THE DENSITY OF THE URBAN GREEN SPACE EFFECT ON THERMAL COMFORT

Sidharta Adyatma[1], Muhammad Muhaimin[2], Deasy Arisanty[3], ISMI Rajiani[4]*

[1]Dr., Universitas Lambung Mangkurat Banjarmasin, INDONESIA, sidharta.adyatma@ulm.ac.id
[2]M.Sc., Universitas Lambung Mangkurat Banjarmasin, INDONESIA, muhammad.muhaimin@ulm.ac.id
[4]Dr., Universitas Lambung Mangkurat Banjarmasin, INDONESIA,deasyarisanty@ulm.ac.id
[3]Dr., Universitas Muhammadiyah Gresik, INDONESIA,ismi.rajiani@umg.ac.id
*Corresponding Author

Abstract

Global warming due to increased activity of the city center from time to time raises the risk of a rise in temperature, but the urban green space can provide a micro-climate control and thermal comfort. This study analyzes the spatial distribution of thermal comfort, based on the method Temperature Humidity Index (THI) and using satellite imagery 2B recording Sentinel February 20, 2019, to Obtain information about the density of the vegetation. The thermal comfort of urban green space has a tendency quite comfortable, being uncomfortable thermal conditions associated with open land and undeveloped land. The density of vegetation on urban green space has big influence on the Decrease in THI. Relationships density urban green space with THI assessed using linear regression with a sample of 117 on one of the major cities in Indonesia.

Keywords: Urban, Green Space, Thermal Comfort

1 INTRODUCTION

Global warming is a phenomenon of global temperature increase from year to year, due to a greenhouse effect caused by increasing emissions of gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons(CFC), so the solar energy trapped in the earth's atmosphere. Changes in global average temperature over the period 2016 to 2035 is predicted to have a range of 0.3 to 0,7ºC (Stocker, Allen, Bex, & Midgley, 2013). Global warming causing widespread impact and serious environmental biogeophysical (such as melting polar ice caps, rising sea levels, expanding deserts, increased rainfall and flooding, climate change, extinction of flora and fauna, migration of fauna and pest), while the impact on socio-economic activities of society includes the disruption of the function of coastal areas and cities near the coast, interfere with the function of infrastructure and facilities, such as roads, ports and airports, disruptions to the settlements, the reduction of agricultural productivity, an increased risk of cancer and disease (Bharat & Onkar, 2015; Hoegh-Guldberg, Jacob, & Taylor, 2018; Masson-Delmotte, 2018; Ramlan, 2002; Shahzad & Riphah, 2015).

The main problem of global warming is the number of pollutants coming from industrial or domestic and potentially as a Greenhouse Gas (GHG), which react with ozone, causing the ozone layer is damaged. Carbon dioxide (CO_2) is a greenhouse gas that is the greatest contribution to global warming. The amount of deforestation and increasing use of motor vehicles fossil fuel, leading to increased levels of carbon in the Earth's atmosphere that forms a kind of shield reflects the heat to the surface of the earth, that the earth's temperature has increased. CFC usage continuously and excessively on Air Conditioner (AC), dry cleaning and electronics industry accounted for 15% of the greenhouse effect. CFC emissions into the atmosphere have increased with an increased rate of 5% per year, since the production of 100 tons in 1931 to 650 tonnes in 1985 (Ashworth, 2009; Benhadid-Dib & Benzaoui, 2012; Fischer, Fairchild, & Hughes, nd; Nurmaini, 2001; Solomon et al., nd; Ward, nd).

Cities are packed with high-rise buildings and crammed as well as reduced green space of urban, causing retaining solar radiation and absorbing carbon dioxide decreased, causing a risk of an increase in air temperature, as more and more elements reflecting the sun's heat and the heat of the result of human activities, including: smoke kitchen and motor vehicles that produce greenhouse gases, such as carbon dioxide, carbon monoxide and methane. Increased temperatures in the urban heat island shape compared with the temperature in the suburbs. Urban heating contributes to global warming (Adinna, Christian, & Okolie, 2009; Mohajerani, Bakaric, and Jeffrey-bailey, 2019; Nuruzzaman, 2015; Qing-Bin, 2013; Synnefa, Dandou, Santamouris, Tombrou, & Soulakellis, 2008).

