The Effect of Green Vegetation Density in increasing Thermal Comfort in Urban Environments Through Preventing Increases in Environmental Temperature: A Study in Yogyakarta, Indonesia, at Kapanewon Depok, Sleman

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Abstract. *Green vegetation has many benefits in balancing nature. This research aims to see the relationship pattern between Green Vegetation Density (NDVI) and Urban Heat, and to see the Effect of Green Vegetation on Human Thermal Comfort. The research was carried out in 3 sub-districts in Depok, Sleman, Yogyakarta making use of Landsat-8 satellite imagery and the remote sensing technology which is equipped with measurements of microclimate elements in the field for calculating Thermal Comfort and also completed with Correlation-Regression analysis. Based on the results, a pattern was obtained that locations that have a high level of Vegetation Density will have a low Urban Temperature, whereas locations that have a low level of Vegetation Density or non-Vegetation will have High urban temperatures, and it was found that all correlations were positive with the highest order being the Caturtunggal Zone with an r value of 0.7 with a correlation level of 0.4901 (49.01%), then in second place namely the Condongcatur Zone, namely with The r value is 0.6998 with a correlation level of 0.4897 (48.97%) and the last is the Maguwoharjo Zone, namely with an r value of 0.1555 with a correlation level of 0.0242 (2.42%). It is concluded that Green Vegetation is anti-urban heat and protects Thermal Comfort. NDVI prevents Temperature increase*

Keywords : *Urban Heat Islan (UHI), Remote Sensing (RS), Human Respiratory Rate (HRR), Thermal Comfort (TC).*

1. INTRODUCTION

The main problem from urbanization that correlated with city size and density is the Urban Heat Island that positively Correlated with Urban Heat Island at the terrain (SUHI) or Land Surface Thermal (LST) [1 - 5] and make uncomfort in thermal environtment because increase uncomfort thermal index [6 - 8]. Increasing urban development will increase urban temperatures, but it can be neutralized and prevent with natural green vegetation landscape concentration (NDVI). LST negatively Correlated with NDVI [9 - 19].

Temperature at the land surface (LST) or Surface Urban Heat Island (SUHI) tends to be negatively correlated with the density or concentration or levels of Green Natural Landscape (NDVI) and tends to be positively correlated with Build Up Area (BU Area), therefore LST/SUHI tends to be directly proportional inline with the

Urbanization process in a region, and is also directly proportional inline with City Size, City Density and inversely proportional to the size and density of Vegetation green spaces (NDVI). [9 - 19]. All of this literature concludes that LST/SUHI and UHI are inversely related to the Density or Concentration of Green Vegetation Spaces (NDVI) or LST/SUHI negatively correlated with NDVI.

Research Gap

Green Vegetation, from Nature sector or Agricultural Sector are important for our live in Urban Environtment with heat phenomenon, many Research about Vegetation and Urban Heat exactly about NDVI that represent the Green Vegetation and LST-SUHI/UHI that represent the Heatwave and about Urban Heat Island (UHI), but the location is not in Kapanewon, Depok, Sleman, Yogyakarta. There is weak reference about LST and NDVI Correllation located in Kapanewon, Depok, Sleman, Yogyakarta, therefore more research must be applied for completed this reference about Correlation between Green Natural Landscape and Heatwave through NDVI and LST/SUHI/UHI analysis.

State of The Art

Based on various research literature, we can conclude that Green Space Concentration (NDVI) is important for our live and important for reduce Urban Heatwave called Urban Heat Island. This research to analysis the Correlation Between NDVI and LST in Kapanewon Depok, in order to understand the typical Correlation in Depok, Sleman to reduce Urban Heat Island.

2. LITERATURE REVIEW

According to the research literature, it is known that LST and NDVI have a tendency to be negatively correlated or inversely proportional to each other. but some literature also summarizes things in more detail, including [9] pointed out that in Raipur, India, the strong negative correlation between LST and NDVI was only valid for Vegetated surfaces, but for bare land LST and NDVI tends to weak-possitively correlated and for water surfaces landscape tends to moderate-possitively correlated. This finding suggests that the correlation between LST and NDVI is also influenced by the condition of the environmental landscape. While based on [10], it is stated that LST and NDVI in Shanghai city are inversely proportional to each other, then LST and landscape diversity (SHDI) are directly proportional, and SHDI is inversely proportional to NDVI. Green Vegetation (NDVI) will absorb geothermal energy in geothermal systems, thus proportionally lowering the Surface Temperature. Based on [11], it is known that Green Vegetation or green plants are able to absorb geothermal energy so as to reduce LST / Temperature. Then [13] also suggested that the correlation between LST and NDVI tends to be negative for watersheds, precisely in the Wanggu watershed, Southeast Sulawesi.

