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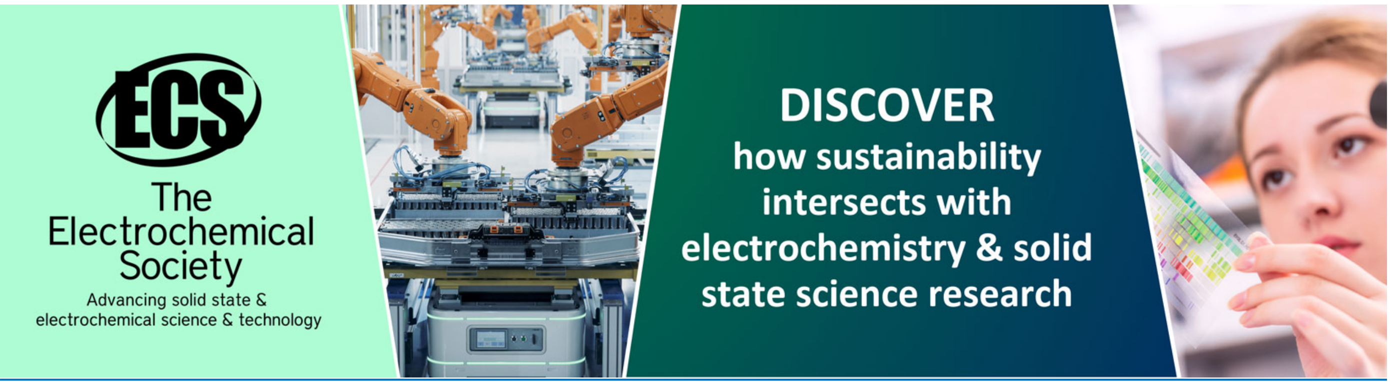

Utilization of remote sensing and GIS to identify radius of urban cool island for planning open green area in urban area (case study of Yogyakarta)

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Abstract. City is a center development of a region that has functions both social and economic. Yogyakarta City is the administrative center of Yogyakarta Special Region province and as educational centers in Indonesia. The complexity of activities that occurring has an impact on the microclimate situation in the region which is called as Urban Heat Island and it will affect the comfort of urban community so that urban area should be arranged especially about microclimate aspects. Open Green Area is one element that can lower the surface temperature. Radius reduction in surface temperature of Open Green Area became the main issue in this research as a basis for determining the location of Open Green Area spaces with an ideal distance interval among Open Green Areas in urban areas. The methods used Split Moving Window Analysis to obtain Land Surface Temperature, Normalized Difference Vegetation Index is transformation to obtain variation of vegetation density, statistic analysis to know LST correlation with NDVI, and buffer analysis to analyze changing of radius temperature. The results show that average surface temperature in Yogyakarta City ranges 25 to 35 ^{o}C. The value of vegetation density is obtained 0-0,3. Based on the result of correlation between LST and NDVI show that they have correlation value with negative gradient. The higher value of NDVI give impact of LST value in the same location will tend to be low with average value of temperature rise of 0.122 ^{o}C per 30 meters , then is obtained the ideal distance interval among Open Green Area ranged from 240-260 meters to maintain maximum temperature rise 1 degrees Celsius from the center of Open Green Area. The results of this study can be used as a suggestion to arrange of planning Open Green Area for the Yogyakarta Government.

1. Introduction

Yogyakarta City has a critical functions as a center of community activities. The changing of various fields in urban areas of Yogyakarta is very faster then other areas. This is closely related to the characteristics of urban areas as a center of government and economic activities. The economic growth caused community migration from suburbs and villages. Increasing population leads to increase settlements and infrastructure. The change land into various fields, like the changing of gardens and city parks into skyscraper, houses, highways and so on byAdiningsih [1].