Symptom improvement of urban air temperature in Indonesia is felt at any time during the day, as indicate climatological data Banjarmasin in February 2019 recorded a maximum of 35° C. Population densityBanjarmasin based on data from the Central Statistics Agency 2018 Banjarmasin city has a population of 692 793 inhabitants with a density of 7036.28 inhabitants per km², While the number of vehicles in the city of Banjarmasin increasing by 7,000 units annually, the condition of the air temperature, excluding vehicles coming from other districts and neighboring provinces.

Trouble getting the comfort of air in urban environments cause people to spend time in a limited space so that the urban environment tend to be hotter because of the number of vehicles and air-conditioned building and working machines (Laksitoadi, 2008). Air temperature and humidity to determine comfort (Arifin & Denan, 2015; Dec, Babiarz, and Secretions, 2018). Convenience is the term used to express the influence of environmental conditions expressed quantitatively based on the relationship between humidity and air temperature called the Temperature Humidity Index (THI) (Conservation, 2013). Maintaining the comfort of air in urban environments requires management to lower the air temperature in areas with high temperature (Rushayati, Alikodra, Dahlan, and Purnomo, 2011).

Vegetation can provide micro-climate control and thermal comfort. Tree planting environmental conditions cooler and more comfortable thermally. Tree cover reduces the duration of the thermal discomfort more than half and limits excess heat from solar radiation. Vegetation can reduce the urban heat island effect and improve air quality and increase the quality of life (Armson, in 2012; Irmak, Ozer, Yilmaz, & Toy, 2013;-bar Shashua, Pearlmutter, & Erell, in 2011).

2 METHODOLOGY

2.1. Study Area

The study was conducted in the city of Banjarmasin, which is the largest and most populous city in South Kalimantan province. Astronomically Banjarmasin city lies between 3°16'46" LS to 3°22'54" LS and 114°31'40" BT to 114° 39'55" BT. Banjarmasin city bordering the North Barito Kuala, east of Banjar Regency, Southside Banjar, and the West Barito Kuala. Conditions Banjarmasin wet tropical climate, with average rainfall between 2000 - 3000 mm per year are affected by the dry season and the rainy season. The research location is shown in Figure 1.

