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The Correlation Between Urban Development and Land Surface Temperature Change in Palembang City

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Abstract

Palembang city has experienced an increase in its population. Population growth results in an increase in activities which enlarge the built-up areas. The increase of built-up areas is one of the indicators of urban growth. The increase in built-up areas is inversely proportional to the vegetation area. Reduced vegetation area might cause an increase in land surface temperature. The aim of the study was to analyze the correlation between urban growth and changes in land surface temperature in Palembang City using descriptive quantitative method and spatial analysis on the data obtained from remote sensing images. The result shows that in 1998-2018, Palembang City has developed to the north (Sukarami District) and to the west (Ilir Barat I District). There has been an increase in the temperature, documented as 2.12°C. There is a correlation between urban growth and changes in land surface temperature in Palembang City.

1. Introduction

Urban areas are experiencing continuous population growth. Urbanization has an impact on high population growth and an increase in the number of urban population to 68% by 2050 (United Nations, 2018). Complete facilities and job opportunities are attractive factors for population movement (Rana & Parves, 2011). There is a particular type of relationship between the expansion of the residential area and the distance from the CBD that is affected by the availability of land and the location of facilities (Pigawati et al., 2019). High number of population results in a larger need for space, which implies increasing built-up areas (Sakti, 2016).

Limited urban land causes land expansion (Inostroza et al., 2010; Son et al., 2020). Increasing built-up area is an indicator of urban expansion. The large number of physical developments resulted in increasing built-up area of the city (Radhinal & Ariyanto, 2017). Limited land availability in urban areas has led to the development of population activities towards suburban areas (Barros, 2004; Parés-Ramos et al., 2013; Pigawati et al., 2017). The activities of urban residents are mostly carried out on built-up land, so they tend to reduce the vegetated areas. The rapid development of bulit-up area is inversely proportional to the vegetated land. An increase of built-up areas results in a decrease of vegetated area. The reduction of vegetation may causes several negative impacts such as increasing land surface temperature (El-Hattab et al., 2018; Mathew et al., 2018; Ullah et al., 2019), initiating urban heat island (the temperature in city center is higher than the temperature in suburbs) (Choudhury et al., 2019; Ramachandra, 2012), and climate changes (Ullah et al., 2019).

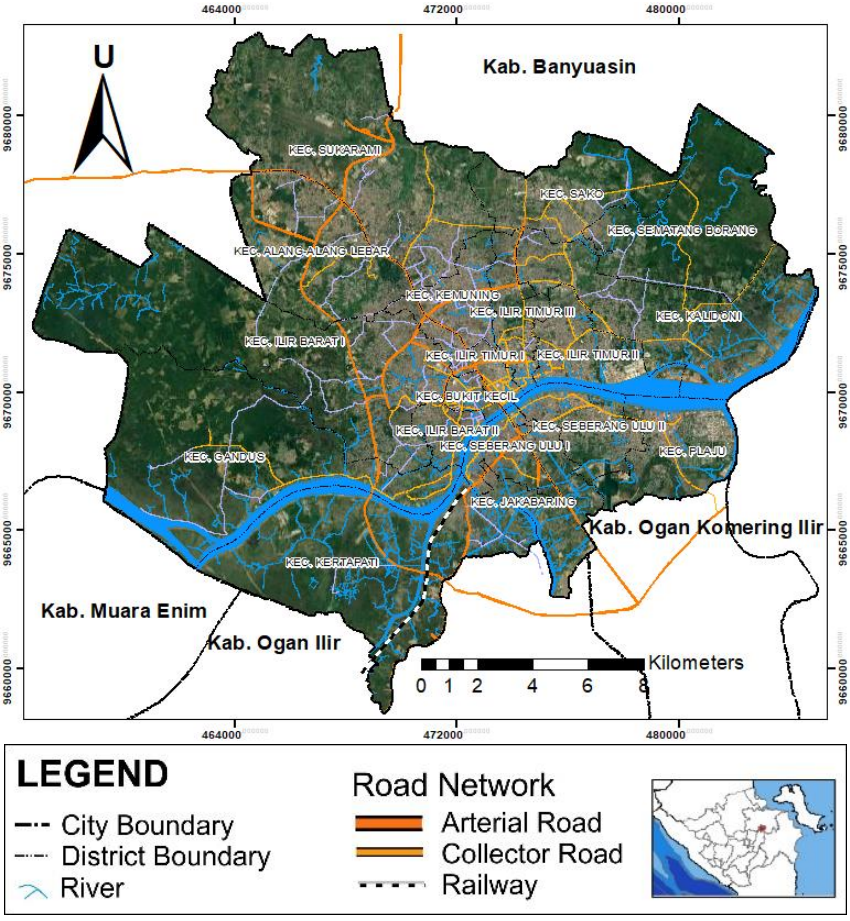
Climate change can worsen environmental conditions, increasing the risk of drought, flooding and extreme temperatures. Intergovernmental Panel on Climate Change (IPCC) reports that the impact of climate change is getting worse and requires serious handling (Watts, 2018). Countries in the world, have formed the United Nations Framework Convention On Climate Change (UNFCCC) resulted Paris Agreement in 2015

aimed at limiting the rise of temperature surface between 1.5 ° C - 2 ° C. Indonesia as a member of the UNFCCC has implemented the agreement stated in the Law of the Republic of Indonesia Number 16 of 2016.