The population of Yogyakarta City has uncontrolable condition because of the position as also a student city. The population is increasing from 392506 in 2011 to 412704 people in 2015. During that period there was an increase in average annual temperature from 26.4°C to 27.1°C, so that the comfort zone of the city decreased. Increasing activity that concentrated in an urban or industrial area will form characteristic of a typical microclimate. This microclimate characteristic is one of the occurrence of Urban Heat Island. Urban Heat Island is rising an average temperature phenomenon in areas with denser buildings than the surrounding open air temperature by Atkinson [2]. UHI phenomenon occurs because of differences in the use of heat absorption energy, latent heat exchange and pressure and wind flow by Buyadi et al [3]. The existence of UHI resulted in the emergence of climate problems or global warming. UHI and its problems can be overcome by the expansion and provision of Open Green Area (OGA).

Green Area is an area that must be available in a city because it has a role both ecologically, economically, socially and culturally in this case can act as urban cool island. Ecologically, through the development of green area will help in lowering the city temperature so that it becomes an appropriate alternative in UHI mitigation. Through vegetation also creates a cool, comfortable and fresh environment. OGA development can not be done at a place, the allocation must be adjusted to the effect presented. Each expansion of the green area that has been built has its own territorial influence.

The aim of this paper is analysis urban heat island with remote sensing; firstly, the influence of LST distribution in Yogyakarta city; secondly, the effect of UCI on the decrease of surface temperature in Yogyakarta city; thirdly, the surface temperature rises gradually from the center of the Open Green Areas in Yogyakarta City; and fourth knowing the ideal distance interval between Open Green Areas. The use of remote sensing data makes it possible to obtain accurate and fast spatial data in a relatively short period of time.

2. Methodology

2.1 Urban Heat Island Indices

This research use some tools and materials there are Landsat 8 OLI imagery, MODIS imagery, ArcGis, and ENVI. There are some processes to obtain land surface temperature. Land cover is needed to add emissivity of every object as a land cover. Every object class has their own emissivity because every object class has different characteristic to absorb and reflect the energy. Land cover classification used maximum likelihood algorithm cause it use a probability value on every pixel to be divided into specific information classes by Danoedoro [4]. In this research we consider Curran, 1985; Lillesand dan Kiefer, 1997; Sabins Jr., 1978 on Sutanto [5] to add value of emissivity. The emissivity can be added using band math on ENVI as below

e1 * (b1 eq 1) + e2 * (b1 eq 2) + ... + en * (b1 eq n) (1)

Information:
e = emissivity
b1 = land cover image
1, 2, ..., n = sequence of closing object according to ROI retrieval

Processing of Landsat Imagery also process on TIR band i.e band 10 and band 11 become brightness temperature as below

T = K_2 / {alog (K_1 / L_λ + 1)} (2)

Information:
T = brightness temperature
L_λ = TOA radians
K_1 = thermal constants of band 10 or 11
K_2 = thermal constants of band 10 or 11

MODIS imagery is also needed to obtain total water vapor as a reflectant value using this algorithm

wn = ρ * bn / (C1 * ρ * b2 + C2 * ρ * b5) (3)

Information:
wn = water vapor in band n (g / cm2)
ρ = density of water 1 g / cm3
bn = band n
C1 = 0.8
C2 = 0.2

Calculation of total water vapor using formulation on bandmath based on Gao and Kaufman [6]:

w = f17 * w17 + f18 * w18 + f19 * w19 (4)

Information:

w = total water vapor (g / cm2)
fn = weighting factors band n
w n = water vapor at band n (g / cm2)

That value should be converted to landsat value using algorithm estimates of the calculation of Central Latitude Heat based on Rozenstein, et al, [7].

$\tau\_10 = -0.1134w + 1.03$ (5)

$\tau\_11 = -0.1546w + 1.0078$ (6)

Beside that we also processed NDVI value of Landsat imagery to know the greeness area of our location and it will help us to determine which one as green space area by looking at NDVI value. NDVI can be obtained using this algoritm as below

$$\text{NDVI} = \frac{(NIR-Red)}{(NIR+Red)} \quad (7)$$

To analyze of hotspot (NDVI) buffer can be a tool to look range area that be influenced by a hotspot. Range of buffer that is used is 30 meters adjust to spatial resolution of Landsat. The data values which have been extracted from buffer analysis will be continue with statistical analysis using regression of distance and temperature values

