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The Effect of Changes in Land Cover and Vegetation Density on Urban Heat Island in Semarang City

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Keywords

Forecasting Analysis; Land Cover Change; Surface Temperature Distribution; Urban Heat Island; Vegetation Density.

Abstract

The urbanization process can be seen not only as influenced by increasing population growth but also the phenomenon of urbanization. The city of Semarang from 1999 to 2019 saw an increase of half a million people with a total population of around 1.81 million people. Along with population growth that occurs, land conversion to meet the needs of life often clashes with the presence of vegetated land. As a result, the area of vegetated land slowly decreases. On the other hand, the massive build-up of this area makes it easier to reflect and absorb solar heat. As a result, the average surface temperature of the city gradually rises which causes the formation of hot spots that cause changes in climate and weather elements, thus triggering the formation of an Urban Heat Island (UHI). The increase in temperature in urban areas affects not only the comfort of cities but also the health of urban communities, which will impact various city line activities. This urban heat island study, related to changes in land use in Semarang, is urgently needed to make wiser spatial planning decisions. In line with the problems above, this study is aimed at analyzing the effect of changes in land cover and vegetation density on the area of Urban Heat Island (UHI) in Semarang City. The approach used is forecasting with multiple regression analysis methods. Sources of data used are secondary data and population data. The data used is time series data. Based on the statistical analysis results indicate that the variables of land cover and vegetation density have a significant influence on the distribution of surface temperature. The land cover component has a positive effect while the vegetation density component harms the surface temperature distribution area. The appearance of the trendline results in an increasing area of surface temperature distribution in 2030 with 3 scenarios, namely, pessimistic, moderate, and optimistic. The preparation of a planning scenario in which an optimistic scenario can be adopted by the government so that the area of high urban surface temperatures does not expand and have an impact on the level of community vulnerability to extreme weather.

1. INTRODUCTION

The urban area is a function of the central residential area, which has a relatively large population with a high density, has a limited area, and is usually non-agricultural. The denser the population who inhabit an urban area, of course, will result in the activities and services of the city undergoing a reasonably rapid development change (Pontoh & Kustiawan, 2009). One form of this rapid development can be seen in the large number of large cities that were born or expanded where more and more people live in them (Mirzaei, 2015; Sobirin & Fatimah, 2015). The world's urban growth is increasingly rapid, and the size of cities is getting bigger. Concurring to 2019 World Bank data, the population in the world's cities is 55.71%. This indicates that more than half of the world's population has occupied land and has activities in urban areas. While in Indonesia, World Bank data (2019) shows that the population in urban areas is 55.99%. This percentage is slightly higher than the world average. This implies that more than half of Indonesia's population is scattered and lives in large urban areas such as Greater Jakarta, Surabaya, Semarang, Medan, Makassar, and other cities.

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Of course, the higher the population and the high level of urban development will result in changes in land use and the emergence of the issue of limited space (Arie, 2012). As a result of this limited space, changes in land use for development and fulfillment of living needs are unavoidable, even in some cases, there is a mismatch between the designation plan and the land use. This, of course, can guide to a reduction in the quality of the urban environment due to the conversion of vegetated land. According to (Afriana & Others, 2013; Eko & Rahayu, 2012; Fawzi & Nahari, 2013), this urgent development of vegetation land allocation has a broader goal. Where vegetated land will be converted into built-up lands such as asphalt and concrete for roads and other buildings and structures, which are easier to absorb heat and raise surface temperatures in urban areas (Hardyanti, Sobrim, & Wibowo, 2017), these activities trigger the emergence of new hot spots and the longer the existing hot spots will cause changes to the elements of climate and weather. The increase in surface temperature occurs in the downtown area, and the temperature will be more relaxed in the suburbs. Generally, the annual mean temperature in urban areas will be around 4°C-8.2°C higher than in suburban areas (Estoque, Murayama, & Myint, 2017).

Such a situation, when the average annual temperature in urban areas is greater than in the suburbs, is called Urban Heat Island (Adiningsih, Soenarmo, & Mujiasih, 2001; Belgaman, Lestari, & Lestiana, 2012). Urban Heat Island itself is one of the most critical urban environmental problems and a challenge for many cities to find alternative solutions to the problem. IPCC (Intergovernmental Panel on Climate Change) as an international climate organization in the IPCC Special Report on Global Warming calls for countries in the world to limit the increase in the earth's temperature to around 1.5°C. It was explained that an increase of 1°C would have quite dire effects such as extreme weather, sea level rise, melting of ice in the Arctic continent, and other impacts. It is expected that with the 1.5°C limitation, sea level rise will be 10 cm lower. However, achieving this requires cooperation from various aspects of society.

One of the urban areas in Indonesia that has significant population growth and land conversion is the city of Semarang. Administratively, The provincial capital of Central Java is Semarang City. Situated on Java Island's northern shore. Semarang City is in the traffic lane connecting the region with conditions like this, Semarang City has become a city of trade, industry, and manufacturing and is growing quite rapidly. Currently, in 2019 there are nearly 1.8 million people with a population growth of 0.47%. Until the span of 5 years (2016-2021), the population density in the city of Semarang increased. With an area of almost 378 km2, with a population of 1.8 people, which means that the population density of Semarang City reaches 4.79 per square km. Currently, the city government is also trying to increase green space, one of which is through planting 58,000 tree seedlings which are expected to be able to neutralize the existing heat because the temperature in the Semarang urban area is already quite hot around 33°-36° CelsiusStudies related to the urban heat island in Semarang are currently being carried out a lot. However, this is the first time anyone has specifically discussed how far the effects of changes in land use and vegetation density have on the urban heat island. Many of them only conduct correlation research but do not further examine the magnitude of the effect. Therefore, this research is urgently needed to support decision-making and prevention of extreme climate change in the city of Semarang by looking at the vitality of the city of Semarang. This study aims to analyze the effect of changes in land cover and vegetation density in the Urban Heat Island (UHI) area in Semarang City which is expected to be the basis for making spatial planning decisions and enrich scientific knowledge related to urban heat islands, especially in Semarang City.

