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The Effect of Land Cover Change on Surface Temperature Based on Satellite Image in Thirty Cities of Indonesia

Tia Dwi Irawandani*, Arie Dipareza, Joni Hermana

Department of Environmental Engineering, Faculty of Civil, Environmental and Geo Engineering Institut Teknologi Sepuluh Nopember, Surabaya, East Java, Indonesia

* Corresponding author: tia.dwi.irawandani@gmail.com

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Abstract

Urban density in Indonesia are getting increasing. These conditions have an impact on the function alternative land use that makes land cover change. Urban development triggers increased pollution and heat production. The purposes of this study were to determine the effect of land cover change on surface temperature and determine surface temperature based on elevation (plateau and lowland areas). Study area is thirty provincial capitals in Indonesia. Data processing based on satellite imagery covers Terra MODIS and Google Earth data from 2007 till 2016. Generally, land cover (vegetation) of cities in Indonesia had decreased by an average of 1.4% per year. In contrast, surface temperatures are increasing. Accuration regression equation show that the change in green land cover affects urban surface temperature by 33% of total variation variables. Urban in the lowlands and plateau (high-elevated land), vegetation is also inversely proportional to temperature. Based on the regression, vegetation giving almost the same effect to the city with different elevation.

Keywords; Indonesia, land cover change, satellite image, surface temperature

1. Introduction

Urbanization in emerging Southeast Asian countries increased by 48% in 2010 and is predicted to reach 64% by 2050. Increased urbanization indicates that the increasingly heavier activity of various sectors in urban areas (UNESCAP, 2015). Traffic, industrial, and construction activities for residential and commercial houses are the main factors causing denser urban areas. These activities have impacted changes in urban land cover. The facts show that the large land cover changes are vegetated land. These conditions indicate that vegetated land as an absorber for various air pollutants is getting smaller while the number of buildings, industries, and transportation as the source of emissions is increasing (Wijaya, 2015).

The decreasing presence of vegetated land due to increased development and transportation activities has a negative impact on urban air quality. The first impact is the rise in urban temperatures. The heat released in the air resulting from increased anthropogenic activity in urban areas causes the surface temperature to rise unevenly. The temperature difference between urban and rural areas is a phenomenon called Urban Heat Island (UHI) (Fawzi and Naharil, 2013). The difference in temperature of the UHI region compared to its surrounding reaches 2˚C - 10˚C. High surface temperatures indicate high energy consumption (industry, transportation, or building). The impact of this land cover change becomes prolonged and affects climate change if not controlled. Wardana (2015) analyzed the surface temperature extracted from Landsat Tematic Mapper satellite image as a consideration for green planning open spaces in Bandung. The results show that the average surface temperature has increased for 10 years. Areas with high building density indicate areas most affected by high surface temperatures. The composition and configuration of vegetation cover have a strong influence on surface temperature. But the achievement of green area functions for temperature drop is also highly dependent on the size and type of high density trees. Vegetation has an effect on climate through two processes: canopy shade and evapotranspiration. In the canopy shade leaves and twigs reduce the amount of solar radiation that reaches the area under the canopy of trees or plants. The amount of sunlight transmitted through the canopy varies by plant species. In the dry season, generally 10-30% of the sun's energy reaches the area under the tree, and the remainder is absorbed by the leaves and used for photosynthesis, and some return to the atmosphere. Evapotranspiration cools the air by using heat from the air to evaporate water (EPA, 2014). The purposes of this study were to determine the effect of land cover on surface elevation and surface temperature based on elevation (plateau and lowland areas).

2. Materials and Methods

This study has a study area of thirty cities which is the capital of the province in Indonesia (Figure 1).