2.2. Flow Chart

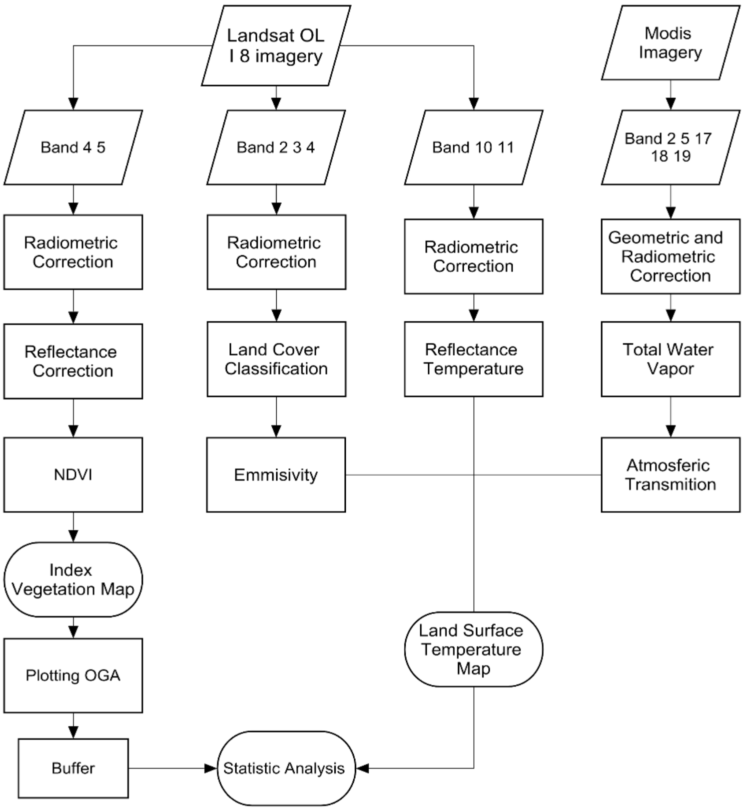

Figure 1. Flowchart

3. Result and Discussion

Surface temperature around the city of Jogja has ranges between 25-30 and 30-35 degrees Celsius which can be seen from the visualization on the map (Figure 2). However, it can be seen from the processing done at the highest temperature ENVI in Jogja city ranges at a temperature of 30 degrees with the value of decimal numbers that fluctuate so that in the visualization classified in the range 30-35 degrees Celsius.