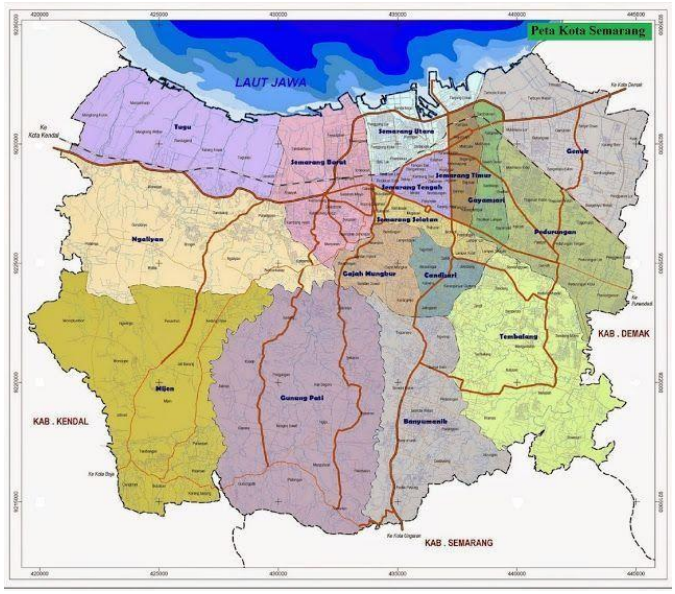


Figure 1. Semarang City Administration Map

Based on the urgency above, this research points to analyze the effect of land cover changes and vegetation density on the Urban Heat Island (UHI) area in Semarang City. While the research questions to be answered are as follows:

1. Are changes in surface temperature significantly affected by land cover and vegetation density variables?
2. What is the projected urban heat island trend in Semarang City until 2030?

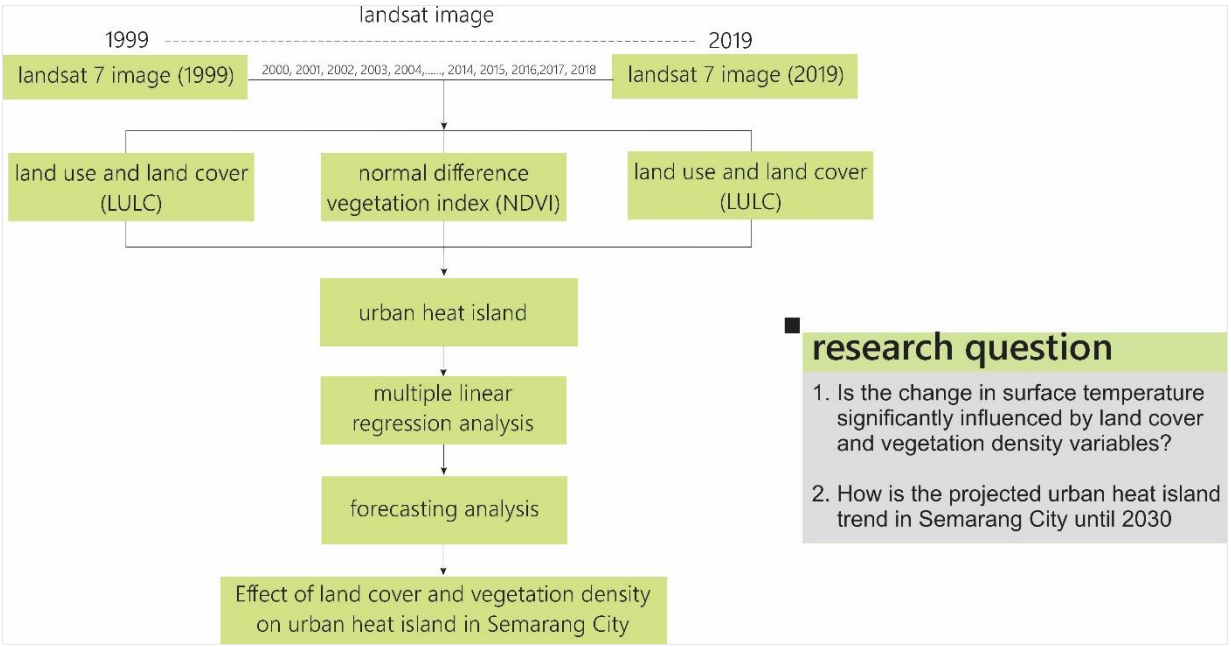


Figure 2. Research Flowchart

2. LITERATURE REVIEW

Urban Heat Island is a phenomenon of thermal pollution in urban areas which is higher than suburban areas. Increasing temperature not only has an impact on comfort but also health. Heat stress can cause death in certain people. In addition to health, which can be fatal for certain groups, an increase in temperature can also increase the need for electrical energy so that more fossil fuels will be used and then exacerbate the greenhouse effect (Nuruzzaman, M. (2015). In addition, a decrease in water quality will also decrease when an increase in temperature occurs which will certainly have an impact on marine ecosystems (Vujovic, S., et al. (2021).

Urban heat islands can be caused by several things, namely the low amount of evapotranspiration due to vegetation, absorption of solar radiation due to low albedo, airflow resistance due to higher rugosity, high amount of anthropogenic heat release (Nuruzzaman, M. (2015). Several studies also state that UHI is affected by urban urbanization, urban sprawl, and increasing population (Mohajerani, A., et al, T. (2017). Other causes are urban structures that absorb heat and the greenhouse effect and urban air pollution (Madhumathi, A., et al (2018). In line with previous research, Ramakreshnan, L, et al (2018) stated that urban heat islands are caused by urbanization, vegetation density, urban materials, land use change, high sea level, urban geometry, landscape morphology.

Specifically, several studies have attempted to explore the characteristics of an urban heat island in the city of Semarang. Some of them stated that there was a positive relationship between land use change, urbanization, and decreased vegetation density with increasing temperature in the city of Semarang. But so far no one has revealed how far the influence of this variable has on the urban heat island phenomenon in Semarang City. The following is a synthesis of previous research that has been done.

Table 1. Synthesis of Previous Research In Semarang

Author	Title	Method	Data	Results	Comparison	Annotation
Pamungkas, B. A., Munibah, K., & Soma, S. (2019)	Land use changes and relation to urban heat island (case study Semarang City, Central Java)	Spatial Analysis	-Landsat TM 5 of 2008 year -Landsat 8 OLI of 2018 year path images 120 rows 065.	-The surface temperature in Semarang has increased -The highest surface temperature values were in the landuse of built-up area and bare land, which were 26-30 C in 2008 and 30-34 C in 2018, respectively.	examine the relationship of land change with UHI	There is no research that looks at the effect of changes in land use and vegetation density on urban heat island in Semarang
Delarizka, A., & Sasmito, B. (2016)	Analisis fenomena pulau bahang (urban heat island) di Kota Semarang berdasarkan hubungan antara perubahan tutupan lahan dengan suhu permukaan menggunakan citra multi temporal landsat	Corellation analysis	-Landsat 7 -Landsat 5 -Landsat 8	changes in land cover and vegetation index have a correlation with surface temperature	examine changes in land cover with surface temperature	
Sejati, A. W., Buchori, I., & Rudiarto, I. (2019)	The spatio-temporal trends of urban growth and surface urban heat islands over two decades in the Semarang Metropolitan Region	Stochastic Cellular Automata	-Landsat 5 T M -Landsat 8 OLI	SUHI mitigation scenarios through the Spatial Planning instrument	make predictions using CA, not focusing on seeing the influence of urban growth on UHI	
Darlina, S. P., Sasmito, B., & Yuwono, B. D. (2018).	Analisis Fenomena Urban Heat Island Serta Mitigasinya (Studi Kasus: Kota Semarang)	Corellation Analysis using Regression	- Landsat 8 year 2009, 2013, 2018	UHI mitigation that can be done is: physical modification of buildings, in the form of using materials with high albedo, application green walls, green roof, green parking lot, as well as dditional vegetation around the building and along the road. Besides It is also necessary to monitor changes in land use and their suitability with the RTRW of Semarang City which has been set.	do a correlation analysis to produce recommendations regardless of how much influence	
Sasmito, B., & Suprayogi, A. (2017).	Model of Environmental Criticality Index with Urban Heat Island Algoritm in Semarang City	Spatial Analysis	-Landsat 8 TIRS -Landsat 8 OLI	- The northern and central areas of Semarang were identified as the most critical environmental areas based on LST and availability of vegetation cover	identify critical areas using the environmental index criticality model, regardless of impact or influence	