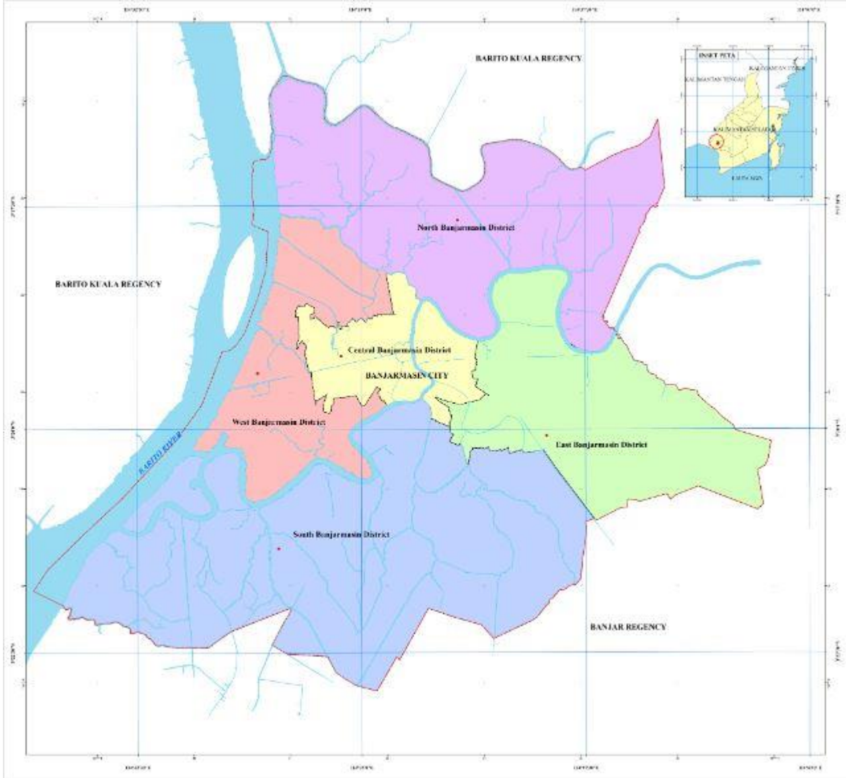


Figure 1: Research area

The research data consisted of: image recording 2B Sentinel February 20, 2019, to obtain information about the presumption of vegetation density; field measurement data consisted of temperature and humidity are measured on February 20, 2019, from 09:00 to 10:00 GMT 8+; and vector data Banjarmasin city administrative boundaries. Using research software: ArcGIS 10.3; QGIS 3.6; ENVI 5.3; and Microsoft Office 2013. The flow chart is shown in Figure 2 study.

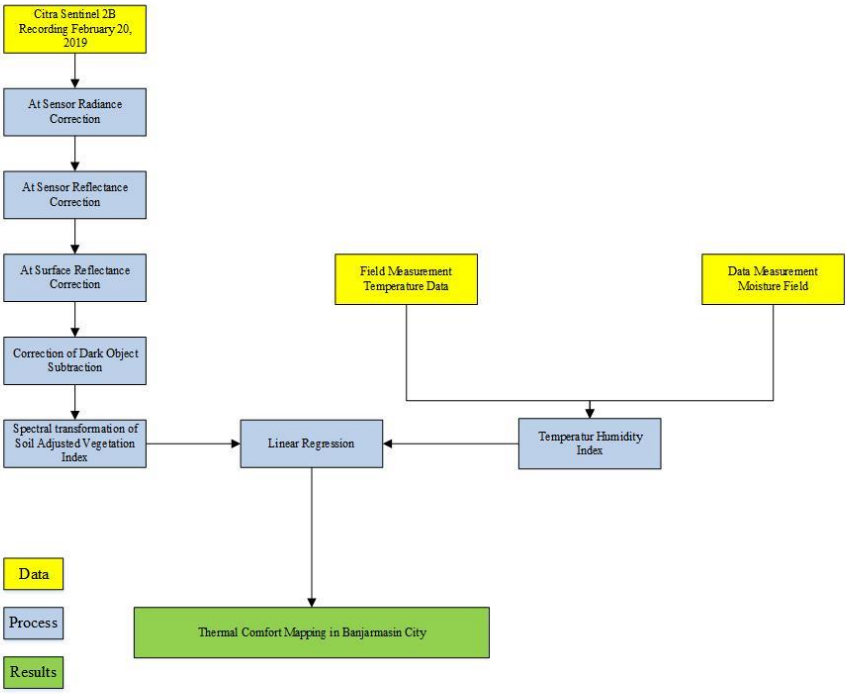


Figure 2: Research flow diagram

2.2. Samples

The research sample was measured in all urban green space in the city of Banjarmasin at 7 locations, using the method of Systematic Pattern unaligned so that each pixel image and the measured temperature and humidity measurements obtained by 117 samples (see Table 1)

Table 1: Research Samples.

No.	Urban Green Space	Large (m2)	Vegetation Cover (m^2)	Sentinel Resolution (m^2)	Vegetation Cover/ Image Resolution	sample
1	Sabilal Park	30,100	26 653	20	66.6325	67
2	Korem City Park	2,000	1,736		4:34	4
3	Cambodia Park	15 216	4,259		10.6475	11
4	PKK Park	4,460	3,848		9.62	10
5	Jahri Saleh Park	14,000	8672		21.68	22
6	PDAM Tower Park	1,430	701		1.7525	2
7	Basirih Park	360	290		0725	1
					Total	117

