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THE EFFECT OF CITY DEVELOPMENT ON TEMPERATURE IN THE CITY OF SEMARANG

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ABSTRACT

Semarang City is one of the most densely populated cities in Central Java Province, which has experienced land conversion due to increased development. The purpose of this study is to analyze the relationship and influence of urban development on temperature in the urban area of Semarang from 1980 to 2020. Population data, land use changes, temperature change data from 1980 to 2020, and remote sensing images were used.The influence of city development and temperature used inferential statistics, which is a method related to data analysis for forecasting or drawing conclusions about the overall data. Regression analysis is one part of inferential statistics that is widely used in the decision-making process. Semarang is experiencing development, both in terms of physical appearance and population growth. The population continues to increase until it almost doubles over a period of 40 years, which is directly proportional to the increase in temperature in the city of Semarang. The results of the analysis show that the development of the city seen from changes in population and changes in built-up land has an effect on temperature changes in the city of Semarang by up to 69.9%. The spatial distribution of temperature changes shows the direction of the center of Semarang City activities in the Districts of Central Semarang, North Semarang, East Semarang, South Semarang, and Gajah Mungkur, which is also in accordance with the condition of the area, which is also a residential area and the city center.

Keywords: Population Condition, Land Cover, Temperature.

INTRODUCTION

The development of the city is strongly influenced by the growth and development of the population, and the city is a physical container. More than 50% of the world's population now lives in cities, and this figure is expected to reach almost 70% by 2050. The world's population is expected to reach 10.7 billion by 2050 (UN, 2000). (United Nations, 2000). It is predictable that 7.7 billion people in 2050 will live in urban areas, while the rural population will remain constant or decrease. Similarly, in Indonesia, we find that the urban population increased from 21 million to 123 million between 1970 and 2010 (Kirmanto et al., 2012). The urban population continues to grow and is projected to reach more than 200 million by 2035, which is almost 70% of the total population of Indonesia (BPS, 2015), with Java Island being the concentration of Indonesia's urban population.

In 1980, the population of Semarang City was 1.2 million with an area of 372.7 sq km and continued to grow to 1.8 million in 2020. Population growth causes a higher rate of land conversion from vacant land to built-up land (Setiawan et al., 2005). Changes in urban land that affect the surface climate have important consequences for the role and contribution of cities to regional climate

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change (Wang et al., 2017). According to Tursilowati (2015), the increase in built-up land and the lack of vegetation area are two of the factors causing the widespread increase in air temperature in urban areas. Areas with increasing temperatures are in the city center of Bandung (2001), Semarang (2002), and Surabaya (2002). Based on this description, the authors are interested in seeing the relationship between urban development and the effect of temperature changes in the urban area of Semarang.

Studies of urban development are mostly carried out in big cities, so this research was conducted with the aim of knowing the development of the city of Semarang by comparing the information received from related agencies with available images by utilizing remote sensing techniques as well as relating it to changes in temperature. This research is expected to provide benefits for the development of science as well as provide information for all parties who live in or have an interest in urban areas regarding the development of the city of Semarang.

LITERATURE REVIEW

The acceleration of urbanization is part of the urban development policy formulated by the government (Tjiptoherijanto, 2016). Urbanization has changed many aspects in developing countries such as Indonesia, including the spatial aspect that extends to the surrounding area (Mardiansjah et al., 2018). Population growth will certainly be positively correlated with the urbanization of each region and will trigger complex spatial processes and developments in developing countries (Buhaug & Urdal, 2013), both internally and externally.

Atmospheric temperatures vary in different land-cover areas. Temperature can be used as an indicator of the urban thermal environment (Oxoli et al., 2018). The number of residents as an influence on temperature intensity needs to be reviewed because there are other determining factors, such as urban structure, availability of green areas in the city, building density, and anthropogenic heat (Givoni, 1998). Density and other aspects, such as building density and land cover, have a larger impact on cities than city size or population size. Therefore, urban design can affect the urban climate, both in big and small cities.

