the urban planning. The municipality will always doing development in the urban center and concentrate in the CBD, for the results, people will have high preference to live in the urban center and lack of provision of green and open space (Fukuda, 2013). Therefore, with understand the whole concept and the condition of UHI, the municipality of Surabaya will make a good strategy to adapt and mitigate UHI.

Enhancing the current strategies to address UHI in Surabaya can be implemented for other cities which have the similarity of characteristic, particularly on provision of green space, electricity energy consumption (use of air conditioning) and use of asphalt as a road pavement. Furthermore, focusing in enhancing the current city strategies can effectively reduce UHI due to basic approach. Hence, assessing the current strategies conditions are needed to identify successfulness of the strategies to reduce UHI. In the next step forward, this research can be refined with using strategy assessment before enhancing the quality of strategy.

"*This page is additionally blank*"

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The major findings from the analysis conducted in this research are summarized in this chapter. Explanations of the major findings are conclusions and recommendations related to the research objectives. In addition, recommendation on possible applications of research results are also discussed. Last but not least, further research as well as the limitation of this research are finalized.

7.1 Summary of Key Findings

The findings of this research are presented according to the research objectives. As mentioned in previous chapters, the main objective in this research is to determine the most significant factors that influence UHI in Surabaya. The result shows that area of green space, electricity energy consumption and use of asphalt variables which contribute the most significant value to influence UHI in Surabaya. Moreover, these independent variables are influencing UHI (dependent variable) by 63.8%.

Based on DPSIR analysis, it can be found that the driving force for increasing UHI effects in Surabaya is urbanization factor. Furthermore, it causes the pressure to lack provision of the green space and the increase of air pollutants as well as greenhouse gas. Meanwhile, the condition of UHI in Surabaya can be identified by cooling degree days and maximum-minimum temperature. The temperature in Surabaya for over 20 years is raising 1^0C and there is 1.4^{o}C temperature difference between urban and rural area. Therefore, the requirement of cooling degree days is influenced by the temperature differences. It can be concluded that the most comfortable place to live is rural area when considering the temperature difference and the value of cooling degree days. Moreover, UHI phenomenon in Surabaya is causing the negative impact to increase the energy consumption for cooling buildings. Additionally, as the response to those condition, the municipality of Surabaya has implemented several strategies to address the situation by conducting greenery program, reducing carbon emission in the transportation sector, protecting trees, zoning and building codes, procuring and implementing green building standard

Then the analysis of the existing strategy analysis reveals that the municipality of Surabaya is implementing direct and indirect strategies that related to urban heat island. In detail, for direct strategies, the municipality of Surabaya is implementing several activities such as tree protection, one million trees program, and park-open space revitalization. In addition, for electricity energy consumption, the municipality is implementing indirect strategy such as green building award. Meanwhile, for pavement variable the municipality of Surabaya is still lack of concern to manage it.

Lastly, according to triangulation analysis, to enhance the provision of green space, the municipality needs to consider the selection and location of the tree, while increasing the publicity of the regulation. In addition, in order to enhance the electricity energy consumption, the municipality needs to implement green building standard and reward to the Surabaya citizen which aim is to get involving of all stakeholders in Surabaya. Meanwhile, due to lack of strategies which is related with use of asphalt, Surabaya municipality needs to at least make city regulation associated with the usage of cool pavement and greenery program along the road to enhance the solution for this effects.

7.2 Conclusions

The increase of population in Surabaya is from urbanization that brings the direct force to the city. It will also effect to the less of green space, high pavement area, high consumption of energy and high air pollution. This condition leads to create UHI in big city. The most influencing factors related to UHI in Surabaya is provision of green space, electricity energy consumption and use of asphalt. The green space becomes the first influencing factor due to the importance to address UHI. Green space or vegetation can absorb air emission, absorb solar radiating, doing evapotranspiration and even can reduce the consumption of air conditioning.

Comprehensive strategy is needed to enhance the current strategies, to avoid overlapping and to integrate related departments as well as related sector. Furthermore, to reduce UHI the municipality can study and try to implement other city's strategies which have similarity of city characteristics. The results of this research can be a reference for other city to reduce UHI based on own city characteristics. Moreover, this research can be a good source for further research to identify the current condition of UHI and determine the significant factors or enhance the current strategies to address UHI. This research figures out that determining the most significant factors that influence UHI in the particular city and enhancing the current strategies, are one of the possible way to address UHI problems. Moreover, it can be a baseline data to develop itself with new objectives or even deeply focus in a higher level education such as a PhD dissertation.

7.3 Recommendations

7.3.1 Possible Applications of Research Results

The most significant factors to influence UHI in Surabaya are the change in surface cover (provision of green space and use of asphalt) and individual heat emitting (electricity energy consumption). Nowadays, the policy implementation of those two factors is only in the provision of green space and electricity energy consumption, while there is no strategy related with use of asphalt. It can be indicate that there is lack of concern and understanding how to address UHI in Surabaya. Hence, this result can be a reference for municipality to address UHI in Surabaya or other cites which similar characteristics. Municipality can focus to implement or establish strategies to emphasize these three factors to address UHI.

Nevertheless, in order to identify the current condition of UHI, DPSIR analysis can be used as an analysis tool which can be applied in other researches that have the same objectives. In addition, to identify the state condition, this analysis starts from driving force to city's or stakeholders responses. Moreover, this research is giving recommendations to enhance the current strategies by enhancing the comprehensive strategies, increasing people awareness and knowledge, stimulating people involvement and more clarifying to objective of the strategies. This recommendation can be applied not only for reducing UHI in Surabaya municipality but also other cities which has the similarity characteristics. Elaboration for all stakeholders (municipality, citizen, NGO, private company) and comprehensive planning are needed to enhance the strategies. Furthermore, city needs their own city regulation to regulate or manage city development by considering and using local wisdom.

7.3.2 Limitations of the Results

Based on the previous study, this research only uses several factors that related to urban development in order to identify the cause factors that influence UHI in Surabaya, namely the change in surface cover, individual heat emitting and air pollution. Therefore, the result is the independent variables influence UHI only 63.8%, while the rest comes from other causes such as wind direction, urban design and urban structure. It would be better if those other factors were also involved. In addition, this research only uses on-going strategies to address UHI, while considering the past and future strategies may enhance the research results.