Tools and materials used include earth surface temperature data from Terra MODIS image, interpretation of Land cover data from Google Earth imagery, and digital map of administration of thirty cities of research area. Some of the tools used Include Internet-connected computer sets, Google Earth to digitize urban land cover, ArcGIS 10 software used to analyze satellite imagery data, and Minitab to facilitate statistical tests. Land cover data processing using Google Earth Pro with magnification till1000meter and time series used is 2007 to 2016. After getting a detail image, identification can be started by biting the appearance of a map of vegetaed land. Digitization can be done by creating polygons. Then calculate the area of polygon by looking at the properties of polygon. Further processing of Citra Terra MODIS data for earth surface temperature. Data of Terra Modis taken is monthly MOD11C3 product during 2007 until 2016. Based on Terra MODIS data guide by Wan (2006) MOD11C3 product has scale factor of 0.02 used in surface temperature identification algorithm. Map Calculation menu in ArcGIS is used to convert temperature values with formulations,

$$^{o}\text{Celsius} = ([\text{LST\_Day}]*0.02) - 273.15$$

Temperatures are converted in degrees Celsius and then searched for the average city by inputting the minimum and maximum temperatures of the city and then taking average. The sought-after effect is the change of green land cover to the earth's surface temperature of thirty cities, to lowland cities, and cities in the plateau are testing regressions.

Figure 1. Thirty cities where become study areas. All of cities are capital of provinces in Indonesia.

3. Results and Discussion

The classification of land cover used is unclassified classification where the land cover is classified into two classes are vegetated land and non-vegetation. In this green space classification does not pay attention to vegetation type or vegetation density. For 2007 till 2016 the change of each city is different. Almost the entire change in green land cover is decreasing. Reduced green areas occur in urban and rural areas. The Figure 2 explains that almost all 30 rural areas. The Figure 2 explains that almost all 30 cities that are provincial capitals in Indonesia are experiencing a decrease in the green spaces each year. The average decrease in green land area 30 cities for 14.56%. The cities with the highest percentage of green space decline were Mataram (35.7%), Banda Aceh (32.8%), Kupang (26.6%), Pangkal Pinang (25.2%), and Jambi (24.2%). The decline in the area of green space is due to the conversion of land into land for building. This is supported by the increasing number of residents and various activities so that the change of development cities is micadyn. Five cities with the lowest percentage of green space during the last ten years are Jakarta (0.9%), Yogyakarta (2.7%), Jambi (6%), Bandung (4.2%), and Denpasar (6.6%). Cities where is the widely of green land cover are the capital cities in eastern Indonesia and Kalimantan, the five cities with the highest green areas are Ambon (95.5%), Jayapura (94.5%), Palangkaraya (97%), Samarinda (75.5%), and Palu (84.4%).

During the last five years the whole city experienced a decrease in green area except for the city of Surabaya. Surabaya green land has increased the green area since 2012 in a row until now. Based on the analysis of green land cover by google earth image percentage increase of green land of Surabaya for five years reached 4.7%. As for several factors that influence are the area, type and shape of topography of urban land surface, population, development and building of city that influence the density of city. The socio-economic factors that influence government development policies, urban sprawl (uncontrolled urban sprawl), the need for land for agricultural activities, and the growth of new hierarchical centers (Pribadi et al., 2006). Some cities in Java, Bali, Sumatra, and Nusa Tenggara have a tendency to change the area of green land caused by the development of the expanding city development, while some cities located in Kalimantan, Sulawesi and Papua have a tendency to change the extent of green land caused by urban development and mining activities.

Every year the surface temperature changes in the thirty cities in Indonesia is at an interval of 25-40 °C (Figure 3). Figure 3. explain the change of surface temperature detail all of cities.

Cities where is the highest surface temperature average is Jakarta 38°C, Yogyakarta 34.9°C, Surabaya 34.4°C, Makassar 34°C, Medan 33.5°C. Some of the cities with the lowest temperatures average are Ambon 26.3°C, Ternate 26.9°C, Jayapura 28°C, Manado 28.8°C, and Padang 28.9°C. These conditions can explain that high surface temperatures occur in most cities on the island of Java with high density and urban activity. In addition, cities in Java tend to have lowland topography. Cities with low temperatures tend to be cities in eastern Indonesia or a city with a topography of the plateau or in the form of hills and mountains. When compared to the density of urban development, cities with high temperatures tend to have higher development densities than cities with low surface temperatures.