Build Up Area (BU Area) is an indicator of NDVI and LST/SUHI as well as UHI. BU Area tends to negatively correlated with NDVI, and NDVI inline with Absorbtion of earth thermal energy, therefore if NDVI decrease, the LST will be increase. In the municipalities of Yogyakarta and Surakarta NDVI is inversely related to LST/SUHI and also UHI [14]. Then based on [15] in the Himalayas, LST and NDVI are also inversely or negatively correlated, except in the water table landscape, which is directly proportional. While based on [16] in America LST and NDVI are inversely proportional in summer, while in winter they are directly proportional. Based on the literature study, it is known that LST and NDVI are inversely or negatively correlated, except in the water table landscape and seasonally related, i.e. in summer, if in winter there is a potential to be directly proportional.

The density of green space is reflected in the Normalized Difference Vegetation Index (NDVI), a measure of greenness. Green vegetation space acts as a natural air conditioner, reducing heat in crowded metropolitan areas [20]. The NDVI value reflects the quality of Green Vegetation Space related to greenness and density. Green Vegetation can provide environmental Thermal Comfort by preventing heat. At least green vegetation is needed in the form of a more than ten hectares of city park to best cool the metropolis urban area [20].

Normalized Difference Vegetation Index (NDVI) is represent The Greenspace area, and Accoeding to literature [21 – 27] all concluded that Green Space (Vegetation) is needed to make fresh air and for cooling down, even [22] noted that green space is more efficient and effective in the heat of the city for reducing urban heat than blue landscape (water environmental). Literature [26] states that Green Vegetation in comparatively large and dispersed Parks in Cities is considerably more efficient at cooling the city than Green vegetation in small parks or huge parks, but limited only in one area and not dispersed, evenly literature [20] stated that in order to properly reduce urban heat in an environment, each zone needs to have a minimum of 10 ha of green vegetation.

An increase of 10% in green forest vegetation will result in a 0.83°C decrease in urban heat. The effective cooling temperature radiation of green vegetation is about 15 meters during the day and 60 meters at night, It implies that at night, when compared to during the day, the cooling radius of green vegetation will grow. Green vegetation cools the environment more effectively at night than during the day [21]. LST tends to Negatively Correlated with NDVI. NDVI represent the concentration of Greenspace area in environtment, and according to [28] interaction with Greenspace Environtmen 30 minute every day in one week will decrease 7% prevalence of blood pressure and 9% prevalence of depression, therefore NDVI tend to inline with healthy mentally Environtment.

3. RESEARCH METHODS

Study Area

This Study was conducted in Depok, Sleman Regency, D.I. Yogyakarta, divided in 3 Zone : Sawitsari-Gejayan, Condongcatur, Pandegasari-Kentungan, Caturtunggal and Karangnongko, Maguwoharjo. Depok is one of Districts in the Indonesian province of Yogyakarta, Sleman Regency. The coordinates of Depok are 7.46'43″S and 110.23'21″E having an area of 2,687, 6485 Ha, or 35.5 Km2, and a maximum temperature of 35°C and a lowest temperature of 22°C. The three villages or sub-districts that make up the Depok district are Condongcatur, Caturtunggal, and Maguwoharjo. [29]

Depok has a 123,689 population in all, made up of 62,530 women and 61,159 males, with 41,551 heads of family. with 3,723 persons per km^ as the population density value.. (Sleman Regency Government) [29]