2.3. Spatial Data Process

Sentinel 2B imagery is used to extract information through the transformation of the spectral density of vegetation Soil Adjusted Vegetation Index (SAVI). Before the transformation of spectral vegetation, do some corrections: At-sensor correction Radiance; At-sensor correction Reflectance; At-surface correction Reflectance; Corrections Dark Object subtraction, which aims at reducing the effects of atmospheric disturbances that SAVI more accurate spectral transformation. The next step, the calculation Temperature Humidity Index data from field measurements of temperature and humidity. The process of a linear regression between vegetation density map of the presumption of spectral transformation results THI SAVI data to produce maps of thermal comfort. Processing and data analysis are described as follows:

2.3.1. Initial processing of Satellite Data

Geometric correction processing of the initial data image of Sentinel 2B is not performed on the image of Sentinel 2B, because the level has been corrected geometrically 1C. Radiometric correction is made to change the number of digital numbers into the reflectance values, aimed at correcting the pixel values correspond to atmospheric interference factors are considered as the main source of error, such as the location of the sun, the absorption of gases and aerosols are scattered in the atmosphere.

Radiometric Calibration and Atmospheric, Radiometric calibration carried out by converting the image of Sentinel 2B are still stored in digital format Number (DN) be a radian format Top of Atmosphere (TOA). Radiometric correction in digital image processing is used to improve the accuracy of the amount of the value of the brightness in the image. Correction At-sensor Reflectance, corrections At-surface Reflectance and correction Dark Object subtraction, aims to correct for atmospheric effects on image data measured by the sensor, which can affect the accuracy of satellite image data (Jilani, Matsushita, Yang, and Fukushima, 2013). Atmospheric correction using the correction parameter processing results through the software QGIS 3.6.

2.3.2. THI processing, SAVI, and Linear Regression

2.3.2.1. Processing temperature Humidity Index (THI)

Temperature and humidity data obtained at each sample location in the urban green space, analyzed using the formula *Temperature Humidity Index* (THI) (Formula 1), and analysis the relationship between the value of THI with the comfort of air empirically shown in Table 2.

$$\text{THI} = (0.8 \times \text{T}) + \ldots\ldots\ldots\ldots\ldots (1)\left(\frac{RH\ x\ T}{500}\right)$$

Information:

T = Air temperature (° C)

RH = Humidity (%)

Table 2: Empirical Relationship between THI Value and Comfort.

No.	THI value	criteria
1.	21-24	Comfort
2.	25-27	comfortable enough
3.	> 27	uncomfortable

Source: (Emmanuel, 2005)

2.3.2.2. Processing Soil Adjusted Vegetation Index (SAVI)

Transformation of the vegetation index using *the Soil Adjusted Vegetation Index* (SAVI) (Formula 2), The use of SAVI transformation based on the results of the study stating that the SAVI has a high correlation to the percentage canopy (Sulistyo et al, 2013).SAVI is a transformation that can provide information on the percentage of a canopy with soil brightness correction factor or reduce soil disturbance by changing the isolines of vegetation (which has the same density). SAVI index based on the ratio (ratio) and shift the lines of vegetation meets iso (Danoedoro, 2012; Huete, 1988).

$$\text{SAVI} = \text{x } (1 + \text{L})\left(\frac{\text{NIR-RED}}{\text{NIR+RED+L}}\right) \ldots\ldots\ldots\ldots (2)$$

Information:

NON = DOS Channel 8 Sentinel 2B

RED = DOS Channel 4 Sentinel 2B

L = L is a correction factor, from 0 for very high vegetation cover up to 1 for very low vegetation cover. L value that is often used is 0.5 to medium vegetation cover.

2.3.3. Processing Linear Regression

Effect of land cover urban green space to the air comfort were analyzed using linear regression analysis (Formula 3).

$$rxy = \frac{\sum xy}{\sqrt{(\sum x^2)\ (\sum y^2)}} \ldots\ldots\ldots\ldots\ldots (3)$$

Information:

rxy = Coefficient of correlation

x = Independent variable

y = The dependent variable (Hadi, 2000).