The data that have been used in this research is limited due to data availability, for the example, data of carbon emission and air conditioning consumption. Therefore, to solve those constraint, equivalencies of data is needed. The number of vehicles and electricity energy consumption was used as basic data. Moreover, this condition can influence the accuracy of quantitative result. Therefore, it will be more convincible if there is a complete version of data availability.

7.4 Future Study

Complementary research to fill the gaps and improve the new research is very important. To enhance the quality of this research, the future studies can also assess the condition of current strategies before recommending how to enhance it. In addition, the analysis of current strategies condition can improve the strategies by not only using the ongoing strategies plan but also considering the past and future version.

The next research can address UHI in more deeply research with only emphasizing in how to solve one particular factor. For the example, it can use the provision of green space as a factor. Then the researcher can only focus on the provision of green space which starts from identification of the current condition to address UHI related to green space. Furthermore, that research will be more focus and profound to the objective. The future research can divide the overall data to three meteorology stations that not only mentions nature data but also utilizes man-made data, in order to make it more accurate. Last but not the least, the future research in other cities around the world can used this research as a baseline study for deeply understanding and addressing UHI.

"This page is additionally blank"

REFERENCES

Abdi, H. (2007). *Partial Least Square Regression PLS-Regression*. Encyclopedia of Measurement and Statistic. The University of Texas at Dallas. USA

Ariyaningsih (2012). Direction of Commercial and Service Land Use Intensity Based on Telecommuting`s Opportunity along Mayjen Sungkono Street Surabaya. Institute of Sepuluh November. Surabaya. Indonesia

Akbari, H. (2005). *Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation* Lawrence Berkeley National Laboratory. Available at: < http://www.osti.gov/scitech/servlets/purl/860475>

Bertaud A, Agnes M (2012). *Note on Surabaya Mobility and Housing Issues*. Surabaya

Bisset R. (2013). *Climate Change Overview*. The World Bank. Available at: <http://www.worldbank.org/en/topic/climatechange/overview>

Borbora J, Das A. (2013). Summertime Urban Heat Heat Island Study for Guwahati City, India. *Sustainable Cities and Society*, 45, 145-151

Byrne J, Sipe N (2010). *Green and Open Space Planning for Urban Consolidation-A Review of The Literature and Best Practice.* Griffith University

Chirarattananon, S. (2000). "*The Sun and Climate" Lecture Note for Chapter 3 Ed06.24 Energy Management in Building,* Energy Program, SERD, AIT, Thailand

Doulus, L., Santamouris, M., Livada, I. (2004). Passive Cooling of Outdoor Urban Space. The Role of Materials. *Solar Energy*, 77, 231-249

Enete, I., Chukwudeluzu, V. and Kolie, A. (2012). Evaluation of Air Pollution Tolerance Index of Plant and Ornamental Shrubs in Enugu City: Implication for Urban Heat Island Effect. *Experimental Science*, 42, 179-185

Fariz, I (2012). *Relationship between Green Space Area and Urban Temperature in Surabaya Indonesia*. Institute of Tenth November, Indonesia (Indonesia Language)

Fukuda, Chisako. (2013). *Urban Development Overview*. The World Bank. Availabe at: http://www.worldbank.org/en/topic/urbandevelopment/overview

Founda D. (2011). Evaluation of The Air Temperature in Athens and Evidence of Climate Change: A Review . *Building Energy Research*, 5, 7-41

Gago EJ, Roldan J, Pacheco-Torres S, Ordonez J. (2013). The City and Urban Heat Island: A Review of Strategies to Mitigate Adverse Effects. *Renewable and Sustainable Energy,* 25, 749-758

Ganesan S, Giridharan R, Lau SSY. (2004). Daytime Urban Heat Island Effect in High Rise and High Density Residential Developments in Hongkong, Energy and Building. *Energy and Buildings*, 36, 525-534

Harmadi S. (2012). *Strategy of Population Mobility in National Security point of view to Enhance the Alignment of Central and Regional*. National Security Agency of Indonesia

Hirano Y, Fujita T. (2012). Evaluation of The Impact of The Urban Heat Island on Residential and Commercial Energy Consumption in Tokyo. *Journal of Energy,* 37, 371-383

Kolokotroni, M. (2007). The London Heat Island and Building Cooling Design. *Solar Energy,* 83, 3393-3404

Kondo, H, Kikegawa Y. (2003). Temperature Variation in The Urban Canopy with Anthropogenic Energy Use. *Pure and Applied Geophysics*, 160, 317-324

Kwong, K and Wong K. (2013). Partial Least Squares Equation Modeling (PLS-SEM) Techniques Using SmartPLS. *Marketing*. 1, 24-42

Lee K, Baek H, Cho C. (2014). The Estimation of Base Temperature for Heating and Cooling Degree-Days for South Korea. *Journal of Applied Meteorology and Climatology*, 53, 300-308

Liu, J.; Ma, F.; Li, Y. (2011) The Effect of Anthropogenic Heat on Local Heat Island Intensity and The Performance of Air Conditioning Systems. *Adv. Mater. Res*, 250–253, 2975–2978.

Lormaneenopparat, S. (2002). *The Prospects Of Mitigating The Urban Heat Island Effect in Bangkok Through Appropriate Landscape Design: A Case*

Study Of Public Parks And Their Surroundings in Pathumwan and Klongtoey Districts. Asian Institute of Technology, Thailand

Lundgren, K., and Kjellstrom, T. (2013). Sustainability Challenges for Climate Change and Air Conditioning Use In Urban Areas. *Sustainability*, 5, 3116-3128

Madlener R, and Sunak Y. (2011). Impact of Urbanization on Urban Structure and Energy Demand: What Can We Learn for Urban Planning and Urbanization Management?. *Sustainable Cities and Society*, 1, 45-53

Pantavou, K., Theoharatos, G., Mavrakis, A., and Santamouris, M. (2011*)*. *Evaluating Thermal Comfort Conditions and Health Responses during an Extremely Hot Summer In Athens.* Building and Environment 46 (2), 339–344.

Prilandita, N. (2009). *Perceptions and Responses To Warming In An Urban Environment: A Case Study of Bandung City, Indonesia*. Asian Institute of Technology.

Memon, A, R., Leung, Y, C, D., and Chunho, L. (2007). A review on The Generation, Determination and Mitigation of Urban Heat Island. *Environmental Science,* 20, 120-128

Nitivattananon, V. (2014). Urban Environmental Management Systems. Environmental Management Measures (EMMs) course work. Asian Institute of Technology. Thailand

Rosenberg, M. (2014). *The CBD or Central Business District is the Core of the City*. Available at : http://geography.about.com/od/urbaneconomicgeography/a/cbd.htm

Sakka, A., Santamouris, M., Livada, I., Nicols, F. and Wilson, M. (2012). On The Thermal Performance of Low Income Housing during Heat Waves. *Energy and Buildings* 49, 69–77.