METHODS

The population census in 2000 stated that the urban concept had changed according to regional developments, so that the urban criteria in 1980 and 1990 were still used, but were added by looking at the percentage of the employment sector. Bambang & Ali (2001) stated that urban areas in 1980 and 1990 can be seen by the population density per km^2 and also by urban/urban facilities.

Population data processing

The data used is time series data or time series data for 40 years from 1980 to 2020. Time series data is data in the form of time sequences that are recorded periodically to report or confirm the progress of an investigation. (Marina & Lestari, 2017). The long time series is based on the assumption that the longer the time series, the more detailed the changes that can be seen (Manik, 2009).

Population density analysis in the 1980s–2020 was carried out using the geometric method. The geometric method assumes that population growth follows a geometric series. Population growth will be assumed to be constant for a certain period of time. Calculating population density with the formula (Muta'ali, 2012):

$$KP = \frac{Population\ (people)}{area\ (km^2)} \quad (1)$$

Calculate the average population growth rate, which aims to determine the change in population over time. The figures obtained show the annual population growth over a certain period of times (BPS, 2010).

$$Pt=Po(1+r)^t \ with \ \ r= (\frac{Pt}{Po})^{1/t}\text{-}1 \quad (2)$$

explanation:

r = population growth rate
Pt = population in years t (2000/2010)
Po = first year population (1980/2000)
t = time period base year and year t (40)

Data processing for land change

Land cover change data from Landsat were obtained from Google Earth Image Pro and USGS Earth Explorer, and were then processed using ArcMap's guided

classification method. Landsat image selection was also adjusted to the appropriate time to avoid the study area being covered by clouds.

The guided classification method is an image classifier based on spectral recognition (reflection value) obtained from pixel samples (polygons representing area samples for each different land cover type). The results of image classification, namely changes in land cover, obtained are then used to explain the development of land cover changes in the urban area of Semarang. The results of image classification used are independent and relatively accurate estimates of the shape and area of urban areas (Fu & Weng, 2016).

Temperature processing

Temperature data obtained by the BMKG of Semarang City is calculated and compiled every year based on the required temperature data. The BMKG temperature data is daily, so the data is processed to obtain the average temperature data calculated for each year from 1980-2020, which is then used as material in the analysis of temperature changes in the Semarang city area. In addition, the temperature can be observed through remote sensing technology using satellite images that have thermal sensors, such as Landsat 5 and Landsat 8 images (Darlina et al., 2018), to map the temperature distribution in the study area.

The data in the satellite image is in the form of a digital number, so it must go through several conversion stages first to get the actual surface temperature value (AlMukmin et al., 2016), while the image processing stages are as follows:

1. Radiometric correction aims to improve image quality (Kustiyo et al., 2014).
2. The selection of the study area (cropping) is done by cutting the image using a reference in the form of the administrative boundaries of the research area.
3. The selection of bands in making the temperature zone, air temperature, using Landsat 5 and 7 with a combination of 3 multispectral bands in order to form a color image or produce the same target color appearance as the original (Prahasta, 2014).
4. Based on the temperature distribution generated from Landsat image processing, a class can be made to classify the temperature areas in the research location (Triyanti, 2018).

Relationship and influence analysis

According to a study conducted by Jones & Warner, (2016) shows that the proportion of global warming observed on the time scale of the last century can be attributed to local warming caused by the urbanization process resulting in changes in urban development. One of the statistical methods that can be used to see how much influence one variable has on other variables is inferential statistics, namely through simple or multiple linear regression. The researcher uses regression analysis to identify independent variables/criteria that can be predicted by independent variables or predictor variables only. As a result of using regression analysis, it can be used to decide whether increasing and decreasing the dependent variable can be tried by increasing and decreasing the condition of the independent variable and vice versa.