Increasing or heating urban temperatures are one of the effects of global climate change. Climate change itself is a change in the physical condition of the earth's atmosphere, among others, temperature and distribution of rainfall that bring widespread impact on various sectors of human life. In Indonesia climate change is indicated by four things namely: (a) Average annual temperature increase of about 0.3 ° C, (b) Annual rainfall tends to decrease by 2-3%, (c) Average change rainfall, in the southern part of Indonesia tends to decrease and in the northern part tends to increase, (d) Occurrence of seasonal shifts (rain and dry) (Hairiah et al., 2016). increasing of temperature is due to changes in land cover, population increase, and urban development. Vegetation has a big role in dampening the maximum temperature to be lower. Effendy (2011) explained that the first mechanism of forest canopy is able to reduce the solar radiation coming to the forest floor surface so that the surface temperature of the forest becomes low. The second mechanism is the

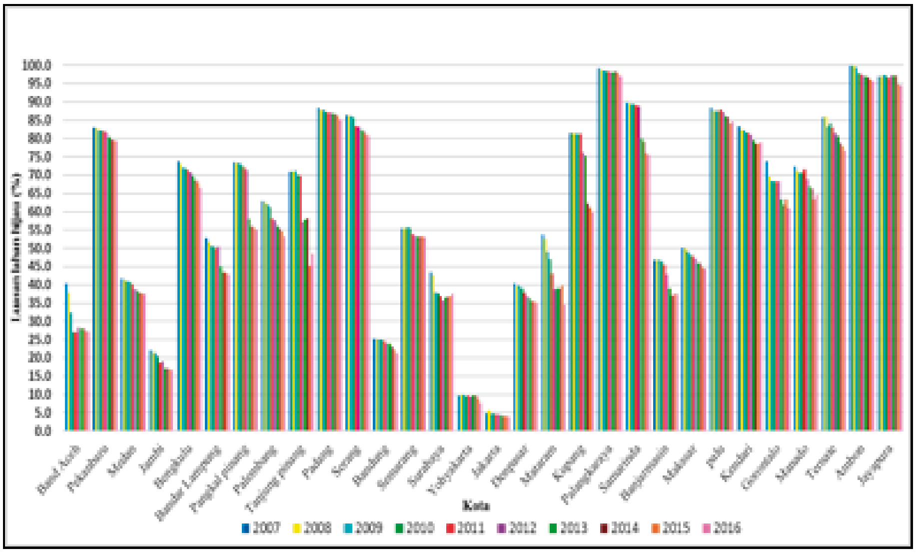

Figure 2. Percentation of Green Land Cover of Thirty Cities in Indonesia 2007 - 2016