Salladien. (2003). *Population Development Strategy and Policy in Globalization Era*. University Malang. Malang-Indonesia

Santamouris, M. (2013). Using Cool Pavements as A Mitigation Strategy To Fight Urban Heat Island-A Review of The Actual Developments. *Renewable and Sustainable Energy Reviews* 26, 224-240

Santamouris, M. (2007). *Heat Island Research in Europe-The State of The Art.* James and James Science Publisher. London

Santamouris M. (2001). Energy and Climate Change in The Urban Built Environment. *Building Energy Research,* 1, 123-150

Sarrat, C., Lemonsu, A., Masson, V., and Guedalia, D., (2006). Impact of Urban Heat Island on Regional Atmospheric Pollution. *Atmospheric Environment* 40, 1743–1758.

Susetyo, C. (2008). *Urban Flood Management In Surabaya City: Anticipating Changes In The Brantas River System.* International Institute for Geo-Information Science and Earth Observation. Enschede-The Netherlands

Surabaya Municipality. (2010). *Existing Condition of Energy Use*. Surabaya: Environmental Protection Agency

Surabaya CSA. (2013). *Surabaya in Figures 1998-2013.* Surabaya: Central Statistical Agency of Surabaya City

Surabaya PDA. (2005). *Surabaya City Master Plan 2015*. Surabaya: Planning and Development Agency of Surabaya City

Surabaya PDA. (2009). *Document Review of Regional Planning 2005-2025*. Surabaya: Planning and Development Agency of Surabaya City

Surabaya PDA. (2005). *Surabaya Regional Planning 2005-2025*. Surabaya: Planning and Development Agency of Surabaya City

Surabaya PDA. (2005). *City Regulation No 3/2007 in terms of Regional Planning of Surabaya* . Surabaya: Planning and Development Agency of Surabaya City

Surabaya Municipality. (2005). *Air Pollution Emission 2005-2013*. Surabaya: Environmental Protection Agency

Surabaya Municipality. (2000). *Area of Green Space Data Record 2000-2013.* Surabaya: Cleanliness and Landscape Agency

Surabaya Municipality. (2005). *Daily Average Traffic Data 2005-2012*. Surabaya: Transportation Agency

Thompson, R. (2011). *Stakeholders Analysis*. Available at: < http://www.mindtools.com/pages/article/newPPM_07.htm>

Tobias, D Randal. (2012). *An Introduction to Partial Least Squares Regression*. SAS Institute Inc., Cary, NC

Trappey, A., Trappey C., Hsiao, C,T., Ou, J., Li, S, J and Chen, K. (2012). An Evaluation Model for Low Carbon Island Policy: The Case of Taiwan`s Green Transportation Policy. *Energy Policy*, 45, 510-515

Tutiempo Network, S.L . *World Weather*. Madrid. Spain. Available at : http://www.tutiempo.net/en/

Ukhisia, B, Astuti, R, Hidayat, A. (2013). *Analysis of the Occupational Health and Safety Effects on Productivity of Employees using Partial Least Square Methods*. Brawijaya University. Malang: Indonesia

Union of Concerned Scientist. (2011). *Climate Hot Map* Available at: < http://www.climatehotmap.org/about/global-warming-causes.html>

United States Environmental Protection Agency (2012). *Heat Island Impacts*. Available at : < http://www.epa.gov/heatislands/impacts/index.htm>

UNEP. (2011). *Environmental Impact Assessment Manual*. Available at : < www.unep.ch/etu/publications/EIA_ovrhds/top07.pdf>

Umar, H. (2002). Methodology of Business Research. PT. Gramedia Pustaka Utama. Jakarta: Indonesia

Velazquez-Lozada, A., Gonzales, J.E. and Winter, A. (2006). Urban Heat Island Effect for San Juan,Puerto Rico. *Atmospheric Environment*, 40, 1731-1741

Wong, NH, Jusuf, S.K, Syafii,N.I (2011). Evaluation of The Impact of The surrounding Urban Morphology on Building Energy Consumption. *Solar Energy,* 85, 57-71

Williams, S., Nitscke, M., Weinstein, P (2012). The Impact of Summer Temperature and Heatwaves on Mortality and Morbidity in Perth, Australia 1994-2008. *Environment International*, 40, 33-38

Wiyono, G. (2011). *Design of Business Research with SPSS 17.0 and Smart-PLS 2.0*. UPP STIM YKPN. Yogyakarta: Indonesia. 111-124, 395-402

Yamamoto, Y. (2006). *Measures to Mitigate Urban Heat Island.* In Science and Technology Trends No 18, January 2006

"This page is additionally blank"

BIOGRAPHY

Author, Ayu Candra Kurniati was born in Pasuruan on January 18, 1988. Author were finished her bachelor degree in Urban and Regional Planning, Brawijaya University Malang on 2010. Furthermore, author has continued her master degree in Urban Development Management, Institute of Technology Sepuluh Nopember Surabaya on 2012. In the end of 2013, author had received double degree scholarship to Asian Institute of Technology Thailand in Urban Environmental Management field of study and graduated on December 2014. The donor funding is from Dikti and AIT fellowship. Author can be contacted in ayucandrakurniati@gmail.com.