3.3.4. Interpretation of the value of r

Interpretation of the value of r using Spearman's correlation analysis to determine the relationship between variables that influence each other, divided into 5 categories (Table 3).

Table 3. Rule of Thumb for Interpreting Spearman's Correlation Value

No.	Size of Correlation	Interpretation
1	±.90 to ±1.0	Very high positive / negative correlation
2	±.70 to ±.90	High positive / negative correlation
3	±.50 to ±.70	Moderate positive / negative correlation
4	±.30 to ±.50	Low positive / negative correlation
5	.00 to ±.30	negligible correlation

Source: (Mukaka, 2012)

3 RESULTS

3.1. Field Measurements

3.1.1. Temperature Humidity Index (THI)

Earth's surface temperature is influenced by several factors, namely the amount of radiation received per year - per day - per season, the influence of the land or the oceans, the effects of altitude, the effects of wind indirectly, the effect of latent heat, ground cover, soil types and the influence of the angle of incidence sunlight. Conditioned comfort was analyzed using the formula *Temperature Humidity Index (THI)*, By calculating the data of temperature and humidity (Emmanuel, 2005). Measurement of the temperature and humidity at each sample point in Urban Green Space using a digital thermometer and hygrometer (Kestrel 4000) and result in an average for calculating the value of THI and interpretation of convenience (Table 4).

Table 4. Value THI

No.	Urban Green Space	Average temperatures (°C)	The average Relative Humidity (%)	THI	Convenience
1	Sabilal Park	28,9	61,8	26,7	quite Comfortable
2	Korem City Park	29,2	61,2	26,9	quite Comfortable
3	Kamboja Park	29,9	61,1	27,6	Uncomfortable
4	PKK Park	29,1	62,1	26,9	quite Comfortable
5	Jahri Saleh Park	29,3	60,6	27	quite Comfortable
6	PDAM Tower Park	29,5	61,4	27,2	Uncomfortable
7	Basirih Park	29,1	60,9	26,8	quite Comfortable
Rata-rata		29,3	61,2	27	

Source: Primary Data, 2019

3.1.2. Soil Adjusted Vegetation Index (SAVI)

SAVI transformation using the formula (2). SAVI transformation to obtain vegetation density mapUrban

Green Spacein Banjarmasin. The result of the transformation is the distribution value SAVI with SAVI values ranging from -1 to 1. Values obtained from image SAVI 2A Sentinel average of -0.737858 until 1:00 (Table 5).

Table 5. Value Calculation SAVI on Urban Green Space

No.	Urban Green Space	The average value Cover Canopy density SAVI
1	Sabilal Park	0.950454
2	Korem City Park	1
3	Cambodia Park	-0.01567
4	PKK Park	0.458811
5	Jahri Saleh Park	0.96879
6	PDAM Tower Park	0.667847
7	Basirih Park	0.888682

3.1.3. Thermal Comfort Analysis

Analysis of thermal comfort using linear regression analysis between the THI with SAVI, to get the value of the relationship between the density of vegetation on thermal comfort (Figure 3). Results of linear regression equation y = -0.667x + 27 483, with the coefficient of determination (R2) that is equal to -0.6746, or 67% of the value SAVI affect THI. Value -0.6746 based classification interpretation of the value of r is categorized as a moderate negative correlation.

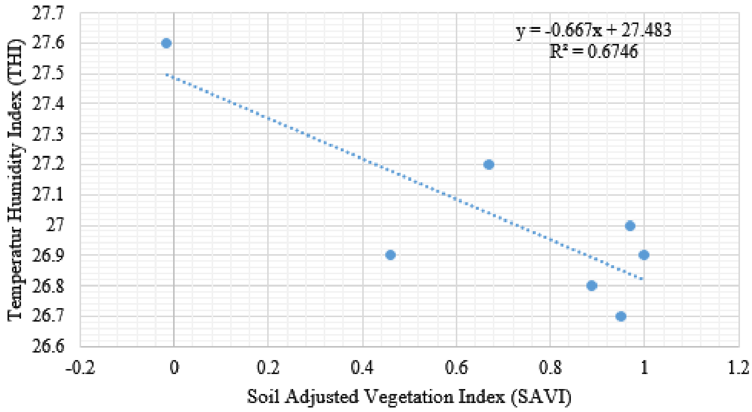


Figure 3. The regression equation between SAVI with THI

The results of the linear regression equation above are used as a reference equation for mapping thermal comfort throughout the city of Banjarmasin (Figure 4).