1. **Correlation analysis** aims to see the relationship between one variable and another. Correlation analysis produces a value called the correlation coefficient. In this study, the correlation coefficient was calculated using statistical software or SPSS. In addition, after obtaining the correlation coefficient value from the results of the analysis, then hypothesis testing is carried out on the correlation coefficient. The hypotheses of this research are:

$H_0 : \rho = 0$ Vs $H_1 : \rho \neq 0$

If through correlation analysis it is proven that there is a relationship between the two variables, then regression analysis can be carried out.

2. **The multiple linear regression equation** is mathematically expressed by (Rinaldi et al., 2020):

$$Y = a + b1X1 + b2X2 + \ldots + bnXn$$

Which one :

Y	= dependent variable (value to be predicted)
a	= constant
b1, b2,.., bn	= regression coefficient
X1, X2,…, Xn	= independent variable

If there are 2 independent variables, namely X1 and X2, then the form of the regression equation is (Rinaldi et al., 2020):

$$Y = a + b1X1 + b2X2$$

3. **The coefficient of determination (R^2)** is used to determine the percentage effect of the independent variables X1 and X2 on the dependent variable Y (Rinaldi et al., 2020).

a. If $R^2 = 0$, then the variation of the independent variables X1 and X2 cannot be the slightestexplain the variation of the dependent variable Y in the regression equation model.
b. If $R^2 = 1$, then the variation of the independent variables X1 and X2 can be explained byperfect dependent variable Y in the regression equation model.
c. If the Coefficient of Determination (R^2) has been determined, then the next step is to doHypothesis test. This hypothesis test is intended to determine whether the independent/ predictor/ independent variable (X) has a significant effect on the dependent variable/response/dependent (Y).

Significant means that the effect that occurs applies to the entire population. **The F-test** was used to determine whether the independent variables X1 and X2 together had a significant effect on the dependent variable Y. **Partial Regression Coefficient Test (t-test)** is used to determine whether the regression model formed by the independent variables (X1 and X2) partially has a significant effect on the dependent variable Y.

RESULTS AND DISCUSSION

Urban development is often associated with urban development in many ways, because indicators of the city's physical development can be identified through the phenomenon of vegetation transformation in urban areas (Nahib, 2016). The city of Semarang, as the center of government and the economy of the Central Java region, shows changes and shows momentum for the better. According to the research of Prianggoro et al. (2015), the presence of arterial roads in Semarang City affects the development of Semarang City and shows a trend of rapid development in the north and spreads to the west and south along arterial roads. This is in accordance with the theory that the existence of urban development can be seen from various perspectives. One of them is urban morphology, which in this case emphasizes the physical aspects of urban areas, which are reflected in the road network system and building blocks (Herbert 1973; Yunus 2000).

Population

The population of Semarang City in 2020 was 1,653,524 people (BPS, 2020). With such a large number, Semarang City is included in the 5 largest administrative regions/cities in Central Java. Based on the results of the calculation of the population rate from 1980 to 2020 for 40 years, it can be seen that the population growth rate is 1.2%, or the value of $r > 0$, which indicates that the population growth is positive or there is an increase in the number of residents from the previous year. Meanwhile, if we look in more detail every 20 years, based on the calculation results from 1980 to 2000, the population rate was 1.4%, and in 2000–2020 the population rate decreased to 0.9%. Although the population growth rate continues to decline, the population in Semarang City continues to increase until 2020, based on the results of the population census.

Population growth increases population pressure on land availability along with the increase in population while the land area is constant (Muta'ali, 2012). Semarang City's population density in 1980 was 2,742.68 people/km2 and in 2020 it was 4,424.74 people/km2 . There is an increase of 1,500 people/km2 in the span of 40 years. The population density is increasing every year. From 1980 to 2020, South Semarang District was the most densely populated area in Semarang City. This was because South Semarang District was the development center of the economy and public services. However, Candisari District is the most populous subdistrict in 2020. In 2020, the population in various regions had decreased. In addition, if seen, it includes a small area between subdistricts in Semarang City.