Indonesia is a developing country, so the characteristics of cities in Indonesia tend to continue experiencing population increases, changes in land use and land cover. Population growth is closely related to changes in land use and land cover (*Land Use and Land Cover Change/LULCC*). The phenomenon of increasing the built-up area in an urban area shows that the city is experiencing development. Changes in land use and land cover can encourage urban development (Belal & Moghanm, 2011; Hegazy & Kaloop, 2015).

Changes in vegetated land to built-up land can cause changes in temperature. Based on the results of research conducted by Wang et al., (2019) in the Pearl River Delta area, there has been an increase in temperature in areas that have changed vegetation land cover into developed land. Palembang City has experienced a change in the distribution of land surface temperatures in 2001-2010 (Fajar, 2010).

This study aimed to analyze the correlation between urban development and land surface temperature change in Palembang City. The research has used the quantitative descriptive method and spatial analysis using the Geographic Information System and Remote Sensing technology. Remote sensing methods can be used to analyze urban development (Banzhaf et al., 2009; Belal & Moghanm, 2011). Figure 1 shows study area location,



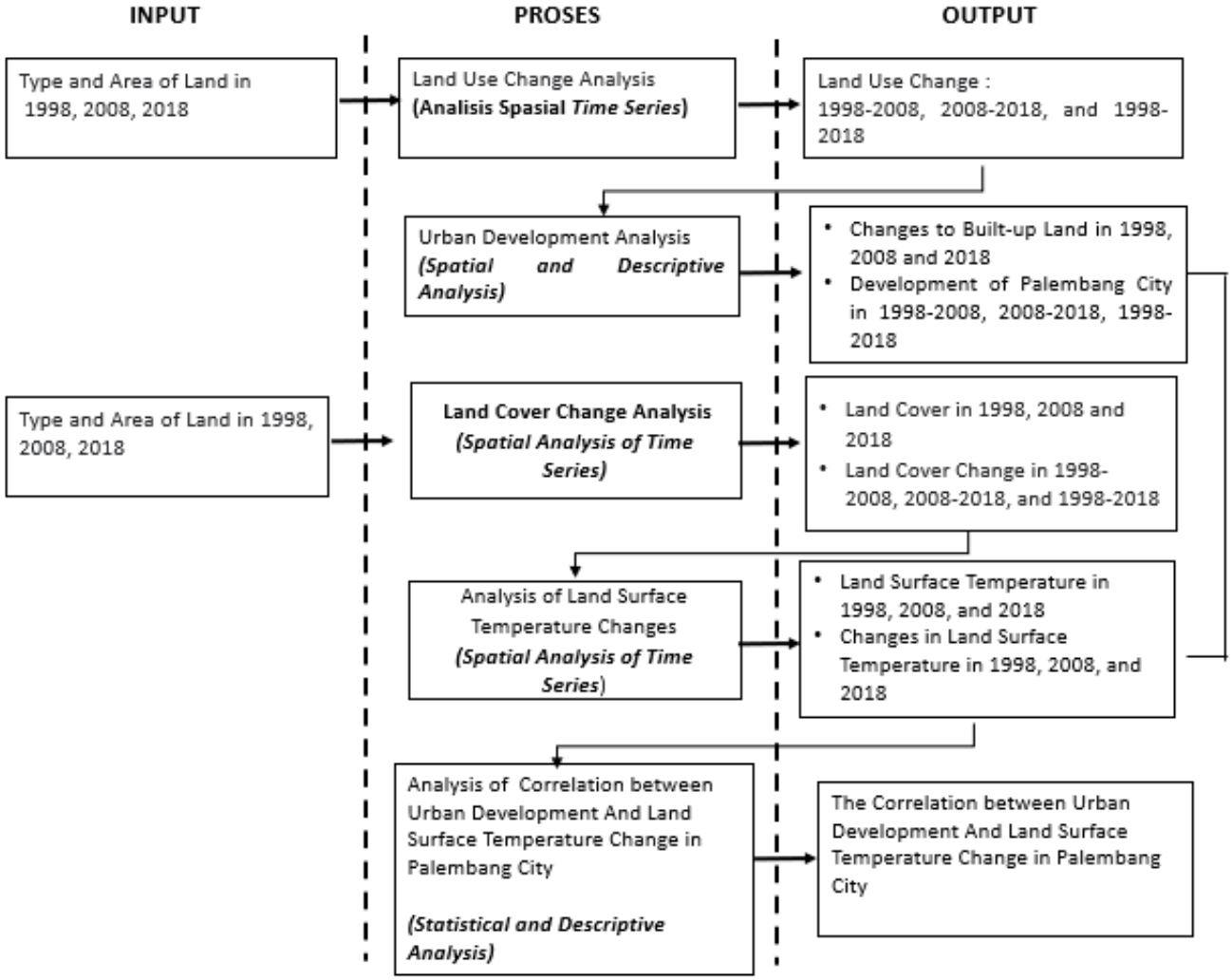
Source: SAS PLANET, 2020

Figure 1. Study Area Palembang City

2. Data and Methods

This research aimed to analyze correlation between urban develpoment and land surface temperature change in Palembang City. Using images as its main data, which were obtained from Landsat 5 TM for the data