Thermal comfort throughout the city of Banjarmasin based on analysis of THI was regressed with SAVI, showed that a range of thermal comfort is in the range quite comfortable and uncomfortable. Thermal comfort with a range of comfortable yet, being quite comfortable thermal conditions in several locations associated with vegetation mainly located in urban green space, with an area of 2948.10 hectares site. A spacious location that has not comfortable thermal conditions in several areas associated with open land and undeveloped land, with an area of 6914.83 hectares site.

4. CONCLUSION

The existence of urban green space in the city of Banjarmasin can affect the microclimate. The thermal comfort of urban green space or areas covered by vegetation has a higher level of thermal comfort when compared to the open land and undeveloped land. Therefore, efforts to improve the thermal comfort in a wider area required the addition of urban green space and an increase in the density of vegetation cover, especially in the area of open land and undeveloped land which tends to release a lot of heat emission, the result of community activities.

REFERENCES LIST

Adinna, EN, Christian, EI, and Okolie, AT (2009). Assessment of the urban heat island and possible adaptations in Enugu urban using Landsat-ETM. Journal of Geography and Regional Planning, 2 (2), 30-36.

Arifin, NA, & Denan, Z. (2015). An analysis of the indoor air temperature and relative humidity in the office room with various external shading devices in Malaysia. Procedia - Social and Behavioral Sciences, 179, 290-296. http://doi.org/10.1016/j.sbspro.2015.02.432

Armson, D. (2012). The Effect of Trees and Grass on the Thermal and Hydrological Performance of an Urban Area. Manchester.

Ashworth, RA (2009). CFC Destruction of Ozone - Major Cause of Recent Global Warming, 1-16.

Benhadid-Dib, S., & Benzaoui, A. (2012). Refrigerants and their environmental impact Substitution of hydrochlorofluorocarbon HCFC and HFC hydrofluorocarbon. Search for an adequate refrigerant. Energy Procedia, 18, 807-816. http://doi.org/10.1016/j.egypro.2012.05.096

Bharat, RS, & Onkar, S. (2015). GLOBAL WARMING - Causes, Impacts, AND REMEDIES Chapter-2: Study of Impacts on Continue shrinkage of Arctic Sea & Sea Level Rise - Glaciers Can Be Growing and Creating New Challenges ... Continue Study of Impacts on shrinkage of Arctic Sea & Sea Level Rise, http://doi.org/10.5772/58506

Danoedoro, P. (2012). Introduction to Remote Sensing Digital. Yogyakarta: Andi Yogyakarta.

Dec, E., Babiarz, B., & discharge, R. (2018). Analysis of temperature, air humidity and wind conditions for the needs of outdoor thermal comfort, 44, 1-9.

Emmanuel, R. (2005). Thermal comfort implications of urbanization in a warm-humid city: The Colombo Metropolitan Region (CMR), Sri Lanka. Building and Environment, 40 (December 2005), 1591-1601. http://doi.org/10.1016/j.buildenv.2004.12.004

Fischer, SK, Fairchild, PD, & Hughes, PJ (nd). Energy and Global Warming Impacts of CFC Alternative Technologies for Building Foam Insulations.

Conservation, J. (2013). Study the development of green open space with a green city concept approach in Kandangan city, South Kalimantan Jamilah biodiversity.

Hoegh-Guldberg, O., Jacob, D., & Taylor, M. (2018). Impacts of 1.5 ° C of global warming on Natural and Human Systems. In IPCC (pp. 1-138).