APPENDIX 1: ANALYSIS OF METEOROLOGY STATION`S COVERAGE AREA

APPENDIX 1.1 COVERAGE AREA OF EACH STATION

Stations	Coverage Area (m^2)	Coverage area to Total area of Surabaya[1] (m^2)
Perak 1 station	36,610,292.7	0.11
Perak 2 station	179,943,300.5	0.54
Juanda station	116,385,187.3	0.35
Total area of Surabaya	332,938,780.4	1.00

[1] Total area of Surabaya is 332,938,780.44 m^2

APPENDIX 2: DATA OF NATURE FACTORS FOR EACH STATION

APPENDIX 2.1 AVERAGE TEMPERATURE OF SURABAYA CITY

Year	Perak 1 (°C)	Average temperature to area of Surabaya (0.11)	Perak 2 (°C)	Average temperature to area of Surabaya (0.54)	Juanda (°C)	Average temperature to area of Surabaya (0.35)	Temperature (°C)
1993	28.4	3.12	29.55	15.96	27.93	9.78	28.86
1994	28	3.08	29.38	15.87	27.45	9.61	28.55
1995	28.1	3.09	29.53	15.95	27.64	9.67	28.71
1996	28.5	3.13	29.18	15.76	28	9.80	28.69
1997	28.3	3.11	29.36	15.85	27.87	9.75	28.72
1998	28.88	3.17	29.71	16.04	28.38	9.93	29.15
1999	28.32	3.11	29.35	15.85	27.8	9.73	28.69
2000	28.38	3.12	29.67	16.02	28.1	9.84	28.98
2001	28.47	3.13	29.93	16.16	28	9.80	29.09
2002	28.69	3.15	29.63	16.00	28.24	9.88	29.04
2003	28.7	3.15	29.64	16.01	28.28	9.90	29.06
2004	28.9	3.17	29.81	16.10	28.17	9.86	29.14
2005	29.08	3.19	29.64	16.01	28.03	9.81	29.01
2006	28.93	3.18	29.37	15.86	27.78	9.72	28.77
2007	28.69	3.15	29.49	15.92	27.95	9.78	28.86
2008	28.49	3.13	29.12	15.72	27.59	9.66	28.52
2009	28.95	3.18	29.35	15.85	27.91	9.77	28.80
2010	28.56	3.14	28.93	15.62	27.78	9.72	28.49
2011	28.28	3.11	28.63	15.46	27.43	9.60	28.17
2012	28.49	3.13	28.81	15.56	27.8	9.73	28.42
2013	28.52	3.13	28.72	15.51	27.96	9.79	28.43

APPENDIX 2.2 MAXIMUM TEMPERATURE OF SURABAYA CITY

Year	Perak 1 (°C)	Max temperature to area of Surabaya (0.11)	Perak 2 (°C)	Max temperature to area of Surabaya (0.54)	Juanda (°C)	Max temperature to area of Surabaya (0.35)	Temperature (°C)
1993	32.4	3.56	32.56	17.58	32.43	11.35	32.50
1994	32.2	3.54	32.49	17.54	32.4	11.34	32.43
1995	32.2	3.54	32.59	17.60	31.94	11.18	32.32
1996	32.7	3.60	32.65	17.63	32.86	11.50	32.73
1997	32.6	3.59	32.61	17.61	32.33	11.32	32.51
1998	33.05	3.64	33.13	17.89	32.5	11.38	32.90
1999	32.63	3.59	32.41	17.50	32.01	11.20	32.29
2000	32.57	3.58	32.1	17.33	31.82	11.14	32.05
2001	32.93	3.62	32.68	17.65	31.93	11.18	32.45
2002	33.42	3.68	33.33	18.00	32.38	11.33	33.01
2003	33.26	3.66	33.66	18.18	32.39	11.34	33.17
2004	33.43	3.68	33.53	18.11	32.39	11.34	33.12
2005	33.53	3.69	33.49	18.08	32.36	11.33	33.10
2006	33.18	3.65	33.26	17.96	32.28	11.30	32.91
2007	33.41	3.68	33.46	18.07	32.45	11.36	33.10
2008	33.27	3.66	33.38	18.03	32.18	11.26	32.95
2009	33.8	3.72	34.05	18.39	32.34	11.32	33.42
2010	33.32	3.67	33.63	18.16	32.28	11.30	33.12
2011	33.16	3.65	33.4	18.04	31.78	11.12	32.81
2012	33.52	3.69	33.78	18.24	32.1	11.24	33.16
2013	33.03	3.63	33.14	17.90	31.79	11.13	32.66

APPENDIX 2.3 MINIMUM TEMPERATURE OF SURABAYA CITY

Year	Perak 1 (°C)	Max temperature to area of Surabaya (0.11)	Perak 2 (°C)	Max temperature to area of Surabaya (0.54)	Juanda (°C)	Max temperature to area of Surabaya (0.35)	Temperature (°C)
1993	24.5	2.70	25.08	13.54	23.32	8.16	24.40
1994	23.9	2.63	24.84	13.41	22.56	7.90	23.94
1995	24.4	2.68	24.17	13.05	23.32	8.16	23.90
1996	24.5	2.70	24.82	13.40	23.33	8.17	24.26
1997	24.3	2.67	24.97	13.48	22.95	8.03	24.19
1998	25.2	2.77	25.83	13.95	24.38	8.53	25.25
1999	24.26	2.67	24.88	13.44	23.43	8.20	24.30
2000	24.53	2.70	25.12	13.56	23.78	8.32	24.59
2001	24.68	2.71	24.57	13.27	23.8	8.33	24.31
2002	24.55	2.70	24.5	13.23	23.62	8.27	24.20
2003	24.52	2.70	24.1	13.01	23.61	8.26	23.97
2004	24.85	2.73	24.46	13.21	23.68	8.29	24.23
2005	24.9	2.74	25.42	13.73	23.98	8.39	24.86
2006	24.57	2.70	25.28	13.65	23.45	8.21	24.56
2007	24.39	2.68	25.55	13.80	23.95	8.38	24.86
2008	24.17	2.66	25.19	13.60	23.72	8.30	24.56
2009	24.71	2.72	25.48	13.76	23.87	8.35	24.83
2010	24.4	2.68	25.68	13.87	24.47	8.56	25.12
2011	24.59	2.70	25.12	13.56	23.84	8.34	24.61
2012	24.57	2.70	25.09	13.55	23.99	8.40	24.65
2013	24.75	2.72	25.27	13.65	24.47	8.56	24.93

APPENDIX 2.4 CDD OF SURABAYA CITY

Year	Perak 1 (CDD)	Max temperature to area of Surabaya (0.11)	Perak 2 (CDD)	Max temperature to area of Surabaya (0.54)	Juanda (CDD)	Max temperature to area of Surabaya (0.35)	Temperature (CDD)
1993	310	34.1	319	172.26	292	102.2	308.56
1994	298	32.78	316	170.64	279	97.65	301.07
1995	303	33.33	307	165.78	291	101.85	300.96
1996	288	31.68	318	171.72	303	106.05	309.45
1997	309	33.99	319	172.26	284	99.4	305.65
1998	326	35.86	340	183.6	308	107.8	327.26
1999	310	34.1	315	170.1	286	100.1	304.30
2000	312	34.32	317	171.18	290	101.5	307.00
2001	318	34.98	317	171.18	291	101.85	308.01
2002	326	35.86	321	173.34	295	103.25	312.45
2003	325	35.75	322	173.88	294	102.9	312.53
2004	330	36.3	327	176.58	296	103.6	316.48
2005	331	36.41	336	181.44	301	105.35	323.20
2006	320	35.2	327	176.58	291	101.85	313.63
2007	322	35.42	342	184.68	301	105.35	325.45
2008	317	34.87	336	181.44	294	102.9	319.21
2009	333	36.63	349	188.46	299	104.65	329.74
2010	321	35.31	346	186.84	306	107.1	329.25
2011	322	35.42	333	179.82	289	101.15	316.39
2012	323	35.53	339	183.06	297	103.95	322.54
2013	322	35.42	332	179.28	299	104.65	319.35
Total							6,612.48
Average							330.62