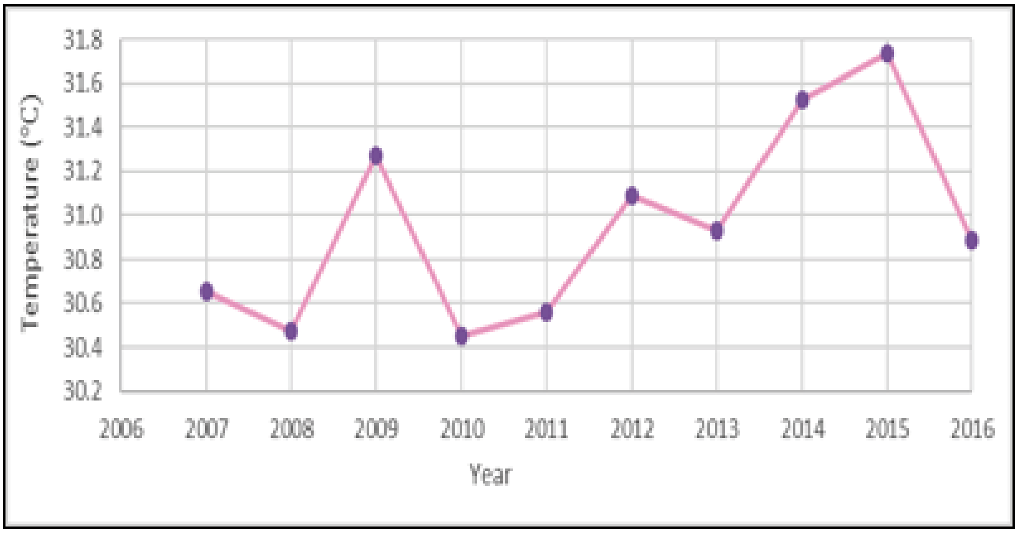

Figure 3. Average of surface temperature of Thirty Cities in Indonesia 2007-2016

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Regression Analysis: SUHU versus VEGETASI

The regression equation is
SUHU = 35.1 - 0.0700 VEGETASI

Predictor        Coef    SE Coef        T      P    VIF
Constant      35.1176     0.1073   327.17  0.000
VEGETASI    -0.070023   0.001651   -42.42  0.000  1.000

S = 2.61453   R-Sq = 33.3%   R-Sq(adj) = 33.3%

Analysis of Variance
Source            DF     SS     MS        F      P
Regression         1  12298  12298  1799.07  0.000
Residual Error  3598  24595      7
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Figure 4. Regression test for influence of vegetation change to temperature of thirty cities in Indonesia.

use of sunlight energy during the day is usually widely used for evapotranspirasi while to heat the air a little more. The condition can be interpreted that the earth surface air heating comes from the accumulation of micro air heating. The magnitude of the effect of urban land cover on surface temperature in Indonesia is presented through the following linear regression equation (Figure 4).

F test value on variance analysis (Anova) and partial T test has P value 0.000 < from 0.05 so that vegetation variable individu or partial have significant effect to temperature variable. The model of regression equation formed on is "Temperature = 35.1 - 0.0700 Vegetation". From the results of the equation, it can be seen that the intercept coefficient of 35.1, which means that if the variation of vegetation changes equal to zero then the temperature has an initial value of 35.1. The vegetation regression coefficient is -0.070 which means that if the vegetation has an increase of an area then the temperature will decrease by 0.070 celcius. The value of determination coefficient (R Square) is 33.3%. This means that 33.3% of all variations in total temperature can be explained by vegetation, while the remaining 66.7% are other factors that are not used as independent variables in this study. R square model with a small result relatively show that the model equations are not enough to describe the influence between the two variables. It is also found in some previous studies, Iswanto (2008) stated that the relationship between vegetation with Pangkal Pinang city temperature yielded regression model with the conformity of Rsquare 36%. Although based on the equation model formed from this research indicates that vegetation has little effect, but the results of research and experiment show that vegetation can decrease the environmental temperature (micro) or surface temperature. In a satellite-based study, Rinner and Hussain (2011) mentioned that the effect of the extent of this type of land use also affects surface temperatures. The magnitude of the effect of vegetation on temperature also has different results on different environmental conditions. Munier and Burger (2001) found differences in the influence of vegetation on ambient temperatures measured in daylight conditions and night (dark) with daytime results having a higher effect. Based on the variety of research, the following discussion of the effect of vegetation on surface temperature based on city elevation in Indonesia.