Huete, AR (1988). A soil-adjusted vegetation index (SAVI). Remote Sensing of Environment, 25, 295-309. http://doi.org/10.1016/0034-4257(88)90106-X

Irmak, MA, Ozer, S., Yilmaz, H., & Toy, S. (2013). Evaluation of different thermal conditions based on THI under different kinds of tree types - As a specific case in Ata botanic garden in eastern Turkey. Global NEST, 15, 131-139.

Jilani, LM, Matsushita, B., Yang, W., & Fukushima, T. (2013). Evaluation of four MERIS atmospheric correction algorithms in Lake Kasumigaura, Japan, (October), 2-3. http://doi.org/10.13140/RG.2.1.3208.1760

Laksitoadi, B. (2008). Sports hall of thermal comfort in terms of airflow (Case Study: GOR Bulungan and Gymnasium UI).

Masson-Delmotte, V. (2018). IPCC- global warming of 1.5 ° C.

Mohajerani, A., Bakaric, J., & Jeffrey-bailey, T. (2019). The Urban Heat Island Effect, its Causes, and Mitigation, with Reference to the Thermal Properties of Asphalt Concrete. Journal of Environmental Management, (July 2017). http://doi.org/10.1016/j.jenvman.2017.03.095

Mukaka, MM (2012). Statistics Corner: A guide to Appropriate use of correlation coefficient in medical research. Malawi Medical Journal, 24 (September), 69-71.

Nurmaini. (2001). Increased Substance Causes Global Warming Pollutants, 1-4.

Nuruzzaman, M. (2015). Urban Heat Island: Causes, Effects and Mitigation Measures - A Review. International Journal of Environmental Monitoring and Analysis, 3 (November), 67-73. http://doi.org/10.11648/j.ijema.20150302.15

Qing-Bin, L. (2013). Global warming is the caused by chlorofluorocarbons, not carbon dioxide, new study says. Journal of Modern Physics B, 27 (May), 3-5.

Ramlan, M. (2002). Global warming (Global Warming). Journal of Environmental Technology, 3 (1), 30-32.

Rushayati, SB, Alikodra, HS, Dahlan, EN, and Purnomo, H. (2011). Development of open green space by the surface temperature distribution in the districts of Bandung, 17-26.

Shahzad, U., & Riphah. (2015). Global Warming: Causes, Effects and Solutions. Durreesamin Journal, 1 (4), 1-7.

Shashua-bar, L., Pearlmutter, D., & Erell, E. (2011). The influence of trees and grass on outdoor thermal comfort in a hot-arid environment. International Journal of Climatology, 31 (June 2010), 1498-1506. http://doi.org/10.1002/joc.2177