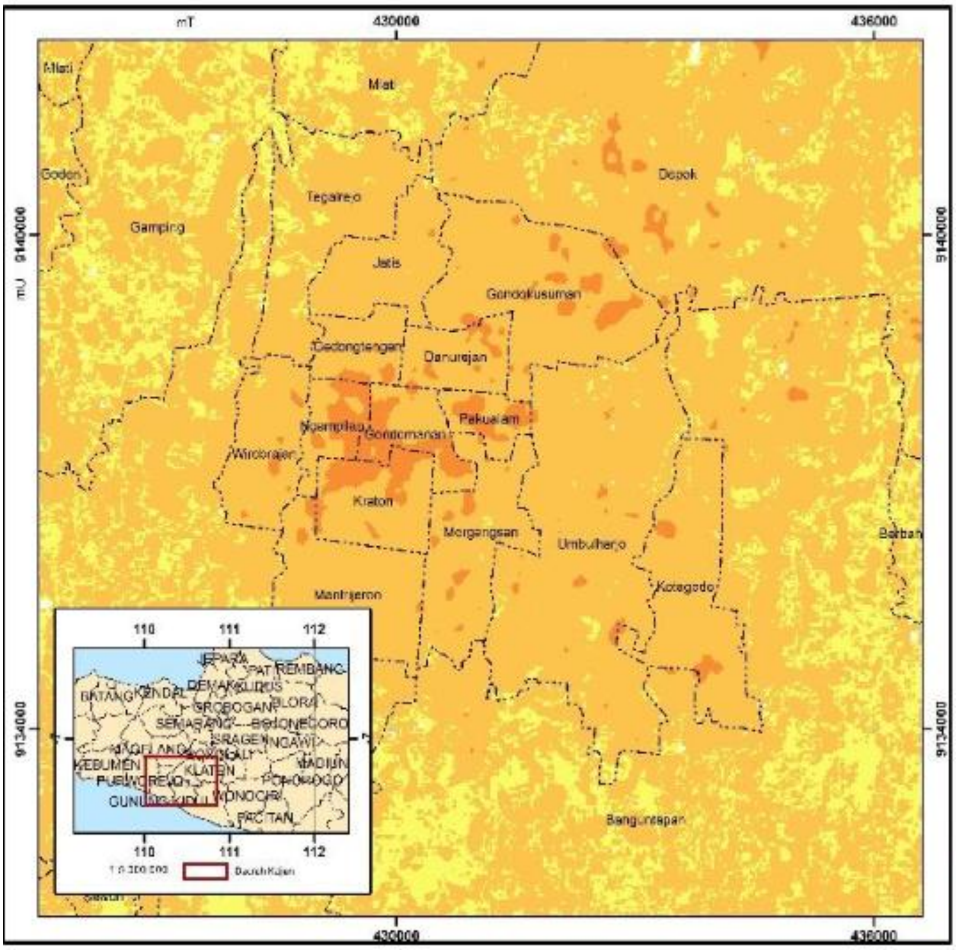

Figure 2. Land Surface Temperature Map in Yogyakarta

The high temperatures are around the city of Yogyakarta is located in the district of Kota Gede, Umbulharjo, Mergangsan, Sewon, Mantirejon, Kraton, Wirobrajan, Ngampilan, Gondomanan, Pakualam, Gedongtengen, Danurejan, Gondokusuman, Depok, and Banguntapan. The area is an area which is bounded by functional boundaries of surface temperature rather than administrative boundaries. However, in general the surface temperature is highest in the District Kraton, Gondomana, Ngampilan, and Pakualaman. Some of these sub-districts are centers of activity in Jogja City, in which was built as center government, and economic center, as well as tourism center for example is the Malioboro area. The high surface temperatures are a consequence of increased activities carried out by communities in a region.

From these surface temperatures can be seen pattern of regional development that leads to the north-northeast especially Depok section that has a high level of activity so that the surface temperature is higher than the surrounding area. The direction of these developments can be used as a reference to urban planning in the future. This research has focus on influence of vegetation existing so the other factor is pressed to minimal influence of that factors with using record of imagery at 15th june of 2015 which is in a dry season and effect of the rainfall can be minimalized. The research topic is limited to microclimate so the global condition will be ignored caused it is a local analysis. The high surface temperature can be lowered by the presence of vegetation that can absorb CO^2 so that the surface temperature becomes lower. Based on this, the presence of vegetation can be seen density by using vegetation index.