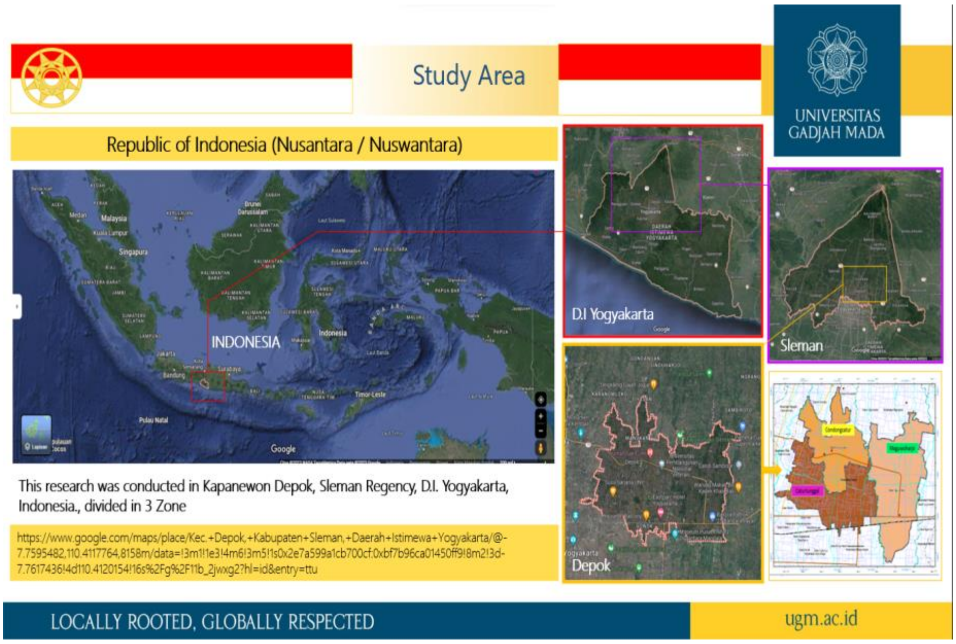

Figure. 1. Map of Study Area [30]

Research Data

This research is a quantitative research Using Landsat-8 Satellite Imagery with Bands 4, 5, and 10 for Remote Sensing to make NDVI map and LST/SUHI map and to analyze the Correlation Between Greenspace Concentration (NDVI) and heatwave of city (LST/SUHI) to Obtain The Correlation value and Regression equation between NDVI and LST/SUHI in Depok, Sleman.

NDVI and LST/SUHI from Landsat-8

This study employed a remote sensing technique, analyzing data with ArcGIS software using USGS landsat-8 images. We focus on Depok, Sleman, using Landsat-8 data in the red band, NIR band, and thermal band (bands 4–10). First, to obtain the NDVI map we use band-4 and band-5 radiometric correction and for LST/SUHI map we use result of Top Atmospheric and Brightness Temperature calibration from band-10 radiometric correction.

This method according to [9 – 15] that using landsat imagery for Analyze NDVI and LST in study area, and according to [1] and [2] we can use LST for Urban Heat Island Analysis.

Radiometric Correction for Green Vegetation and Heatwave

Analyze in ArcGIS software based on radiometric correction. The Urban Heat Island correction formula that put in Ruster Calculator of ArcGIS is like this :

a. Green Space Concentration (NDVI, PVI, EC calibration) :
Normalized Difference Vegetation Index (NDVI) :

Float(Band5-Band4)/Float(Band5+Band4) (1)

Perpendicular Vegetation Index (PVI):

Square("NDVI"-NDVImin)/(NDVImax-NDVImin) (2)

EC (Correction) :

0.004"PVI"+0.986* (3)

Thermal band (TOA and BT Calibration)

Top of Atmosphere (TOA) :

0.0003342"Band10"+0.1* (4)

Brightness Temperature (BT) :

(1321.0789/Ln(774.8853/"TOA")+1)-273.15 (5)

Heatwave Calibration

Land Surface Temperature (LST) or SUHI

("BT"/(1+(0.00115"BT"/1.4388)*Ln("EC")))* (6)

UHI wave : (LST – LST mean) / LST standard deviation (7)

After NDVI and LST analysis in ArcGIS, NDVI and LST Map will be obtained

Field Survey and Measurment of Thermal Comfort

$Yjs = -3.4 - 0.36\ V + 0.04\ Ta + 0.08\ Tg - 0.01\ HR + 0.96\ Adu$ (8)

$Yd = -7.91 - 0.5\ V + 0.047\ Ta + 0.167\ Tg - 0.0007\ HR + 1.43\ Adu$ (8)

$Adu = 0.203\ p^{0.425} .\ h^{0.725}$ (9)

$Y= (Yjs + Yd) / 2$ (10)

Information :

Yjs = Thermal Comfort Index in activity
Yd = Thermal Comfort Index non-activity
Y = Thermal Comfort Index Perception Value (TCIPV)
V = Wind Velocity flow in body (m/s)
Ta = Air Temperature (°C)
Tg = Radiation Temperature → In this Study LST-UHI (°C)
HR = Humidity of Relatif (%)
Adu = Total Area of Human body (m^2)
p = Human Weight (kg)
h = Human Height (m)

Thermal comfort index perception value (Y) data will recorded in log book and MS Excel and Completed with Questionarie data and interview data.