The grouping of 30 cities in this study refers to elevation of the cities (Table 1). The result of regression test of the effect of land cover to temperature in lowland and plateau city can be seen in Figure 5 and Figure 6. Linear regression model that formed in lowland category is "Temperature = 35.1 - 0.067 Vegetation". From the results of the equation, it can be seen that the intercept coefficient of 35.1, meaning that if the variation of vegetation changes equal to zero then the temperature will have an initial value of 35.1. The vegetation regression coefficient is -0.067 which means that if the vegetation increases 1 unit of vegetation area then the temperature will decrease by 0.067 °C. The coefficient of determination (R square) is 26.8%. This means that 26.8% of all variations in total temperature can be explained by vegetation, while the remaining 73.2% is another factor that is not considered into the model or not used as a variable in this study. Based on the regression

Table 1. Classification cities based on elevation

Lowland	Plateau
Banda Aceh, Palembang, Surabaya, Jakarta, Denpasar, Samarinda, Banjarmasin, Makassar, Kendari, ambon, Pekanbaru, Medan, Jambi, Serang, Semarang, Mataram, Bengkulu, Pangkal Pinang, Tanjung Pinang, Kupang, and Palangkaraya.	Bandar Lampung, Padang, Bandung, Yogyakarta, Palu, Gorontalo, Ternate, and Jayapura.

Regression Analysis: SUHU versus VEGETASI

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The regression equation is
SUHU = 35.1 - 0.0670 VEGETASI

Predictor       Coef   SE Coef       T      P    VIF
Constant     35.1195    0.1367  256.99  0.000
VEGETASI   -0.066959  0.002157  -31.04  0.000  1.000

S = 2.74631   R-Sq = 26.8%   R-Sq(adj) = 26.7%


Analysis of Variance
Source            DF       SS      MS       F      P
Regression         1   7268.3  7268.3  963.68  0.000
Residual Error  2638  19896.4     7.5
Total           2639  27164.7
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Figure 5. Regression test for influence of vegetation change to temperature of lowland cities in Indonesia

Regression Analysis: SUHU versus VEGETASI

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The regression equation is
SUHU = 34.8 - 0.0734 VEGETASI

Predictor       Coef   SE Coef       T      P    VIF
Constant     34.8343    0.1581  220.35  0.000
VEGETASI   -0.073432  0.002278  -32.23  0.000  1.000

S = 2.13110   R-Sq = 52.0%   R-Sq(adj) = 52.0%

Analysis of Variance
Source           DF      SS      MS        F      P
Regression        1  4717.5  4717.5  1038.73  0.000
Residual Error  958  4350.8     4.5
Total           959  9068.3
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Figure 6. Regression test for influence of vegetation change to temperature of plateau cities in Indonesia

test, the P-value value of the F test in the analysis of variance (Anova) which is a simultaneous test and partial F test is 0.000 <from α 0.05 which means simultaneously or partially vegetation has a significant influence on temperature. Regression equation formed is "Temperature = 34.8 - 0.0734 Vegetation". Vegetation regression coefficient of -0.0734 which means that if the vegetation increased 1 unit of vegetation areas then the temperature will decrease by 0.0734 celcius. The coefficient of determination (R square) is 52%. This means that 52% of all the total temperature variations can be explained by vegetation, while the remaining 48% is another factor that is not considered into the model or not used as a variable in this study. Rsquare model with relatively small results show that the model equations are not enough to describe the influence between the two variables. Based on the regression test, the P-value value of the F test in the analysis of variance (Anova) which is a simultaneous test and partial F test is 0.000 <from α 0.05 which means simultaneously or partially vegetation has a significant influence on temperature. Based on regression result of each model, got the coefficient of vegetation give almost the same effect. Highland vegetation coefficient values 0.0734 and 0.067 on the lowlands. Although they have similar vegetation coefficients but the actual condition of surface temperatures in the highlands tends to be lower and higher surface temperatures are higher. This is caused by factors other than vegetation ie the elevation of the region or city also affect. Purwantara (2015) states that for every 100meter increase in normal temperature, Indonesian cities will decrease by 0.6 °C. Sasky et al., (2017) obtained a model of vegetation influence on temperature in highland area of Bandung with Rsquare 60%. The results are in accordance with the results of this study on the category of cities in the highlands that the model has a moderate degree of accuracy.

4. Conclusion

Land cover (vegetation) is inversely proportional to surface temperature. In result of regression of vegetation variable give influence 33% from total variable influencing temperature. Vegetation has almost the same effect on cities with different elevations.

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