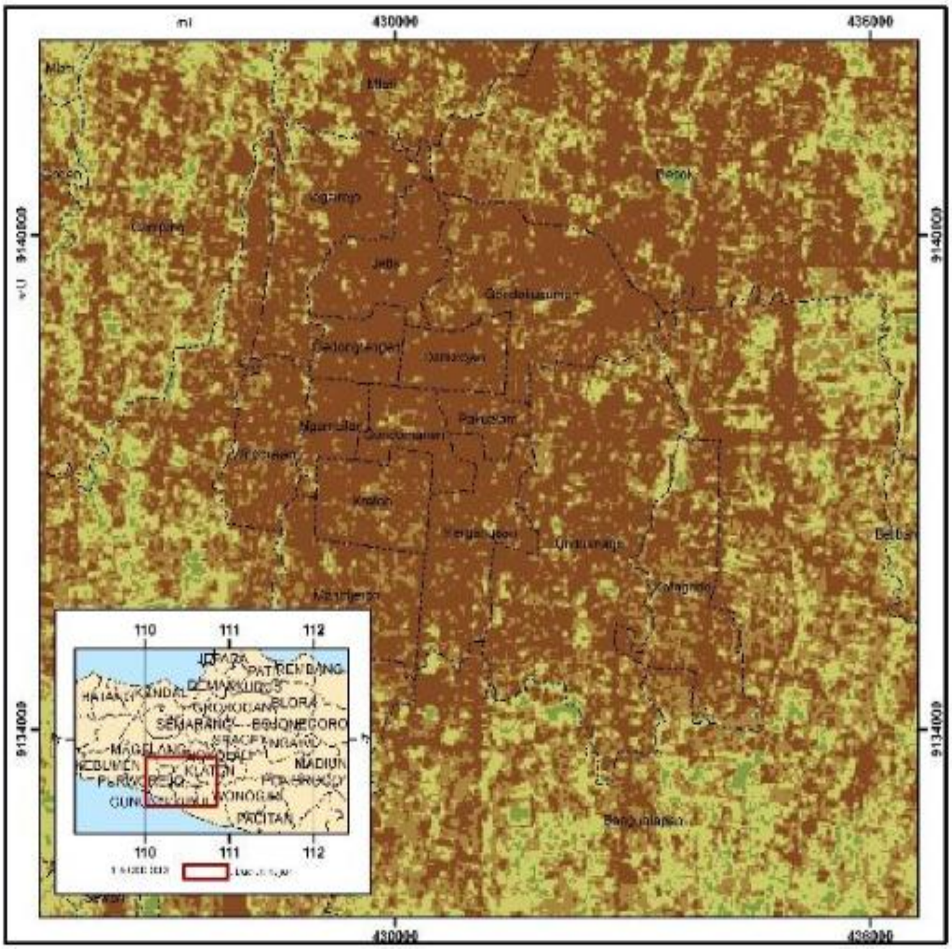

Figure 3. Maps of NDVI in Yogyakarta

The vegetation index used is NDVI. The existence of vegetation in the city of Jogja is very low, almost the entire region is a build up area (Figure 3). Dense vegetation can be found in outer city territory with vegetation index around 0.2 -0.6 while vegetation range is 0-0.2. The presence of vegetation in urban areas serve as an object of study to determine the effect of vegetation on the temperature around the vegetation. Visually in areas with low density vegetation did not have a great influence on the surrounding temperature because the effect on the surrounding temperature differed decimally not gradually very significantly different. However, it can be seen statistically. Here is an area that has a high vegetation index around the city seen from high NDVI values and serve as a test point to see the correlation between the presence of vegetation with changes in the temperature surrounding. NDVI is a parameter to determine the OGA cause it has a dense vegetation that correlate with temperature so in this research did not consider human behaviour, policy of spatial planning from government, or availability of OGA cause our research is focused on existing are that has vegetation so NDVI is used to determine it. Temperature has been influence by a lot of factor such as location of latitude and longitude, rainfall, topography of the place, and existing of vegetation. At that point will be extracted the pixel value of surface temperature and the vegetation index as Figure 4.

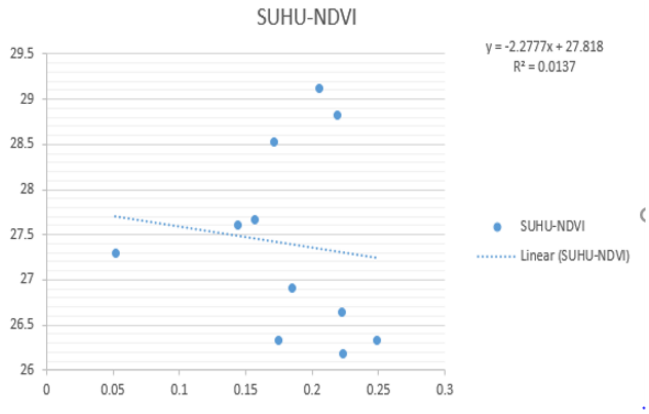

Figure 4. Graphic correlation of temperature and NDVI

Based on the points that be extracted shows that the higher the NDVI values have lower surface temperatures which is indicated by the regression curve that produces a negative correlation. The negative gradient shows an inverse relationship when one variable has a high value then another variable has a low value. Therefore the presence of fairly dense vegetation will give effect to surface temperature. However, in this study the value of R^2 is still relatively low so that another research to increase of R^2 with different samples . The study area used has a low NDVI value so that sampling is limited. R^2 value shows how much variable x will influence variable y, it has mean how much vegetation index influence temperature around it.