After Thermal Comfort Field Measurement Complete, an Thermal Comfort Value Obtain, we use ASHRAE 55 Standard (Table 2) and Sangkertadi (Table 1) Standard to know the State of Human Perception about their Thermal Comfort

Table 1. Scale of Thermal Comfort Index Value Perception [6]

Scale of Comfort Thermal Index Perception Value	
Value of Y	State of Perception
-1	Slightly Cold
0	Neutral
1	Slightly Hot
2	Hot
3	Very Hot
4	Very Hot and Paintfull

Table 2. Scale of ASHRAE Thermal Comfort Sensation [34]

Scale of Comfort Thermal Index Perception Value	
Value of Y	State of Perception
+3	Hot
+2	Warm
+1	Slighly Warm
0	Neutral
-1	Slightly Cool
-2	Cool
-3	Cold

NDVI and LST/SUHI Correlatio-Regression Analisis between

To make Correlation-Regression Analysis we use Arc-tool Box in ArcGIS Sofrware and the Click Feature Class and click Create Fishnet item and then sampling spot will obtaind in NDVI and LST map in ArcGIS, then we make this sampling spot as label data atribute in NDVI and LST layer and then we open this attribute table data and make Correlatio-Regression Analysis and its table. Therefore we can obtain the r value and regression equation or from attribute.