Land cover

Land cover is one of the important indicators in identifying the characteristics of

an area. An area can be said to be developing if there is a lot of built-up land cover (Prianggoro et al., 2015). According to the processed data on the area of land cover change in Semarang City, it can be seen that from 1980 to 2020 there has been a change of up to 207.38km2 from vegetated land to built-up land. The conversion of land is a result of rising population.

From the spatial data of Landsat imagery, the data of built and non-built land cover in each sub-district in Semarang City is generated as shown in the following figure:

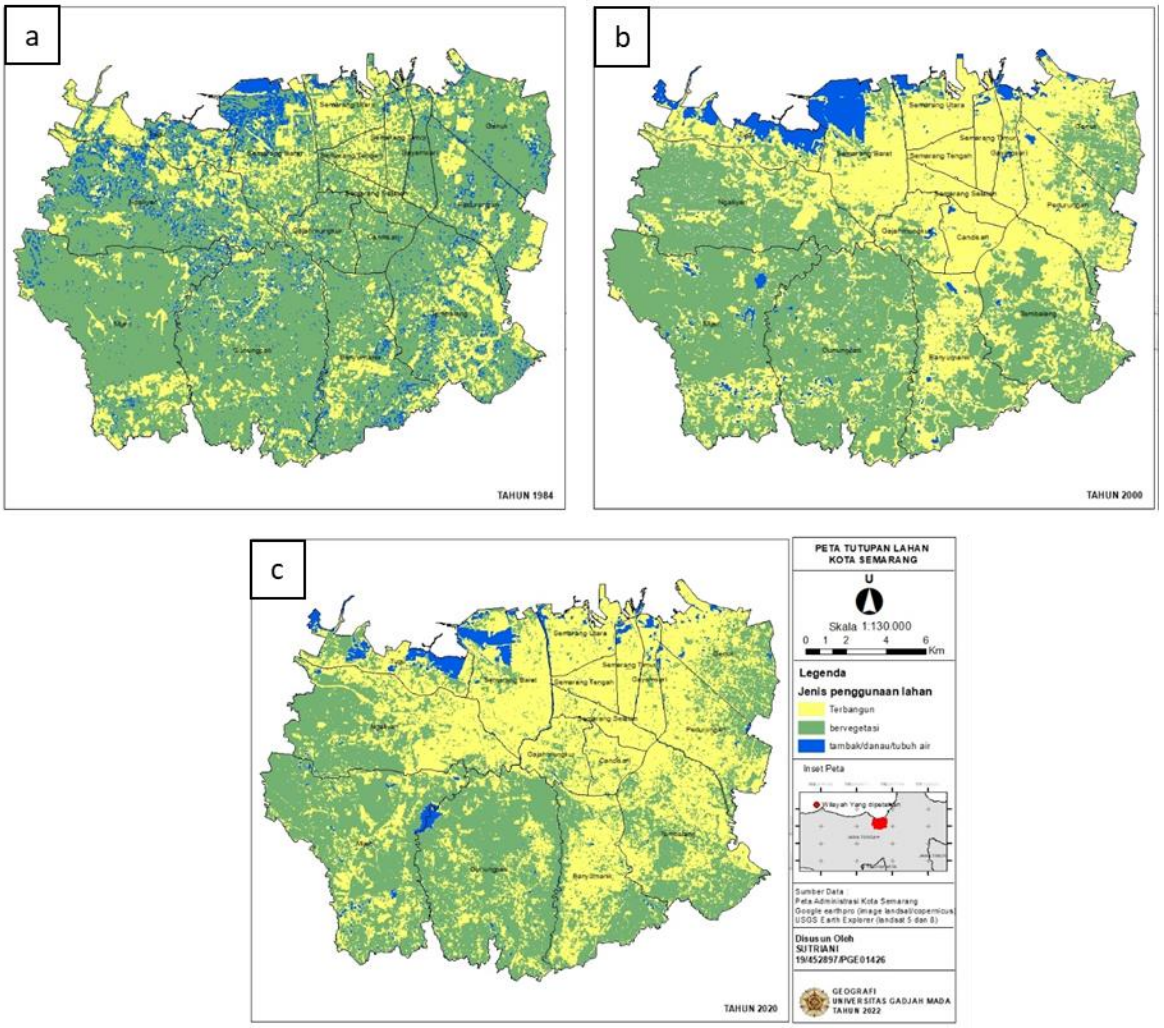

Figure1. the map of land cover change in (a) 1984, (b)2000, and (c)2020; (c) Imagery from Google Earth (1984) and Landsat (2000-2020)

Based on Figure 1 of the map of land cover change in 1984, 2000, and 2020, it can be interpreted that the changes that occur are vegetated land that is converted to built-up land more towards the southeast. The additional built-up area during the period 1980–2020 reached 109.4 km2. This area is equivalent to about 56% of the total increase in built-up land in the city of Semarang. The area of Semarang City, which is located in the northwest part, is mostly a coastal area, so the land for development is very limited. The increase in land was largely due to the construction of new settlements in the buffer zone of Semarang City and massive land clearing for new industrial areas, particularly in the districts of Ngaliyan and West Semarang.

Based on statistical correlation analysis, the R2 value shows that the population influences land use by 75%. From these results, it can be interpreted that the number of residents and the number of buildings is always directly proportional. Every time there is an increase in population, it is followed by an increase in the number of