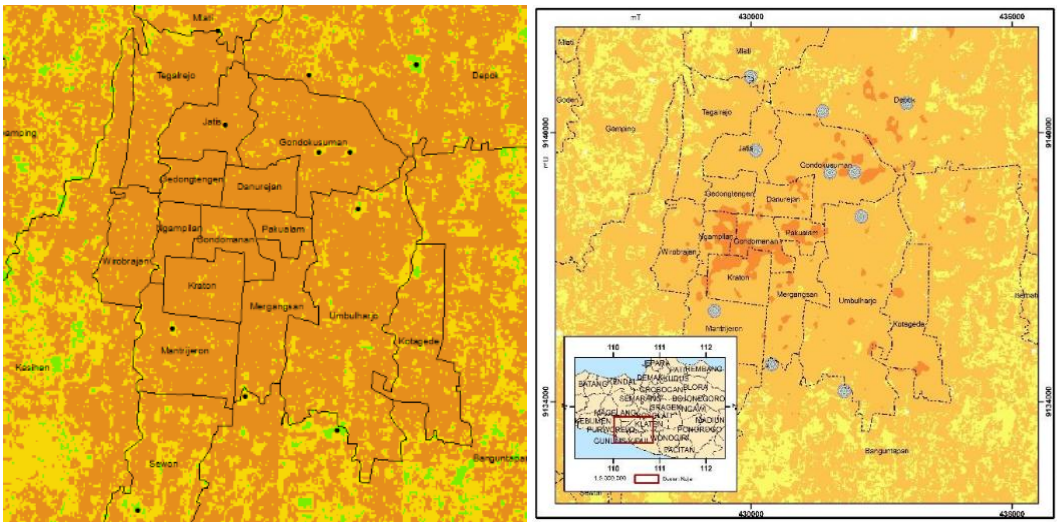

Figure 5. (a) Extraction Result Maps of point on Open Green Areas, and (b) Maps of Radius Open Green Areas to Land Surface Temperature

Determination of the Open Green Areas will be buffered from the center of point with intervals of 30 m, 60 m, 90 m, 120 m, and 150 m (Figure 5). Determination of the buffer interval is adjusted to the map scale used that can determine the minimum mapping unit. At the scale used for 1: 100,000 even though the buffer display results are made on a scale of 1: 60,000 but the scale used refers to the scale used to map the surface temperature and NDVI, then the minimum mapping unit to do is 3mm which is equivalent to 30 m in the field then the value used starts from 30 m with a 30 m interval. The farther away from the central point of Open Green Area in general the temperature increases higher with the average value of temperature rise of 0.122 degrees Celsius. However, in some points there is an anomaly, in the first ring of the buffer or in one of the ring buffer area that is more far from the

OGA has a lower temperature than the center of the OGA. It is suspected to occur due to several factors described as higher vegetation density. This is possible because the center of Open Green Area is one part of the green space represented by a certain area whereas the green space is not only limited to the central point so that although visually described to be the same NDVI class , but NDVI both can have different values. Second is the presence of a water object is indicated by a negative NDVI value approaching zero. Theoretically the value of NDVI which is near 0 indicates the body of water. The negative value is not associated with the built up because the built up has a higher temperature in accordance with its emissivity. Therefore the existence of a water object can be one of the conjectures to the value of this anomaly for example encountering of NDVI value -0.0461 with temperature 22.7622 while the previous ring which closer to the center point OGA have NDVI values 0151 with temperature 27.0511.