4. RESULT AND DISCUSSION

Spatial Analysis NDVI and SUHI-UHI Map in Depok, Sleman, Yogyakarta

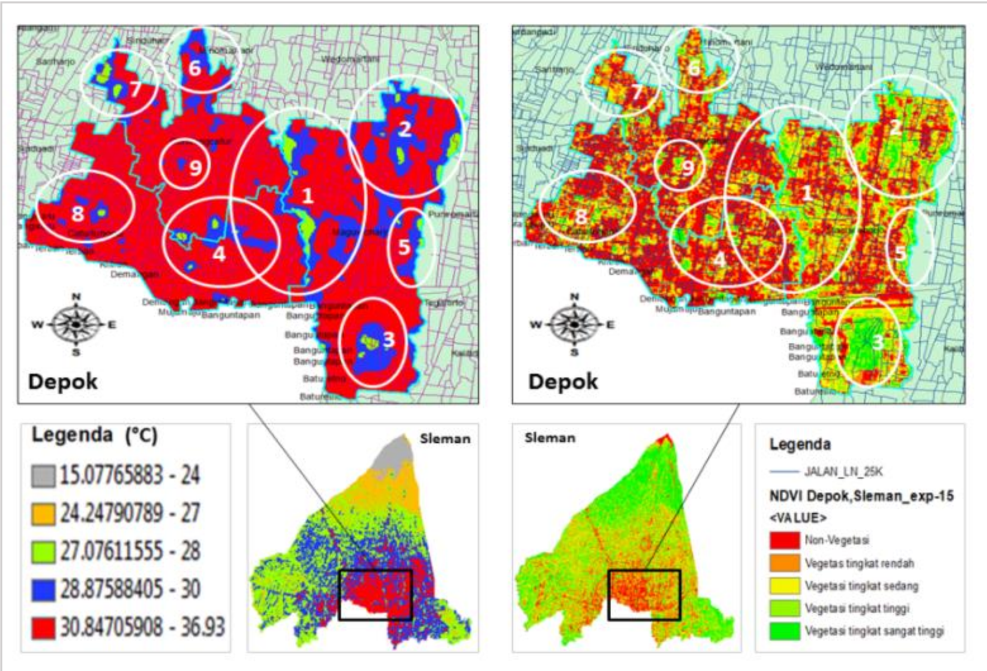

Figure. 2. Comparation Between LST/SUHI Map and NDVI Map

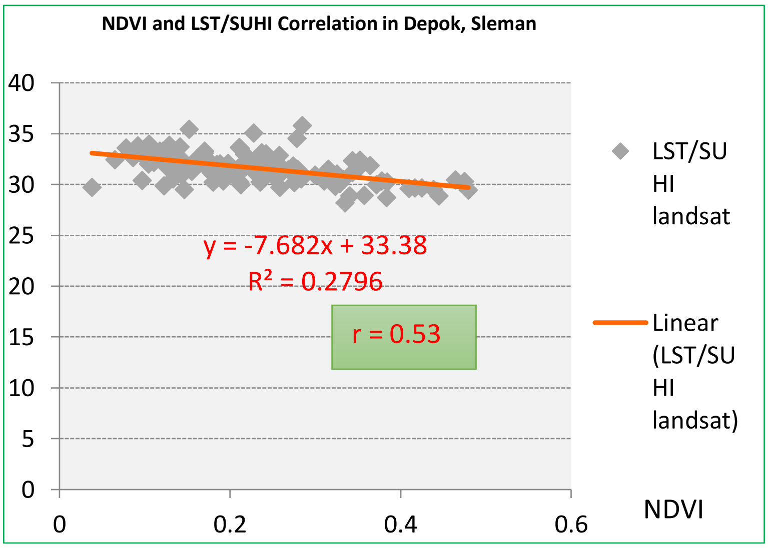

Figure. 3. Graphic of Correlation-Regression of NDVI and LST in Depok, Sleman from Landsat-8 Sampel Spot Analysis

Depok, which is located at 7.46'43″S and 110.23'21″E, has an area of 2,687, 6485 Ha, or 35.5 Km2, a maximum temperature of 35°C, and a minimum temperature of 22°C. The three villages/subdistricts that make up Depok are Condongcatur, Caturtunggal, and Maguwoharjo. There are 123,689 people living in Kapanewon Depok overall, made up of 61,159 men and 62,530 women, with 41,551 heads of family. 3.723% of the population is concentrated in a square kilometer. [29].

According to the Urban Heat Island (UHI) map from landsat-8 analysed by ArcGIS software it is known that in Depok, Sleman UHI still exist and has a temperature of SUHI 30.85°C-36.93°C. Almost area in Depok is UHI zone divided in Condongcatur, Caturtunggal and Maguwoharjo and according to the result of Correlation-Regression Analysis between Greenspace Concentration (NDVI) and Urban Heat (LST/SUHI) it is known that Greenspace (NDVI) is negatively correlated between Urban Heat (LST/SUHI) with r value or correlation value = 0.53 or 53% and R square value = 0.3 or 30 % so the Correlation between NDVI and LST/SUHI is moderat negative , NDVI and LST/SUHI inversely increase proportional to each other, the area with Highest NDVI will be Lowest in LST/SUHI and the area with lowest NDVI will be highest in LST/SUHI, therefore Change of Natural Green landscape to Build Up area, will be make LST/SUHI increase and make hot air in environtment (**Figure 3**).

Thermal Comfort and Urban Heat Correlation Analysis in each NDVI Zone

Table. 3. Field Survey And Measurement

Zone	NDVI	r UHI-Thermal Comfort Scale	R^2 UHI-Thermal Comfort Scale	Wind Velocity (m/s)
Condongcatur	0.27	0.6998 (0.7)	0.4897 (0.5)	0.876 (0.9)
Caturtunggal	0.25	0.7	0.4901 (0.5)	0.718666667 (0.7)
Maguwoharjo	0.26	0.1555 (0.2)	0.0242 (0.02)	1.15666666 (1.2)

Table. 4. Correlation-Regression Between LST/SUHI and Thermal Comfort Value in Each NDVI Level in three zone of Depok, Sleman Study Area

Zone	Average NDVI	Average LST/SUHI (°C)	Comfort Thermal Scale	Perception State
Condongcatur	0.27	31.1	0.7	Comfort - Slightly Hot
Caturtunggal	0.25	31.8	1.1	Slighly Hot - Hot
Maguwoharjo	0.26	31.4	0.9	Comfort - Slightly Hot

According to the results it is known that the highest NDVI value or Density of Greenspace value is in Condongcatur subdistrict with value 0.27, in second place is in Maguwoharjo subdistrict with value 0.26 and the lowest is in Caturtunggal subdistrict with value 0.25 and then the highest average of Land Surface Temperature/LST or SUHI is in Caturtunggal subdistrict, with value 31.8° C, in second place is in Maguwoharjo Subdistrict with value 31.4° C and the lowest LST is in Condongcatur subdistict with value 31.1° C and the highest Comfort Thermal scale is in Caturtunggal with value 1.1 and then in Maguwoharjo with value 0.9 and the lowest is in Condongcatur with value 0.7. Therefore according to the results Caturtunggal has uncomfort thermal state in first rank, followed by Maguwoharjo and the last is in Condongcatur.