APPENDIX 3 QUESTIONER FOR TRIANGULATION ANALYSIS

The aim for this research is to determining the significant factors that influence UHI effects in Surabaya and enhancing the current strategies to address the UHI effects.

Dearest Mr/Mrs that I respect,

My name is Ayu Candra K, iam a student in ITS Surabaya- Management of Urban Development. Iam doing research with the tittle "Factors Influencing Urban Heat Island: Case Study of Surabaya City, Indonesia". The main objective for this research is to determine the most significant factors that influencing UHI in Surabaya and how to address it by enhancing the existing strategies.

Based on quantitative analysis that has been done, the most significant factors are provision of green space, electricity energy consumption and use of asphalt. To obtain the objective of this research, the opinion from municipality, expert and academicians are needed. The opinion is the response to address UHI that related to those three significant factors. Furthermore, it can be an existing strategies that implementing in Surabaya or based on own information/knowledge.

Thank you for the kind help.

With all respect,
Ayu Candra

Factors	**Opinions**
Provision of green space	
Electricity energy consumption (use of air conditioning)	
Use of asphalt	

APPENDIX 4 PLS REGRESSION RESULTS

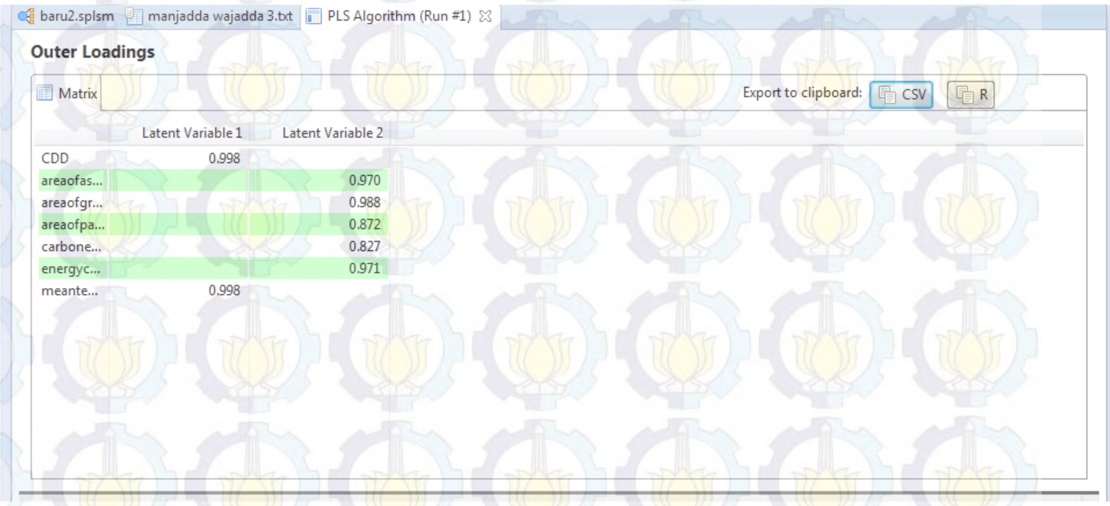
APPENDIX 4.1 R^2 RESULTS

	R square
Latent Variable	0.407

APPENDIX 4.2 PATH COEFFICIENT

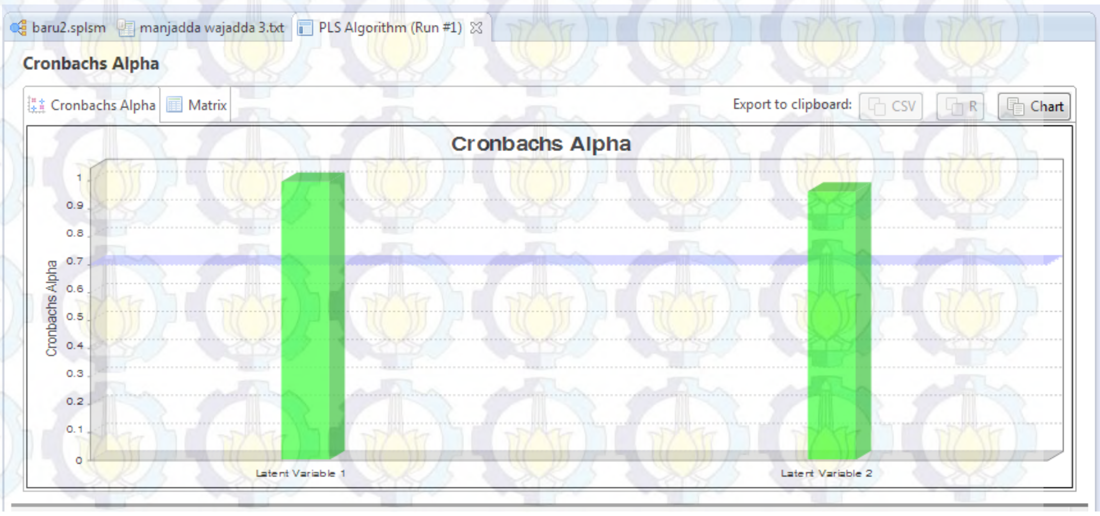
	Path Coefficient
Latent Variable	0.638

APPENDIX 4.3 OUTER LOADINGS NUMBERS

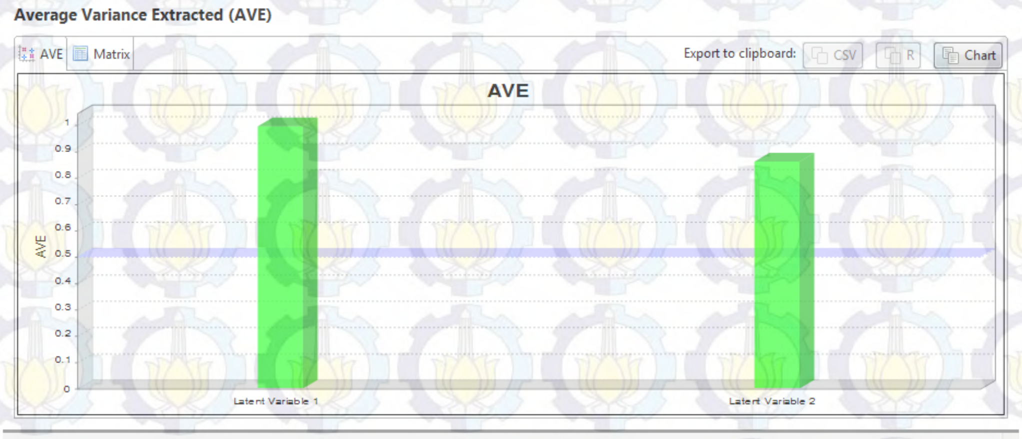


	Latent Variable 1	Latent Variable 2
CDD	0.998	
areaofas...		0.970
areaofgr...		0.988
areaofpa...		0.872
carbone...		0.827
energyc...		0.971
meante...	0.998	

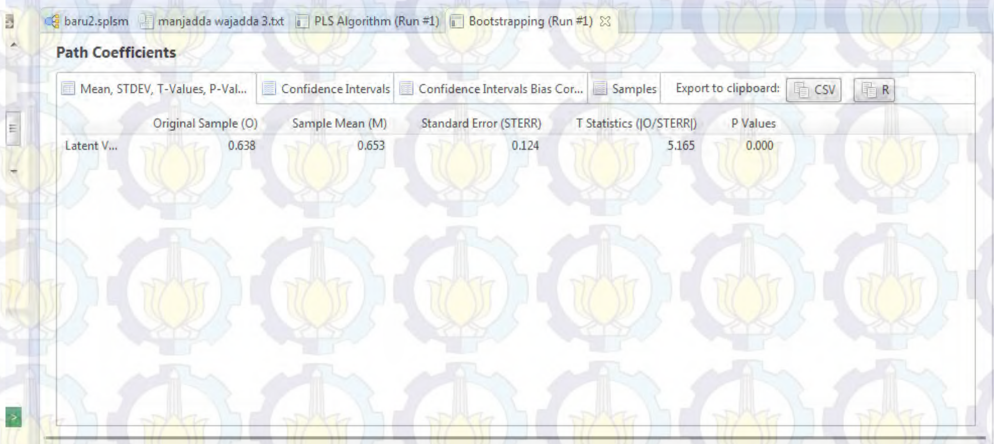
APPENDIX 4.4 CRONBACH ALPHA



APPENDIX 4.5 AVE NUMBERS



APPENDIX 4.6 BOOTSTRAPPING



	Original Sample (O)	Sample Mean (M)	Standard Error (STERR)	T Statistics (|O/STERR|)	P Values
Latent V...	0.638	0.653	0.124	5.165	0.000

APPENDIX 5 DETAILED ANALYSIS RESULTS

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
Provision of green space	A. The National Act No 26/2007 on Spatial Planning. Policy stated that every city/regency should provide 30% of the city`s area for green and open space. In addition, it divided 20% for public and 10% for private green and open space. B. Protect the tree regulation. The regulation stated that the tree replacement will be implemented for tree deforestation with at least 10 trees with the same	A. Potchter, Cohen and Bitan (2006) found that high and wide canopy trees and higher tree/shrub coverage resulted in cooler parks compared to the surroundings. B. To increase the effectiveness and efficiency of green space provision for addressing UHI, there are several things to considerate (Doick and Hutchings, 2013): ▪ **The right tree** in the right place: The extent to which vegetation cools the urban climate depends on species selection and strategic placement. This section presents considerations pertinent to selecting species for the greatest impact and locating trees to maximize summer cooling without compromising on	(Dr.Ir. Eko B S, Lic Rer Reg) : A. Surabaya is implementing the National Act No 26/2007 to provide 30% green and open space of the Surabaya area. B. To increase the effectiveness of green space for addressing UHI, it should considerate to choose the right tree and the right place. For the example, choose the tree with wide canopy to absorb heat and placed in the downtown, industry or high density settlement. (Dr. Ing. Ir. Haryo S): A. Nowadays, the	