buildings. Changes in land cover that occur as shown in Figure 1: Land Cover Changes in Semarang City can also be seen in Table 1: Land Cover Changes in Semarang City below:

Tabel 1 Changes in Land Cover in Semarang City

Information	1984		2000		2020	
	Area	%	Area	%	Area	%
Land built	106,61	28,85	155,92	42,26	207,38	56,10
Vegetation	245,24	66,35	200,31	54,29	150,82	40,80
Body of water and more	17,75	4,8	12,71	3,44	11,44	3,09

Source: Semarang City data processing and land cover map

The conversion of agricultural land in Semarang City is caused by the increasing need for construction land in the form of settlements, government offices, and commercial areas, which tend to increase due to population growth. This is in accordance with the research of Arsanjani et al. (2013), which states that changes in built-up land are influenced by population density. The same thing was also found by Munibah et al. (2010) and Sutriani (2022), where the relationship between the population and the built-up area tends to follow a linear model. During its development period, Semarang City, as the center of government and economy for the Central Java region, has transformed for the better and continues to contribute to important financial problems in Indonesia.

Temperature Conditions In Semarang

The denser an area is, the higher the potential for temperature increases. The spatial distribution pattern of temperature in Semarang City is seen based on land cover. According to data from the Climatology Station, the air temperature in Semarang City has experienced a slight upward trend in recent years. In 1980, the average air temperature in Semarang was around 27 degrees Celsius.At least until 2020, the average temperature in Semarang has been in the 28°C range.