Author	Title	Method	Data	Results	Comparison	Annotation
Mubarok, R., Septiarani, B., Yesiana, R., & Pangi, P. (2021)	Pengaruh Tutupan Lahan Terhadap Fenomena Urban Heat Island di Kota Semarang	Spatial Analysis	-	"The surface temperature value will be inversely proportional with vegetation density".	look at the effect, but only on land cover, not on changes in land use and vegetation density	

3. METHODS

3.1 Type of Research

The research approach is descriptive, explanatory research, where the data is processed. Then each variable component is explained through hypothesis testing, while the research approach is a forecasting research approach.

3.2 Sources and methods of data processing

The data source is secondary data, and 20 units of population data are used in the time series from 1999 to 2019. The data collection method used is a literature study by taking information relevant to the research and downloading Landsat data sourced from the usgs.gov website. The data used are Landsat 7 satellite imagery for 1999-2017, 2015, and 2016. In addition, Landsat 8 data is also used for 2014, 2017, 2018, and 2019.

Landsat data is then processed using ENVI and ArcGIS software so that data are obtained in the form of 1) the land cover area; 2) the area of vegetation density; and 3) the surface temperature distribution area, which is divided into the following components:

- Land cover data: divided into components of water bodies area, croplands, vegetated areas, and build-up areas;
- Vegetation density data: divided into very dense, dense, medium, rare, and very rare vegetation components
- Surface temperature area data: divided into areas for temperatures <21; 22-23; 24-25; 26-27; 28-29; >30;

Table 2. Data source

Years	Surface temperature distribution area > 30^{o} C (ha)	Land buildup area (Ha)	Very dense vegetated land area
1999	2497.84	7427.77	12713.81
2000	3729.19	10086.01	11013.04
2001	3415.58	9184.88	11257.69
2002	3881.69	11695.11	10561.17
2003	4347.81	11205.34	9864.66
2004	4813.93	12619.99	9168.15
2005	5280.04	12049.89	8471.64
2006	5746.16	12693.77	7775.12
2007	5304.54	12007.37	7801.46
2008	5417.53	12934.08	8373.02
2009	7467.67	15188.63	7328.94
2010	8226.38	15058.02	8263.06
2011	8219.21	15356.48	8073.01
2012	8722.63	15654.94	7882.96
2013	9098.40	15953.40	7185.23
2014	8708.32	16970.31	7013.97
2015	8918.23	16651.91	6053.01
2016	9519.81	16533.51	6859.43
2017	9641.00	16715.11	7658.72
2018	9115.53	16726.63	5750.48
2019	9260.05	17745.72	5727.92

3.3 Data analysis methods

Before deciding which analytical method to use, studies related to similar previous studies and analytical models were carried out in the analysis.

Table 3. Synthesis of Analytical Methods

Author	Methods
Dararat Khamchiangta & Shobhakar Dhakal	The forecast is a time series to ascertain how Bangkok's urban heat island is related to land use and land cover in 1991, 1997, 2005, and 2010.
Imaam Nahib	The forecasting used is the Cellular Automata (CA) model and binary logistic regression, which predict the dynamics of built-up land in Semarang City in 2022 and 2032.
Semdi Akhmad Al-Mumin, Arwan Putra Wijaya, Abdi Sukmono	The forecast used is a simple regression test to determine changes in the land cover area, vegetation index, and surface temperature distribution in Cirebon City in 1999, 2007, and 2004.

Subsequently, it can be concluded that multiple linear regression and trendline forecasting analysis approaches are used to determine changes in land cover and vegetation density to the area of distribution of surface temperatures.

3.4 Multiple linear regression analysis

The data analysis method is causal forecasting utilizing time series multiple regression analysis. It explains the pattern of relationships between the independent variable (land cover) and the dependent variable (surface distribution area) (Kachigan, 1986). Multiple linear regression is suitable when the data used uses several variables with ratio interval data types. Before carrying out the regression, a classic assumption test is also carried out to produce an excellent BLUE (Best Linear Unbiased Estimation) model. This method was chosen because it is considered able to explore effects more measurably. The following is the formula used for multiple linear regression analysis below (Gujarati, 1995):

$$Y'=a+b1X1+b2X2+\cdots+bkXk \quad (1)$$

$$Yi=(Y')+ei \quad (2)$$

Y' = prediction of the value of the criterion variable;
A,b = regression coefficient determined from sample data;
Ei = the error value of the difference between Y and Y'.

The stages of multiple linear regression analysis are as follows:

Variable Formulation	Variable Selection	Assumption Checking Predictor	Model Accuracy Check	Model Significance Test
⇩	⇩	⇩	⇩	⇩
The formulation is based on theory, logic, and data availability.	Selection of independent variables and dependent variables.	Checking assumptions with linearity, normality, multicollinearity, homoscedasticity, and autocorrelation tests.	Check the model's accuracy by looking at the value of the correlation coefficient and determination.	Testing by calculating the F value (overall test)

a. Assumption Test

Data normality test

A normal distribution test-like pattern is a sign of good data. The distribution of the data is neither left- nor right-skewed. The normality test is used to examine whether the data distribution, or distribution having a bell-shaped form, is near to the normal distribution. Histograms and p-plot graphs can be used to perform normality tests. Assume that the remaining points spread out and move along the diagonal line's general direction. In that situation, the regression model fulfills the assumption of normality. The regression model, however, does not meet the condition of normality if the remaining points are dispersed far from the diagonal line and do not follow the diagonal line's direction. This is because a decent regression model has a normal or nearly normal data distribution.

Multicollinearity test

The presence of multicollinearity affects the regression model. Assume that all or some of the independent variables in the regression model have a precise and exact linear relationship. Correlation between variables in regression analysis is avoided so that the data obtained will not be over-estimated and have significant errors. With multicollinearity, the Least Square assumption that must be met in all causal analyses will not be achieved. Correlation analysis and VIF calculations are two methods for detecting multicollinearity between independent variables. A variable is deemed to be highly linked if its VIF exceeds 10 and its R2 value exceeds 0.90.