Spasio-Temporal Analysis of SUHI Map in Sleman, The Location of Depok District

Based on the findings, it is known that the Depok consistently becomes the center of an Urban Heat Island, with data from Landsat-8 imagery collected at one- and two-year intervals. Depok is the area with rapid urbanization then around so it will make thermal problem, Urban Heat Island has a negative correlation with green space and a positive correlation with city size and density, this result support and tend to in line with [31- 33], [18], [19] and [3-5].

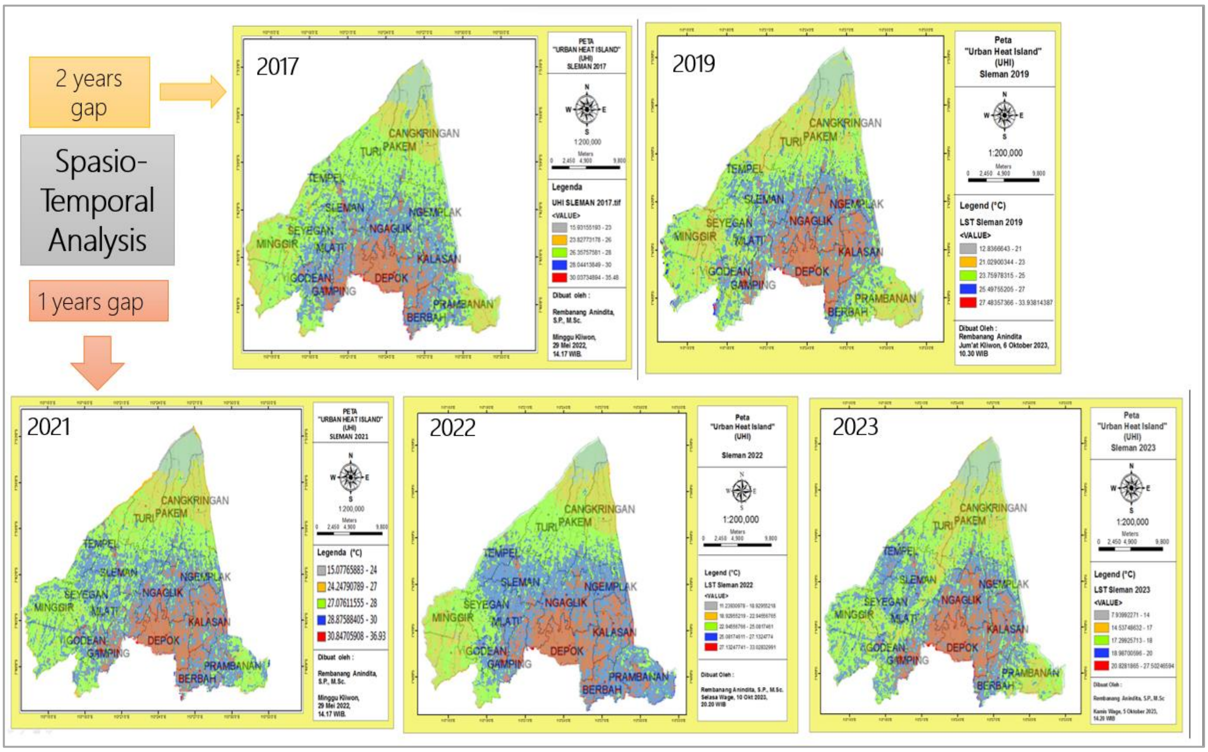

Figure. 4. Spasio-Temporal Analysis of UHI in Sleman, especially in Depok Study Area

Discussion

This research aims to see the relationship pattern between Green Vegetation Density (NDVI) and Urban Heat, and to see the Effect of Green Vegetation on Human Thermal Comfort. Surface Urban Heat Island (SUHI) or Land Surface Temperature (LST) tends to be negatively correlated with the density or concentration or levels of Green Natural Landscape (NDVI) and tends to be positively correlated with Build Up Area (BU Area), therefore LST/SUHI tends to be directly proportional inline with the Urbanization process in a region, and is also directly proportional inline with City Size, City Density and inversely proportional to the size and density of Vegetation green spaces (NDVI). [9-19]. All of this literature concludes that LST/SUHI and UHI are inversely related to the Density or Concentration of Green Vegetation Spaces (NDVI) or LST/SUHI negatively correlated with NDVI.

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5. CONCLUSION

According to the results we conclude that in Sleman, Regency, especially in Study area of Depok District, Green Vegetation tend to negatively correlated with UHI temperature and Green Vegetation is anti-urban heat and protects Thermal Comfort. NDVI prevents Temperature increase.

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