Various authors propose urban greening as a strategy to mitigate the consequences of higher temperatures due to the heat island effect. Urban greening moderates temperatures and favors processes such as evapotranspiration and the shading of surfaces. Surabaya as a big city with high of development is requires green space to control the carbon emission, flood risk and temperature rise. Nowadays, Surabaya is implementing the National Act No 26/2007 that embracing to green	Provision of green space should considering the suitable tree, tree location, and tree density. Suitable tree is needed due to function and morphology of the tree that suitable to decrease high temperature. In addition, tree location is needed to plant the tree that suitable with the location. For example, industry and high density housing area need a lot of tree with high density compare with low density community. Furthermore, tree density is related with tree canopy tend to cast more shade and deliver greater rainwater management and biodiversity benefits

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
	characteristics and will planted near the deforestation area. C. One million trees program. This program requires every city/region to provide or plant at least one million trees for each year. D. Provision and development of green area in Surabaya is having different function, esthetic, ecological and economic aspect. Example: park for sport, park for elderly, park for art and	solar winter warming. Trees can be very long-lived, so species selection should always consider the projected future climate as well as current climatic conditions ▪ **Tree selection**: Not all tree species have the same cooling effect; the lower the foliage temperature the greater the cooling, and canopy size, structure and density also influence the extent of shading. Leaf temperature depends on anatomical (leaf mass, size, shape, angle, reflectance), physical (incoming energy, air temperature, wind) and physiological (transpiration, stomata conductance) factors. Trees with larger canopies tend to cast more shade and deliver greater rainwater management and biodiversity benefits than smaller ornamental species. Health and vitality,	provision of green space in Surabaya is exceeding the national act. In addition, for the public area it reached 22.2% (2014) and for private green space it reached 12%. Therefore, this condition is accordance with the vision of Surabaya, to make Surabaya as a green city. B. The concept to make green space more functional is embracing the kind of tree. Furthermore, if the ground surface is wider it will decrease the air temperature. C. The ground temperature is influence by wind speed, high of tree,	space provision. In addition, there are lot number of park and there are several type of green space in Surabaya, such as green space in grave, field, green space in water body, green space in public infrastructure, green space in protected area, city forest and greenery path along the main road. Furthermore, park with various functions such as park for elderly, park for sport, park of art and entertainment, and etcetera is good in concept, esthetic and function as long as considering to the number of tree, kind of pavement and the comparison between	than smaller ornamental species. Meanwhile, to enhance the implementation of protect the tree regulation and one million trees program is strictness and involves of all city`s stakeholders with complete understanding the importance of green space to the city. Moreover, good publication with provide city website and other media that easy accessible is needed.