Heteroscedasticity test

Heteroscedasticity is a situation where the variance of the confounding factor is the same for all observations or observations on the independent variable. If the value of the variance of the dependent variable increases due to the rise in the independent variance, the variance of the dependent variable will be unequal or not constant, called heteroscedasticity. One method that can be used to detect the presence or absence of heteroscedasticity is by looking at the scatterplot graph. Suppose there is a particular pattern, such as forming a regular pattern on the scatterplot graph. In that case, it indicates the existence of heteroscedasticity.

Autocorrelation test

Autocorrelation test Autocorrelation can occur in cross-section research. If there is a relationship between the variables and the residuals, autocorrelation will happen. To detect the occurrence of autocorrelation in the regression model by looking at the Durbin-Watson value.

b. Model Accuracy Test

Correlation Coefficient (R)

The correlation coefficient, which may be calculated by taking the root of the coefficient of determination, is used to assess the degree of association between variables. Utilizations for correlation analysis include:

1. As the direction of the relationship between the two measures

Tendency to move in opposite directions, either simultaneously (positively correlated), one after the other (negatively linked), or not at all (uncorrelated).

2. As an Association Power

If the correlation between the two measures of association increases as the absolute value of the correlation increases away from zero, it is likely that there is a linear relationship between the two measures of association. Let's say there is a non-linear relationship between the two steps. In that case, the correlation coefficient will not be able to express the strength of the relationship between the two measures.

The following is an interpretation of the correlation analysis:

- If the value of r is positive, then there is a positive relationship between variable X and variable Y. That is, if the value of X increases, then the value of Y also increases or vice versa;
- If the value of r is negative, then there is a negative relationship between the X variable and the Y variable. That is, if the X value increases, the Y value decreases or vice versa;
- If r is close to 1, then the relationship between the variables X and Y is very close;
- If r is close to 0, then the relationship between X and Y is not very close;
- If r = 0, there is no linear relationship between variables X and Y.

Coefficient of Determination (R2)

In regression analysis, the coefficient of determination (R2) is a crucial metric that indicates the accuracy of the estimated model. R2 calculates the proportion of the variance in the dependent variable Y that can be accounted for by the independent variable X. The coefficient of determination R2 has a value that varies from 0 to 1, and it represents how well the estimated model matches the data. Assume that R2 = 0. It implies that X in the scenario. cannot account for the variation in Y. All observation points are directly on the regression line with a high level of model appropriateness if R2 = 1. (Makridakis, 1995).

c. Model Significance Test

The F test/overall test is employed in this investigation. The F test is used to determine the effect of the independent variables simultaneously (simultaneously) on the dependent variable. Significant means that the relationship that occurs can apply to the population.

Hypothesis Formulation:

- H_0 → together, the independent variables have no significant effect on the dependent variable;
- H_i → together means that the independent variables significantly influence the dependent variable.

With the following test criteria:

- If (alpha=0.05) and Fcount > Ftable are significant, then H0 is rejected, and H1 is accepted, indicating that the independent factors have a significant impact on the dependent variable;
- H0 is accepted and Hi is rejected if significance > (a = 0.05) and Fcount Ftable, indicating that there is no significant interaction between the independent factors and that has no significant impact on the dependent variable.

3.5 Trendline forecasting analysis

Forecasting analysis is a method used to predict or predict future events by considering past and current data and information (Makriakis, 1983). Kachigan (1986) in his book states that with similar events, things that used to happen in the past can happen in the future. Trend data patterns define a tendency to go up or down continuously. There is no significant stability. Some forms of trendline models are exponential, linear, logarithmic, polynomials, power, and moving average.

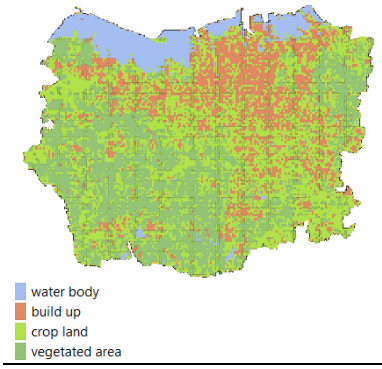
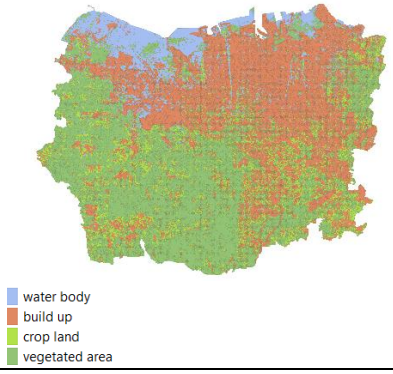
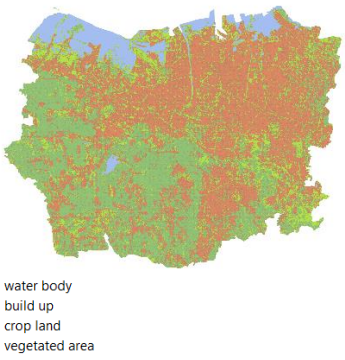
4. RESULT AND DISCUSSION

Semarang City, the capital of Indonesia's Central Java Province and the fifth-largest metropolitan region in the country after Jakarta, Surabaya, Medan, and Bandung, is the subject of the study. Semarang City, one of the most developed cities on the island of Java, is home to more than 1.8 million people, and during the day, that number can increase to 2 million. The following is an analysis and discussion for the study of land cover changes and vegetation density in the urban heat island in Semarang City.

4.1 Identification of land cover changes

The following is the result of the identification of land cover in the city of Semarang using ArcGIS analysis:

Table 4. Changes in Land Cover in Semarang City in 1999-2019

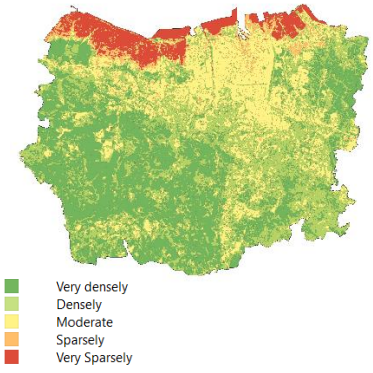
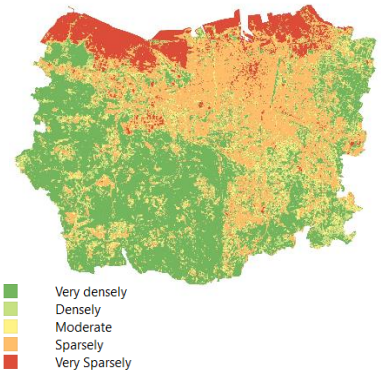
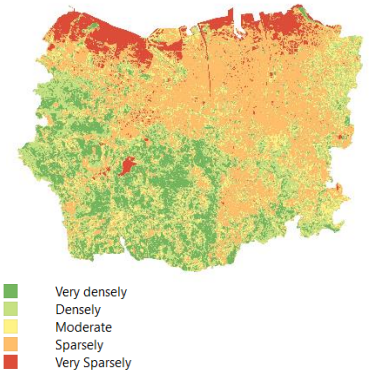
Land Cover		
1999	**2009**	**2019**
		

The build-up area increased from 7427.77 Ha in 1999 to 17,745.72 in 2019, or an increase of 58%, indicating the widening of urban growth towards the periphery, indicating that development favors the vegetated area. The vegetated areas decreased from 17,947.43 in 1999 to 11,350.31, or 37%. Red areas replace vegetation areas, meaning that buildings or roads have replaced them. There is the conversion of vegetated land and cropland into the built-up area; the cropland area increased from 5365.03 ha to 7393.90 ha, but the vegetation area decreased from 1469.98 ha to 11350.31 ha. Identification of the decreased area of open space with time series using Landsat imagery has been carried out in various regions as in the research of Peijun, et al (2010), Wessels, et al (2012), and et al (2023).