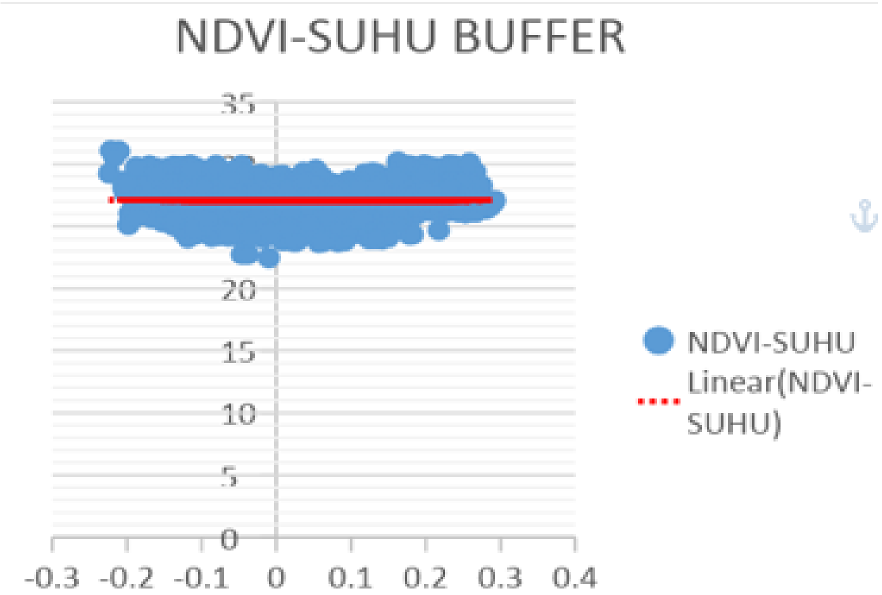

Figure 6. Correlation Buffer of Temperature and NDVI

The NDVI value corresponds to the ability to lower the ambient temperature (Figure 6). In this research is obtained that high NDVI value not necessarily can decrease temperature significantly. NDVI value which pertained high categorize in this area is 0.2911 can decrease temperature equal to 0.0189 while at other point of OGA with value of NDVI 0.2675 can lower temperature amount 3.1579. The second value of NDVI has a lower value than the first value but the temperature drop is bigger than the first. This is alleged due to differences of environmental surrounding condition. In urban areas there is a very dense building that has a high population and activity level while the outer city area has a lower level of activity so that although it has a higher NDVI value changes temperature is lower. This is accordance with the second of thermodynamics laws. Then the surrounding temperature conditions also determine the temperature changes that occur. The relationship between NDVI and the surface temperature of the buffer result is negative or inverse relationship. This indicates that the higher the vegetation index will influence the lower temperature in one area although in some data there is anomaly of results. That causes of the weak correlation regression results. However, in general from the regression results obtained an inverse relationship between the variable NDVI with surface temperature as can be seen in the graph below. The relationships obtained from either single OGA center data or buffer results show the same correlation between objects.

Based on the results of the analysis, the temperature around the Open Green Area will rise about 0.976 degrees at a radius of 240 meters from the Open Green Area center obtained from the calculation of the average increase in surface temperature of 0.122 degrees Celsius per 30 meters, the increase of 1 degree Celsius equivalent to a 240 meter radius. The extent of the affected area of the presence of the OGA can be obtained by calculating the area of the circle with a finger 240m ie an area of 181028,571 m^2 . Therefore, the ideal distance among Open Green Areas in Jogja City is 240-260 m with another Open Green Areas which has scope more or less the same as in the above map while for other areas with different scope will have a different interval distance among Open Green Area so that further research is needed on the extent/scope of Open Green Area with a decrease in surface temperature. The positioning of space on this Open Green Area can be used as input for special region of Yogyakarta to determine the distance among Open Green Areas in Yogyakarta city in draft of urban spatial planning.

4. Conclusion

The urban heat island is pronounce due to the influence of the difference temperature. The distribution of surface temperatures in urban areas of Jogja that have high temperatures are in the center of the city and move towards north-northeast. The highest temperature in Jogja ranges from 30-35 degrees celsius while the temperature generally ranges in the range 25-30 degrees celsius. The specific results about the relation of land surface temperature (LST) value with NDVI has a negative correlation which means that the two variables are inversely proportional where if one variable is high then other variables are low. But of at all, there is a positive influence on the Open Green Area against the decrease on temperature in the city of Yogyakarta. The further the distance of the area from the center of the green space which a radius buffer 30 m per ring is known increasing per ring with average temperature $0.122\,^{o}$C. From this radius we can known the ideal distance interval among Open Green Areas is 240-260m and it has particular condition cause analysis that used is statistical descriptive.

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