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
	performance and etcetera. (Appendix 5)	however, are critical to ongoing delivery of cooling benefit ▪ **Tree location**: Trees placed close enough to directly shade buildings (termed shade-effect trees) can lower summertime energy demand to cool the building's indoor climate. Size is important: smaller trees casting less summertime shade cool less. However, effects are also tempered by building size, vegetation type, spacing and position relative to the building. The positioning of shade trees is particularly important in cool and cold climates, as shade cast by branches can reduce solar radiation penetration to such an extent that increases in winter heating demand outweigh any savings from reduced summertime cooling	vegetation density, building density, the land area and buildings around park (Luluk Indrawati, S.com): A. The provision of green space in Surabaya has increasing although it only in esthetic aspect and unevenly spread. B. Increasing the green space provision should considering the land ownership. In addition, it will make easier to implement the provision of green space (Ayu Utami S.T M. arch): A. The provision of green space in	soil and hard pavement. Moreover, it will be useless if the composition of hard pavement is larger than soil pavement.	

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
		C. The cooling effect seemed to depend on the size of the park and the seasonal radiation conditions, but there was no linear relation between the size of the park and the intensity of the cool island. This intensity was mainly determined by the area occupied by the trees and shrubbery in the park as well as by the shape of the park (Gago *et al*, 2013)	Surabaya has accordance to the National Act No 26/2007 to provide 20% green space of total area of Surabaya (municipality of Surabaya, 2014). B. To control the provision of green space, the existing strategies that Surabaya`s implement is publish SKS (Certificate to build) that requires 10% of total private building to provide green space.		
Electricity energy consumption	Green building certificate, namely Greenship is home self-assignment to assign people`s own building which is including: appropriates site	A. To decrease the use of cooling buildings, one of the suitable ways is increase the albedo of the building and vegetation cover buildings (Gago *at al*, 2013). In addition, light colored surfaces reflect solar radiation and reduce	(Dr.Ir. Eko B S, Lic Rer Reg) : High consumption of electricity energy that comes from utilization of air conditioning is makes increasing the temperature of the city. In addition, to solve	Surabaya just implementing green building standard in early 2014 with refers to Jakarta city regulation No 38/2012 embracing to Green Building. In addition, green	Considering that green building is a new program and up to now there is no city regulation that control the use of green building, municipality should enhancing it with considering Surabaya

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
	development, energy efficiency and conservation, water conservation, material resources and cycle, indoor health and comfort, and building environmental management (Green Building Council Indonesia, 2013) A. Appropriate site development: ▪ Using 50% of green roof from total area of roof, which is not using for mechanical electrical. ▪ Use of materials which have the average value of albedo is 0.3 (minimum). B. Energy	heat absorbed by buildings. Modification of the value of 'albedo' (the measure of a surface's reflectivity) of a building's envelope and in particular walls and roof, can potentially reduce the ambient temperature in an individual building and its surroundings and keep the entire neighborhood cool. B. Santamouris (2005) states that in all cases the temperatures of reflective roof surfaces are significantly reduced, but the degree to which the cooling load decreases depends on the structure of the roof and on the overall thermal balance of the building. Using high albedo materials reduces the amount of solar radiation absorbed through building envelopes and urban structures and keeps their surface cooler, for example,	that condition, enhance the ventilation system can be used. With better ventilation it wills cooler the building. (Dr. Ing. Ir. Haryo S): To reduce the use of air conditioning, the suitable way is use green building. Furthermore, green building not only concentrates about the building but also to the surrounding environment. Start from the site to the environment. (Luluk Indrawati, S.com): A. Unsuitable construction and design for tropic buildings can influence the use of air conditioning.	building is a building which has responsible to environment and efficiency resources started from planning, construction, utilization and maintenance until deconstruction process (City regulation, 2012). Even though this is new program and still need improvement but this is a good start to increase people participation and awareness to implement green building. Furthermore, as a start the municipality of Surabaya has used green roof and green building to	own characteristic, such as the characteristic of the people, building materials, environment and etcetera. In addition, green building has to elaborate all aspect, start from roof, building, design, use of energy, materials even the environment surrounding it. Waste and garbage disposal also being considerate. Benchmarking to another strategy is needed due to overlapping and discrepancy with other city regulations. Moreover strict and honest assessment to evaluate and implement the building is needed. Furthermore, public knowledgeable should be increase related to green building. Furthermore, to clarify

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
	efficiency and conservation: Mechanical ventilation air conditioning (MVAC), is implementing equipment efficiency that using air conditioning for water cooled with minimum efficiency is 0.881 kW/TR, air cooled (1.270 kW/TR) and unitary (1.034 kW/TR)	white elastomeric coatings (with an albedo of 0.72) were 45°C cooler than black coating (with an of albedo 0.08) in the early afternoon of a clear day in summer compare with using a white surface with an albedo of 0.61 was only 5°C warmer than ambient air whereas conventional gravel with an albedo of 0.09 was 30°C warmer than air. C. Using green roof and green wall to reduce the use of cooling the building. Green roofs can be loose laid (built up), in which each of the layers is installed and the plant seeds are sown in the engineered growing media. There are also modular systems that combine several of the layers, including the plants; these units are brought to the roof and laid out. There	B. Enhance the socialization or announcement related regulation to use green building C. Controlling the site of building, not only for building but also for private green space. (Ayu Utami S.T M. arch): To reduce the use of air conditioning, municipality of Surabaya has started to implemented green building award since early 2014. This award to increase people participation to involve in green building program.	implement this program (see Appendix 5).	the regulation further, the regulation should be more practical, like discuss related to green roof, considering that green roofs are an important component in an overall strategy to offset the negative impacts of UHIs and enhance the value of green building practices for occupants and surrounding citizens. It have the ability to improve air quality, reduce combined sewer overflows, provide usable spaces for building occupants, support biodiversity, reduce noise, and extend waterproofing longevity. When green roofs are combined with other measures, such as urban forests and reflective roofs and paving, in green building,