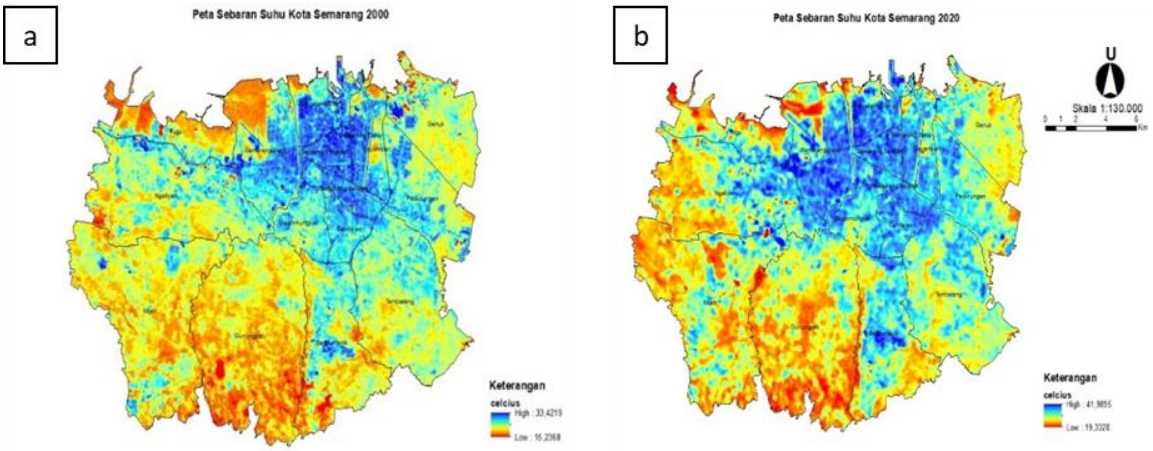

Figure 2. Map of Semarang City's Temperature Distribution in 2000 and 2020
Source: Landsat image processing

In Figure 2, the Temperature Distribution Map of Semarang City in 2000 and 2020, it can be seen that there is an increase in the distribution of higher temperatures towards the center of Semarang City's activities, which are in the Districts of Central Semarang, North Semarang, East Semarang, South Semarang, and Gajah Mungkur. This is also in line with the condition of the area, which is a residential area and urban center. Meanwhile, based on annual data, the average temperature of the city of Semarang from 1980 to 2002 can be seen in the Figure 3.

According to Figure 3, the average annual temperature in Semarang City is between 27°C and 28°C. Meanwhile, the monthly change in temperature in Semarang City, recorded (monthly) was 17°C in March 1993 in Semarang City. Meanwhile, the highest (monthly) temperature was 38°C in October 2019 in Semarang City.

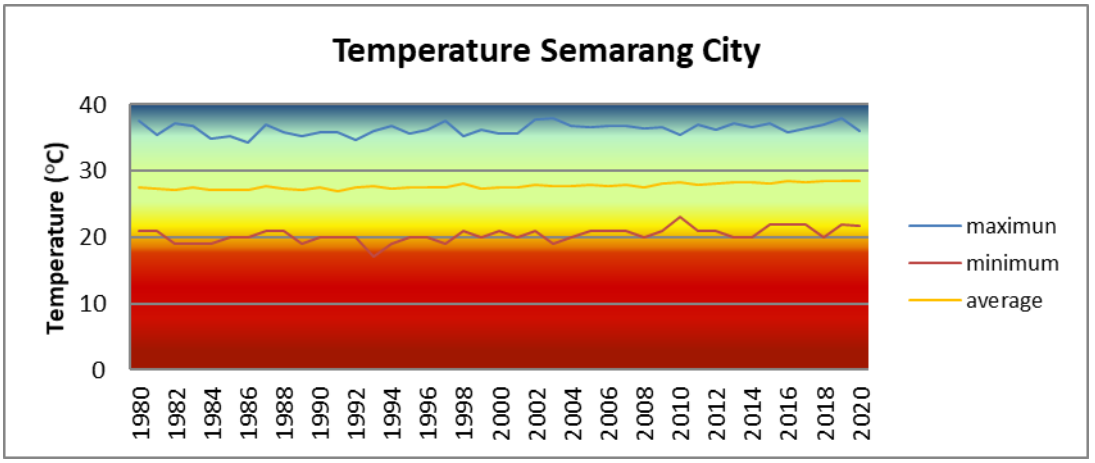

Figure 3. Semarang City Temperature Change Graph

Semarang City is the average hottest month in Indonesia. The average temperature is 37°C-38°C, while the average cold month is March to 17°C.