4.2 Identification of vegetation development

The following is the result of the identification of land cover in the city of Semarang using ArcGIS analysis:

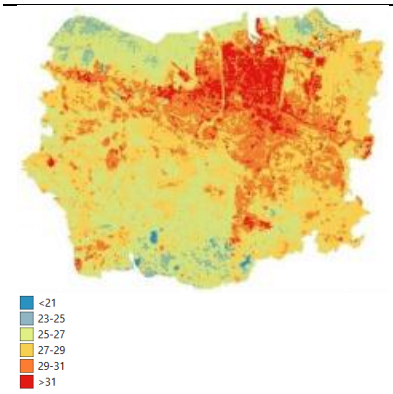
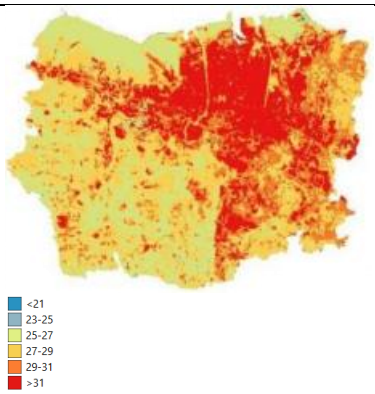
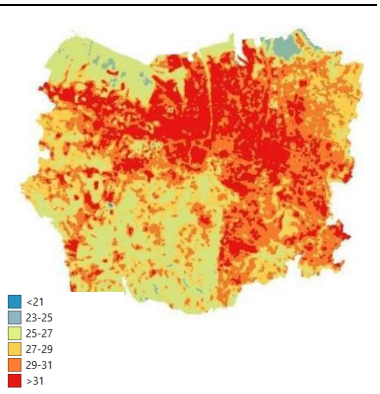
Table 5. Changes in Vegetation Density of Semarang City in 1999-2019

Vegetation Density		
1999	**2009**	**2019**
		

The area of very densely vegetated land has decreased from 12,713.81 Ha in 1999 to 5,727.92 Ha in 2019. There has been a 55% decrease around vegetation density. The area of densely vegetated land has decreased from 13,532.49 Ha to 8,404.20 Ha in 2019 or by 38%, and there are indications that green open space is shrinking. The city is declining. Reviewing past studies reveals that, as in the studies of Solangi et al. (2019), Guha and Govil, (2020), and Rahaman, a decrease in the quality of green open space can significantly contribute to an increase in surface temperature (2022).

4.3 Identification of surface temperature area

Table 6. Changes in Surface Temperature Distribution of Semarang City in 1999-2019

Surface Temperature (℃)		
1999	**2009**	**2019**
		

The land area with a temperature > 300 C increased from 2,497.84 Ha in 1999 to 9,260.05 Ha in 2019 or 73%. There is an increase in the maximum temperature in Semarang City from 330 C in1999 to 36o C in 2019. It suggests the development of the UHI phenomenon, which is characterized by the formation of new hot spots and a higher average temperature in urban regions than in the suburbs.

4.4 Multiple linear regression analysis

To determine how the independent variable affected the dependent variable and to explain the pattern of association between the two variables, multiple linear regression analysis was carried out (Kachigan, 1986). After formulating the variables in the previous section, it was found that: Variable Y: Surface Temperature Distribution (land temperature > 300C); Variable X1: Land Cover (build-up area); Variable X2: Density of vegetation (very dense).

Regression analysis using the SPSS ver.22 application and using the "Entered" method to produce multiple regression models as follows:

Table 7. Results of the Regression Equation

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-2787.477	2784.278		-1.001	0.33
	Land cover	0.747	0.101	0.91	7.384	0
	Vegetation density	-0.106	0.188	-0.069	-0.563	-0.58

The table above shows the regression equation model, where the regression equation model is as follows:

$$\boldsymbol{Y = -2787.477 + 0.747X1 - 0.106X2} \qquad (2)$$

- The constant value -2787.477 means that the land cover (X1) and vegetation density (X2) when they have a constant value / 0 then the area of the distribution of soil surface temperature in Semarang City will be -2787.477;
- If the value of the land cover variable increases by one unit (ha), it will increase the Y value by 0.747%. assuming that land cover (X1) and vegetation density are constant concerning the surface temperature distribution area (Y);
- If the value of vegetation density increases by one unit (ha), it will decrease the Y value by 0.106%;

In the table above, the regression results also display the Standardized Coefficients (beta) value so that you can identify the variable that has the most impact and contributes the most to the Y variable. Because the land cover variable has the greatest Beta value, the Standardized Coefficients (beta) results demonstrate that it is

the most significant variable. That is equal to 0.910 with a positive direction, and the density of vegetation has an effect of 0.69 with a negative direction.

4.5 Assumption check

The classical assumption test includes 4 tests: multicollinearity, autocorrelation, heteroscedasticity,and normality.

- Multicollinearity Test

In a multiple linear regression model, multicollinearity is the existence of a linear relationship between independent variables (Gujarati, 2003). A perfect linear relationship (perfect) and a less-than-perfect linear relationship are both examples of a linear relationship between independent variables (imperfect). A model without multicollinearity in the independent variable is a good example of a linear regression model. This test determines whether the correlation coefficient value for the relevant variable is outside the acceptable range (critical value). can determine the presence of multicollinearity by examining the VIF value (Variance Inflation Factor). Assume the VIF value is less than 10.00 and the tolerance value is more than 0.01. In that situation, multicollinearity is said to be absent from the regression model. The results of the multicollinearity test are summarized below:

Table 8. Level of Collinearity

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Land cover	.196	5.111
	Vegetation density	.196	5.111

The VIF value of each independent variable is 5.111, where this value is less than 10.00, and the tolerance value of 0.196 is more significant than 0.10, according to the results of the collinearity statistical study. The regression model does not have multicollinearity issues based on the two criteria.