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
		are three types of green roofs: ▪ *Extensive roofs* have 6 inches or less of growing medium, low maintenance, low capital costs, and low loading capacity. The plants on these roofs are typically sedums. ▪ *Semi-intensive roofs* have 25 percent of the roof either above or below 6 inches of growing medium. ▪ *Intensive roofs* (also known as rooftop gardens) have more than 6 inches of growing media, greater cost and maintenance, and are usually irrigated. D. Using green building as an alternative way to reduce urban heat island.			environmental benefits associated with investing in UHI reduction. Moreover, in green roof the kind albedo should be maintained. Albedo is a unit less measure with possible values ranging from 0 to 1. Objects that reflect lots of light have a high albedo approaching 1, while a perfect black body would have an albedo of 0
Use of asphalt	There is no specific strategy or regulation to manage the type of asphalt, standard or procedure to use asphalt in Surabaya	A. Doulos et al (2004) studied 93 pavement materials, commonly used in outdoor urban spaces to achieve lower ambient temperatures and thus fight the heat island effect. They	(Dr.Ir. Eko B S, Lic Rer Reg) : A. During daytime asphalt is faster to absorb heat than vegetation (tree). Therefore, road with	There is no city regulation in term of asphalt. The national regulation only embracing the construction, quality of material and the	Enhance the strategies and address UHI with using cool pavement and elaborate with other strategies, such as provision of vegetation along the road and use

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
	that address UHI.	observed variations in the mean daily temperature mainly caused by the differences in the albedo factor of each material. It was found that rough and dark colored surfaces (made of "hot materials") tended to absorb more solar radiation than the smooth, light-colored and flat surfaces (made of "cold materials"). B. Using cool pavement instead of using asphalt for the pavement Doulos et al (2004). Such as: ▪ Colored asphalt or concrete involve pigments or seals that are colored and may be more reflective than the conventional equivalent. These can be applied when new or during maintenance. ▪ Resin based pavements use clear colored tree resins in place of cement to bind the aggregate, thus albedo is mainly determined by	asphalt pavement has high temperature, mainly in the road without vegetation. B. The suitable solution is planting tree near the road to decrease the temperature and change asphalt to more ecological material. (Dr. Ing. Ir. Haryo S): A. The effect from asphalt is increase temperature of the city B. To reduce the temperature that come from asphalt, tree and grass block can be used. C. It is important to maintenance and supervises the use of asphalt. (Luluk Indrawati,	kind of materials but didn't mention the advantages of each material to reduce city temperature. There are no specific strategies to reduce high temperature in the Surabaya city.	green building to reduce other sources that influence UHI intensity in Surabaya. The construction of asphalt is needed to be considerate, due to quality and it also can reduce heat. The night construction is cooler that in the day time. Day time construction can increase the air temperature. Furthermore, using light albedo for asphalt can decrease the solar absorption. Moreover, using cool pavement can also decrease the city`s air temperature.

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
		aggregate color ▪ Porous asphalt more voids than conventional asphalt to allow water to drain through the surface into the base. ▪ Whitetopping is thick layer (thickness greater than 4 inches or 10 cm) of concrete applied over existing asphalt when resurfacing or can be applied to new asphalt. It often contains fibers for added strength. In addition, Lowers pavement surface and subsurface temperature because more of the sun's energy is reflected away ▪ Microsurfacing with high-albedo materials. Furthermore, Light-colored materials can be used to increase the solar reflectance of asphalt C. Santamouris (2013) mentions technological trends of reflective	S.com): To reduce high increase of temperature, asphalt can be change to paving or concrete which has higher albedo that asphalt. (Ayu Utami S.T M. arch): To reduce high temperature in using asphalt, the construction of asphalt should be constructed in the night time rather than day time due to the process of construction that will increase the air temperature.		

Variable	Current strategies	Literature Review	Stakeholders opinion	Analysis	Recommendation to enhance strategies for addressing UHI
		pavement to reduce UHI: ▪ Use of white high reflective paints on the surface of the pavement ▪ Use of infrared reflective colored paints on the surface of the pavement ▪ Use of heat reflective paint to cover aggregates of the asphalt ▪ Use of color changing paints on the surface of the pavement ▪ Use of fly ash and slag to constituents of the concrete.			

APPENDIX 6 PICTURES

Wall garden in Department of Public Works and Planning and Development Agency

Greenery in median road

APPENDIX 7 T-TABLE

(1 tail)	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
(2 tail)	0.1	0.05	0.02	0.01	0.005	0.002	0.001
df							
1	6.3138	12.7065	31.8193	63.6551	127.3447	318.493	636.405
2	2.92	4.3026	6.9646	9.9247	14.0887	22.3276	31.5989
3	2.3534	3.1824	4.5407	5.8408	7.4534	10.2145	12.9242
4	2.1319	2.7764	3.747	4.6041	5.5967	7.1732	8.6103
5	2.015	2.5706	3.365	4.0322	4.7734	5.8934	6.8688
6	1.9432	2.4469	3.1426	3.7074	4.3168	5.2076	5.9589
7	1.8946	2.3646	2.998	3.4995	4.0294	4.7852	5.4079
8	1.8595	2.306	2.8965	3.3554	3.8325	4.5008	5.0414
9	1.8331	2.2621	2.8214	3.2498	3.8325	4.2969	4.7809
10	1.8124	2.2282	2.7638	3.1693	3.6896	4.2969	4.5869
11	1.7959	2.201	2.7181	3.0158	3.4966	4.0247	4.4369
12	1.7823	2.1788	2.681	3.0545	3.4284	3.9296	4.3178
13	1.7709	2.1604	2.6503	3.0123	3.3725	3.852	4.2208
14	1.7613	2.1448	2.6245	2.9768	3.3257	3.7874	4.1404
15	1.753	2.1314	2.6025	2.9467	3.286	3.7328	4.0728
16	1.7459	2.1199	2.5835	2.9208	3.252	3.6861	4.015
17	1.7396	2.1098	2.5669	2.8983	3.2224	3.6458	3.9651
18	1.7341	2.1009	2.5524	2.8784	3.1966	3.6105	3.9216
19	1.7291	2.093	2.5395	2.8609	3.1737	3.5794	3.8834
20	1.7247	2.086	2.528	2.854	3.1534	3.5518	3.8495