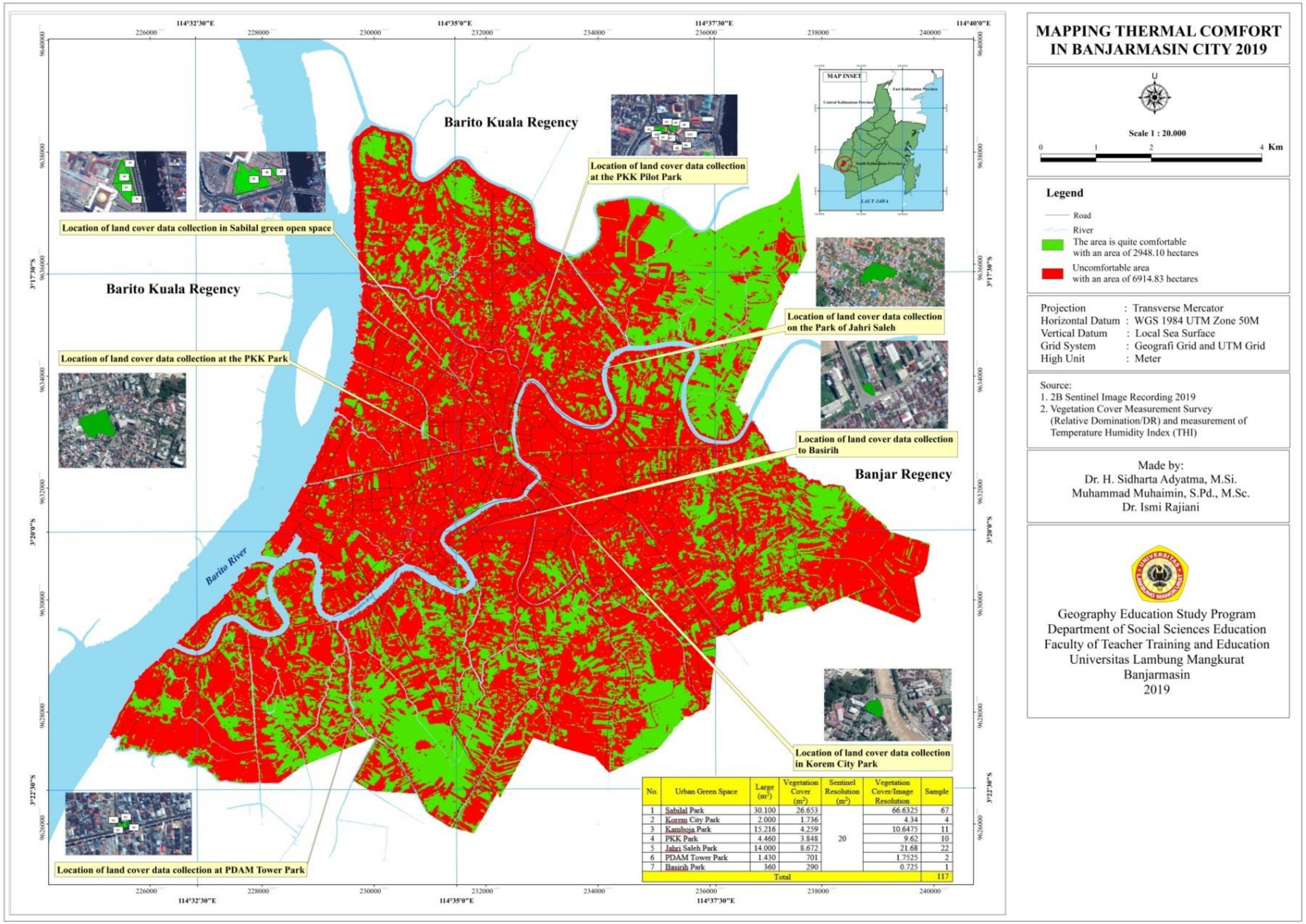
Solomon, S., Wuebbles, D., Isaksen, I., Kiehl, J., Lal, M., Simon, P., & Sze, N.-D. (Nd). CHAPTER 13 Ozone depletion potentials, Global Warming Potentials, and Future Chlorine / Bromine Loading.

Stocker, TF, Allen, SK, Bex, V., & Midgley, PM (2013). Climate Change 2013 The Physical Science Basis.

Sulistyo, B., Gunawan, T., & Danoedoro, P. (2013). Modeling of Percentage of Canopy in Merawu Catchment Derived. Geography Forum, 27 (1), 23-32.

Synnefa, A., Dandou, A., Santamouris, M., Tombrou, M., & Soulakellis, N. (2008). On the Use of Cool Materials as a Heat Island Mitigation Strategy. Journal of Applied Meteorology and Climatology, 47, 2846-2856. http://doi.org/10.1175/2008JAMC1830.1

Ward, PL (nd). Global warming is the caused by ozone depletion, not greenhouse gases



No.	Urban Green Space	Large (m^2)	Vegetation Cover (m^2)	Sentinel Resolution (m^2)	Vegetation Cover/Image Resolution	Sample
1	Sabilal Park	30.100	26.653	20	66.6325	67
2	Korem City Park	2.000	1.736		4.34	4
3	Kamboja Park	15.216	4.259		10.6475	11
4	PKK Park	4.460	3.848		9.62	10
5	Jahri Saleh Park	14.000	8.672		21.68	22
6	PDAM Tower Park	1.430	701		1.7525	2
7	Basirih Park	360	290		0.725	1
Total						117