- Autocorrelation Test

When incorporating time series data into regression models, it's crucial to test for autocorrelation. To determine whether there is autocorrelation, utilize the Durbin-Watson statistic. The acceptance or rejection criteria that are formed based on the dL and dU values, which are determined based on the number of independent variables (n) in the regression model (k) and the number of samples, will alter if there is autocorrelation:

- Number of independent and dependent variables = k = 3;
- Number of population = n = 20 data units;
- Value dL = 0.9976;
- Value of dU = 1.6763;

Table 9. Durbin-Watson Test Results

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.946	.941	581.70452	1.367

Autocorrelation test: DL < DW < (4-d)

After knowing the lower limit value and dU value, it is necessary to find the upper limit by the formula (4 – d) = 4 – 1.367 = 2.633. So that the equation 0.9976 < 1.367 < 2.633 is obtained. Furthermore, positive and negative autocorrelation will be carried out based on these equations with the following results:

- If dw > dL then there is no positive autocorrelation, based on the calculation of the value of dw = 1.367 > dL value = 0.9976 so that there is no positive autocorrelation;

- If (4 – dw) > dU then there is no negative autocorrelation, based on the calculation of the value (4 – dw) = 2.633 > dU value = 1.6763, so there is no negative autocorrelation.

- Heteroscedasticity

In a decent regression model, heteroscedasticity is absent. Examining the scatterplot graph is one way to determine whether heteroscedasticity is present or absent. Let's say there is a pattern, like a regular pattern appearing on the scatterplot graph. In that situation, it shows that heteroscedasticity exists. Imagine, nevertheless, that no distinct pattern emerges or that the dots are dispersed. In that situation, it shows that heteroscedasticity is absent.

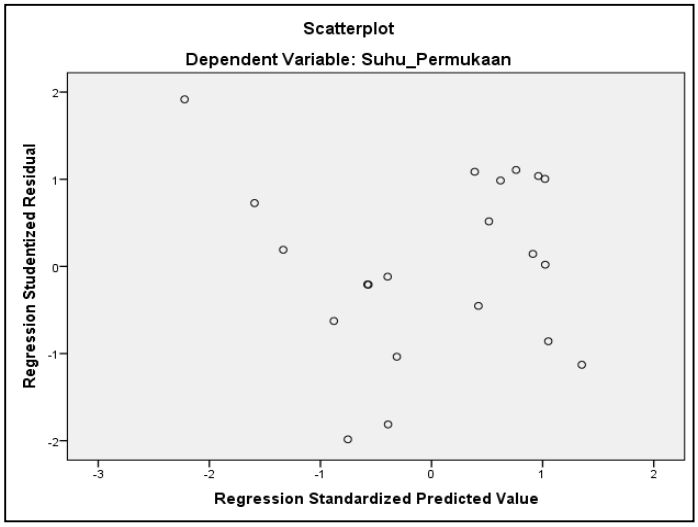


Figure 3. Scatterplot Results

The illustration above demonstrates that the distribution of points does not follow a particular shape or flow, such as a wavy or conical one, and that they are distributed both above and below the Y-axis value of 0. It can be said that homoscedasticity happens, or that there is no heteroscedasticity.

- Normality

The purpose of this normality test is to determine whether the residuals from a research regression are normally distributed. The residuals of a good regression model should be normally distributed or very close to it. The histogram and p-plot display the results of the normality test. It is important to keep in mind that the residual (data) created by a normally distributed linear regression model, not the independent variable or the dependent variable, is what the normality assumption alluded to in the study's classical assumption refers to.

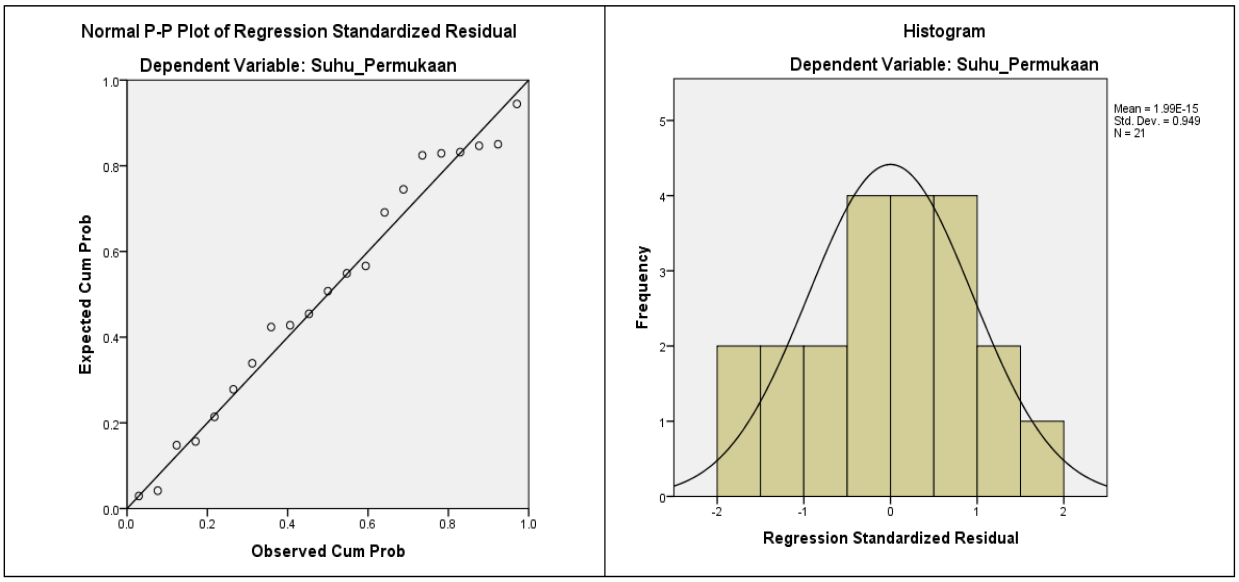


Figure 4. A) P-Plot Graph; B) Histogram Graph

The histogram shows the frequency value of the regression analysis residuals on the dependent variable. On the histogram curve, the model meets the assumption of Normality if the curve is symmetrical, and the data distribution is bell-shaped. According to the histogram curve's results, which indicate that the curve is symmetrical in shape, the regression model is normally distributed. If the points on the curve correspond with the diagonal line on the normal line p-plot, the model satisfies the assumption of normality. By looking at the distribution of points on the diagonal axis, it is possible to determine whether the residuals are normal. If the fata or points spread out along the diagonal line and move in the same direction as the diagonal line, statistics is thought to be regularly distributed. It can be inferred that the residuals are normally distributed because the distribution of points on the P-P Plot Normal Diagram is near to a straight line. This result aligns with the classical assumption of linear regression using the OLS (Ordinary Least Square). The difference between the squares of the distance between the variable points and the line formed is minimal.