The Effect of City Development on Temperature and Rain in Semarang Urban Area

In correlation analysis, the value shows the relationship between two or more variables and the magnitude of the relationship. The results of the correlation test between the temperature variable and the population and built-up land variables are described in the table below:

Table 2. Hypothesis Testing results using SPSS (t-test)

R	R^2	Adjusted R Square	Std. Error	Sig. F Change
0.836[a]	0.699	0.684	0.23879	0.000

Source: Output SPSS

The hypothesis in this assumption test is that if the value of sig.F changes 0.05, it can be concluded that the variables have a relationship. While the degree of relationship can be seen at an R value of 0.836, which means the relationship variables have a perfect correlation. The hypothesis proposed in this study

H1: The temperature (Y) has an effect on the awakened variable (X1).

H2: There is an influence between population variables (X2) and temperature (Y).

The basis for decision making is based on the significance value (Sig.) and t count. It can be seen that, based on the calculation results, it is known that the significance value of the awakened variable (X1) is 0.839, which means the value of Sig. is greater than the probability value of 0.05. It is therefore concluded that H1 is rejected. Meanwhile, based on the t-value of the built variable (X1) of 0.205, it is smaller than the t-table value of 1.68595. This means that there is no effect of built-up land on temperature.

At the significance value of the population variable (X2) of 0.000 < 0.05 or based on the value of t count 4.531> t table 1.68595., it can be concluded that H2 is accepted, meaning that there is an effect of the population variable (X2) on temperature.

If the regression equation is formed, Y = 25,657+0,000X1+1,487X2. A positive slope value indicates that the increasing population will cause the temperature to increase. The f-test on the hypothesis aims to test whether there is a significant effect of the independent variables simultaneously on the dependent variable. The following illustrates the results of the F test below**:**

Table 3. ANOVA test results

F test	F table	Sig.
44.227	3.24	0.000

Based on the ANOVA output table above, it is known that the significant value (Sig.) in the F test is 0.000. Because the value of Sig. 0.000 < 0.05, in addition to the calculated F value of 44,227, which means the calculated

F value is 44,227 > F table 3.24, then as the basis for decision making in the F test, it can be concluded that the population (X1) and the built (X2) simultaneously affect the temperature or significant. Thus, the requirements for interpreting the value of the coefficient of determination in multiple linear regression analysis have been fulfilled.

In the ANOVA table, the coefficient of determination (R2) describes the influence of the independent variable (X) simultaneously on the dependent variable (Y). Based on the results above, it is known that the coefficient of determination R sq is 0.699. The value of R square is equal to 69.9%, where this figure illustrates that the variables population (X1) and built-up land (X2) simultaneously have an effect on temperature of 69.9%. While the rest (100% -69.9% = 30.1%) is influenced by other variables apart from the regression equation or variables not examined.

Based on previous research that vegetation plays an important role in temperature changes (Al Mukmin et al., 2016), if the area of built-up land increases, the surface temperature will also increase, and there is also a large area of built-up land that rarely has vegetation around it, causing high temperatures. One of the factors causing changes in temperature is the lack of vegetation and the reduced area covered by water bodies, vegetation, fields, shrubs, and grass (Khusaini, 2008). Vegetated land absorbs solar radiation in the process of transpiration and photosynthesis. Radiation that reaches the ground surface will be used for evaporation.

CONCLUSION

From 1980 to 2020, the City of Semarang experienced rapid changes in urban development, such as the population, which continued to increase until it almost doubled over a period of 40 years. This is directly proportional to the changes in residential land caused by population growth. Temperature conditions in Semarang City from 1980 to 2020 did not experience a significant increase. However, it is still experiencing an increase that is spread in densely populated areas. City development has an influence on temperature changes, which, based on the regression test, includes the figure of 69.9%, which means the population and changes in built-up land affect temperature changes by up to 69.9%.

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