4.6 Testing the accuracy of the model

- Correlation Test (R)

The correlation test (R) shows the relationship between each variable and the magnitude of the influence of these variables. It is seen based on the Pearson Correlation value. Suppose the magnitude of all variables is close to 1. In that case, the relationship between each variable can be said to be quite close or strong.

Table 10. Correlation Results

		Surface Temperature	Land Cover	Vegetation Density
Pearson Correlation	Surface Temperature	1.000	.972	-.886
	Land cover	.972	1.000	-.897
	Vegetation Density	-.886	-.897	1.000
Sig. (1-tailed)	Surface Temperature	.	.000	.000
	Land cover	.000	.	.000
	Vegetation Density	.000	.000	.
N	Surface Temperature	21	21	21
	Land cover	21	21	21
	Vegetation Density	21	21	21

Based on the output table above on the Pearson correlation row and column, the results obtained are as follows:

o The land cover variable with the surface temperature distribution correlates with 0.972, indicating a strong relationship between the two variables. The direction of the relationship between the two variables is positive (+), where the greater the value of the unit area of land cover (for built-up land), the greater the distribution area of surface temperature above 30 degrees C;

o The vegetation density variable with the surface temperature distribution correlates 0.886, indicating a strong relationship between the two variables. The direction of the relationship between the two variables is negative (-), where the more significant the unit area value of the very dense vegetation density, the smaller the distribution area of surface temperature above 30 degrees C.

- Multiple Determination Test (R2)

The value of multiple determination R2 is meaningful as the contribution of the influence given by the independent variable or the independent variable to the dependent variable. In other words, the value of the coefficient of determination aids in predicting and determining the extent to which variable X and variable Y are both simultaneously influencing each other.

Table 11. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973[a]	.946	.941	581.70452	1.367

The value of the coefficient of determination (R2) is 0.946. It demonstrates that the land cover (build-up area) and vegetation density are responsible for 94.6% of the variation in the distribution of land surface temperatures (very dense). Several factors not looked at in this study have an impact on the remaining 6.4% of the population. This research. This considerable influence shows that the variables of land cover and vegetation density simultaneously have an essential role in distribution of surface temperature in Semarang City.

4.7 Test of model significance

The regression model of this study uses population data of 20 Semarang City units taken in time series. So to test the significance iof this study, using the comprehensive test or F test, where the F test is used to test all independent variables (land cover and vegetation density) as a whole have a significant influence on the dependent variable (distribution area of surface temperature).

Table 12. Table ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	107726355.399	2	53863177.700	159.179	.000b
	Residual	6090842.712	18	338380.151		
	Total	113817198.111	20			

Hypothesis Formulation:

- H0 : land cover and vegetation density variables do not significantly affect the dependent variable, the area of land surface temperature distribution;
- H1 : land cover variable and vegetation density significantly affect the dependent variable, the area of land surface temperature distribution.

Testing Criteria:

- If the significance is ≤ α (α = 0.05) and Fcount > Ftable, then H0 is rejected, and H1 is accepted;
- If the significance > α (α = 0.05) and Fcount < Ftable, then H0 is accepted and H1 is rejected.

It is known that the value of N1 = 2 and N2 = 18 and the value of Ftable = 3.55. So it can be concluded that H0 is rejected and H1 is accepted because:

- The value of Fcount > Ftable is 159.179 > 3.55 and a significance value of 0.000 so that the variables of land cover and vegetation density as a whole have a significant influence on the area of distribution of surface temperature;
- H0 is rejected, and H1 is accepted because the calculated F value is more significant and the significance value is less than 0.05, which is 0.000.

4.8 Trendline forecasting analysis

Forecasting is an assessment or attempt to see conditions in the future. This trendline forecasting method is characteristic that the data analyzed are in series and can show periodic time. The purpose of conducting a trendline analysis of the land cover variable (build-up area) and very dense vegetation density is to help see the projection until 2030. Microsoft Excel has been provided instantly for trendline analysis. There are 5 (five) types of trendline analysis methods, along with considerations for their application.

Table 13. Usage considerations

Methods	Judgments
Exponential	Land cover : R^2 = 0.8603 Vegetation Density : nilai R^2 = 0.8507 **Not used** because the value of R2 tends to be smaller
Linier	Land cover : nilai R^2 = 0.914 Vegetation Density : nilai R^2 = 0.8277 **Used** because the value of R is high, and the result is linear with the constant addition
Logarithm	Land cover: R^2 = 0.9132 Vegetation Density : nilai R^2 = 0.909 **Not used** even though the R2 value is high but the projection results are curved
Polynomial	**Not used** even though the R2 value is high but the projection results are curved **Not used** even though the R2 value is high but the projection results are curved
Power	Land cover: nilai R2 = 0.9395 Vegetation density R^2 = 0.858 **Not used** even though the R2 value is high but the projection results are curved

4.9 Forecasting land cover trendline (built-up area)

After analyzing the trendline forecasting, the trend results for land cover with a simple regression formula are Y = 447.8x + 8905.6 with a coefficient of determination R2 = 0.9148 with the following results:

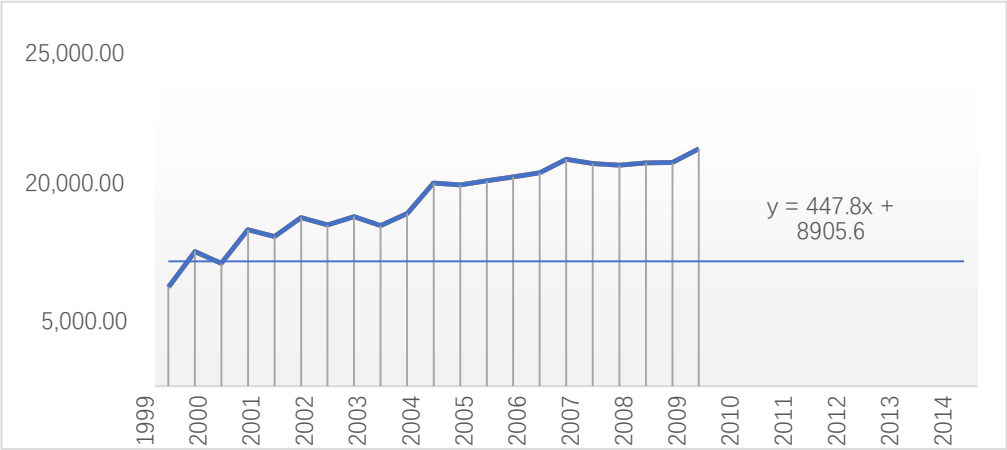


Figure 5. Land Cover Trendline – Build-Up Area 1999 – 2030

4.10 Forecasting vegetation development trendline (very delicious vegetation)

After conducting trendline analysis, the trendline results for very dense vegetation density with a simple regression formula are Y = -272.67x +11323 with a coefficient of determination R2 = 0.8277 with the following results:

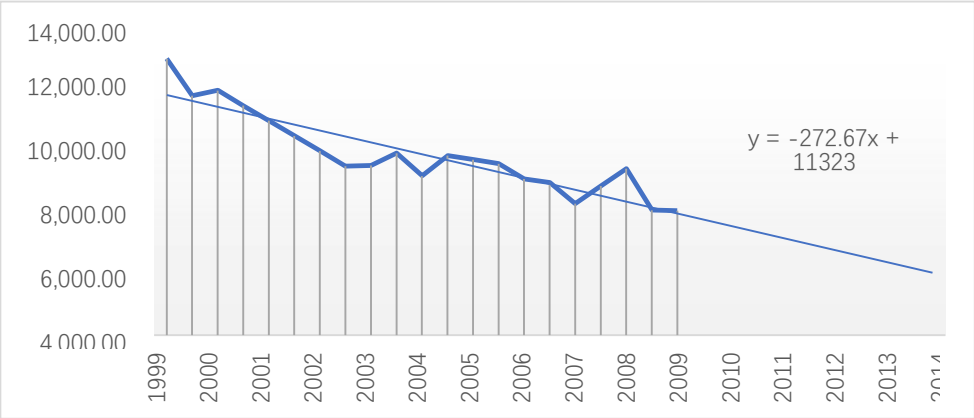


Figure 6. Vegetation Density Trendline – Very Dense 1999 – 2030

4.11 Planning scenario

The analysis of the influence of land cover and vegetation density on the surface temperature has significant implications for the area of regional and urban planning. By utilizing the linear regression analysis results in the previous analysis section, the planner can provide input to relevant stakeholders about what kind of policy/planning can be taken. More broadly, this is also related to the global plan presented by the IPCC (Intergovernmental Panel of Climate Change) in the IPCC Special Report on Global Warming, where the increase in global temperature is no more or limited to 1.5o C. This also implies future expectations. The area of land with hot surface temperatures in the city center is not increasing because it will impact the vulnerability of urban communities to extreme temperatures. The following is a planning scenario that can be an illustration of policymaking by local governments, especially the City of Semarang.

4.12 Pessimistic scenario

It is assumed that the condition of land cover change for the build-up area continues to increase constantly with a trend of Y = 447.8x + 8905.6 for each year. Furthermore, the condition of changes in vegetation density for very dense vegetation areas continues to change with a trend of -272.67x +11323, where the value of land area with very dense vegetation constantly decreases every year.

4.13 Moderate scenario

It is assumed that the condition of land cover change for the build-up area continues to increase constantly with a trend of Y = 447.8x + 8905.6 for each year. Furthermore, the condition of changes in vegetation density for very dense vegetation areas has a fixed value. Government intervention is limited to maintaining the current condition of vegetation and green open spaces.

4.14 Optimistic scenario

It is assumed that the condition of land cover change for the build-up area continues to increase constantly with a trend of Y = 447.8x + 8905.6 for each year. The condition of changes in vegetation density for very dense vegetation areas is increasing with government intervention by adding green open space and reforesting by 10% every year.

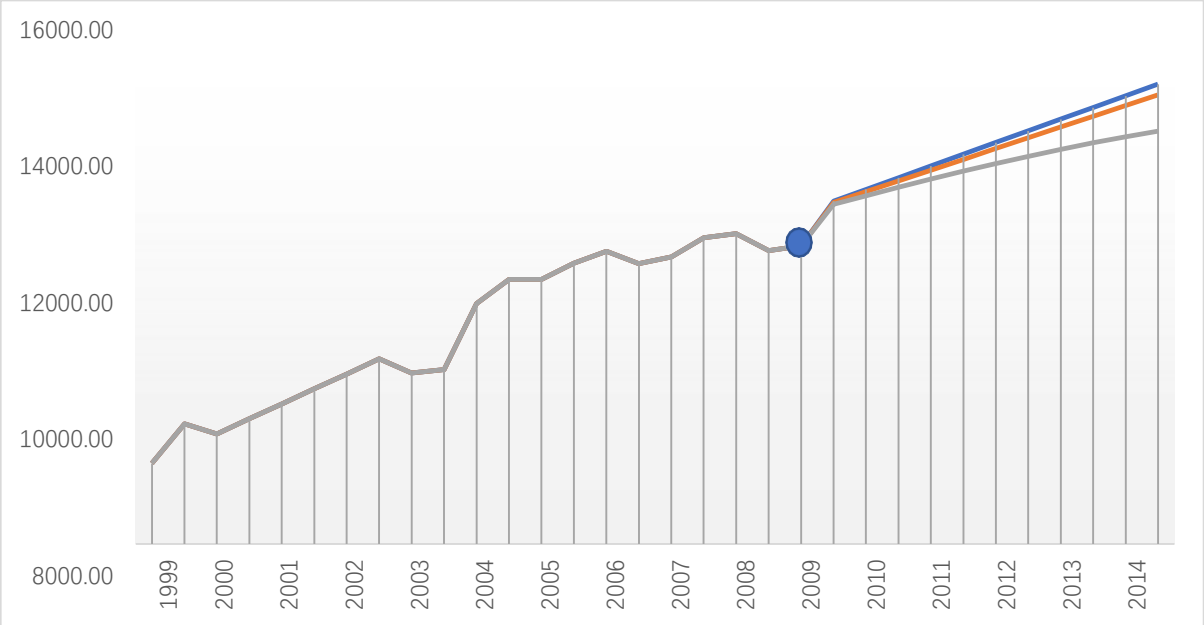


Figure 7. Forecasting of Surface Temperature Area above 300 C Semarang City 1999-2030

5. CONCLUSION

Based on a review of the findings from studies on how variations in land cover and vegetation density affect the area of surface temperature distribution in the city of Semarang, specifically:

The variables of land cover and vegetation density as a whole have a significant effect on the distribution of surface temperature with the regression equation -2787.477 + 0.747X1 - 0.106X2; The land cover component has a positive impact on surface temperature with a magnitude of 0.747 units; The vegetation density component harms the surface temperature with a magnitude of 0.106 units; The trendline results in an increasing area of surface temperature distribution in 2030 in Semarang City with 3 scenarios. Where with a pessimistic scenario, the land area with a temperature of >300 C is 14293.88 ha. With a moderate scenario, the land area has a temperature >300 C is 13962.06 ha, and with an optimistic scenario, the land area has a temperature > 300 C is 12836.92 ha.

In the research that has been carried out, some recommendations can be made by various parties, including:

The government can use this analysis for decision-making, especially policies with the provision of urban green open spaces; Following Indonesia's commitment to the global agenda of the Climate Change Convention, Indonesia plans to reduce carbon emissions by 29% by 2030 and agrees to a global agenda to limit the increase in temperature to 1.5%; So that the optimistic planning scenario can be carried out, if the government does business, as usual, the urban temperature will continue to increase it will have an impact on the level of community vulnerability to increase; The drawback of this research is that no geometric and field corrections are made to the available secondary data so that further research or research is carried out.

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