of 1998 and 2008, and Landsat 8 OLI for the data of 2018. Before conducting spatial analysis, images were processed for radiometric correction, geometric collection, cropping and cloud masking. The steps of the analysis were as follows: a). Analysis of land use change in the study area for twenty-year period; b). Analysis of Urban Develppment Palembang City for twenty-year period; c). Analysis of land cover change in the study area for twenty-year period; d). Analysis of land surface temperature change for twenty-year period; e). Analysis of correlation between urban develpoment and land surface temperature change in the study area. Figure 2 shows a flow chart relating to the methods and analysis used,



Source: Analysis, 2022

Figure 2. Research Analysis Flow Chart

Land-use changes were identified by interpreting verified images which were obtained from Google Earth, such as Landsat/Copernicus images (in 1998 and 2008) and CNES/Airbus images (in 2018). Image interpretation was conducted by using the following parameters, namely, tone and color, texture, shape, size, pattern, location, shadow, and association (Iryadi et al., 2017). Interpretation on images was adjusted to modified land-use classifications proposed by Anderson et al. (1976) which consist of industrial, settlement, commercials and services, and non-built-up area. The development of Palembang City and its direction can be determined based on the expansion of the built up area in 1998-2018.

Land-cover changes analysis can be done by utilizing multi-temporal images to identify changes in 1998, 2008, 2018. Land cover can be identified directly using images which are verified using images from Google

Earth, that are Landsat/Copernicus images (data of 1998 an0d 2008) and CNES/Airbus images (data of 2018). Training sample based on Campbell's standard (Danoedoro, 2012) which requires a minimum of 100 samples which are categorized as land coverage based on the modification of National Standardization Agency of Indonesia which consists of agriculture, water bodies, vegetation, and open space. Classification of land cover was conducted by guided classification technique using Gaussian Mixture Method (GMM) (Sejati et al., 2019).

The analized Land surface temperature change in Palembang City can be done by processing the temperature data of 1998 and 2008 based on images from Landsat 5 TM (band 6), while the temperature data 2018 were analyzed based on images from Landsat 8 OLI (band 10). The analysis is carried out by calculating the Thermal Brightness which is the temperature recorded by the sensor without regard to other factors. The analysis process included conversion of digital number to TOA radiance, conversion of spectral radiance to brightness temperatures and conversion of land surface temperatures to Celsius scale.

The correlation between urban develpoment and land surface temperature change in Palembang City was analyzed using simple linear regression method. This statistical method aims to examine the causal relationship between the independent variable (X) and the dependent variable (Y). In this study, the variable Y (the dependent variable) is the impact caused by the variable X (the independent variable). Average land surface temperature is the Y factor (the dependent variable) while the built-up area in 1998, 2008, and 2018 were the X factors or the independent variables. Spatial modeling validation method in this study is the KAPA Index. This is done by comparing the results of the model with real conditions in the field. Of the 100 samples taken, 70% -80% are valid, so the model can be used as material for analysis.

3. Result and Discussion

3.1. Land-use Changes

Land-use in Palembang City consists of the area of settlement, commercials and services, industrial, and non-built-up area. The settlement area takes up most of Palembang City. The settlement area in Palembang City in 2018 was 13857.49 Ha (34.59%). The settlement area is concentrated in the center of Palembang City along Musi River. Settlement area in Palembang started to sprawl to non-built-up area in 2018, as observed in Sukarami District. The area of commercials and services was initially observed along Musi River which is known as the origin of trade center in Palembang, then expands along the arterial and collector roads as observed in Jakabaring District. The industrial area was initially located on the banks of the Musi River, which is accessible by water transportation. The industrial area then developed in Kertapati and Gandus Districts, which are located along the Musi River but far from residential area.

The biggest land-use change in Palembang City observed in 1998-2018 was the settlement area, recorded at 7754.12 Ha. There was an increase of settlement area to 127.05% in 1998-2018 where the biggest change was located in Sukarami District, recorded at 1714.20 Ha (343.74%). The percentage of land-use changes in Palembang City in 1998-2018 according to the category is presented in Table 1.

Sukarami District is the area with the largest change to settlement area in Palembang City. Sukarami District is passed by arterial road and here is the location of Sultan Mahmud Badaruddin II Airport as a means of air transportation for Palembang City. The an airport has an influence on changes in land use in the surrounding area (Kusumawati et al., 2016).

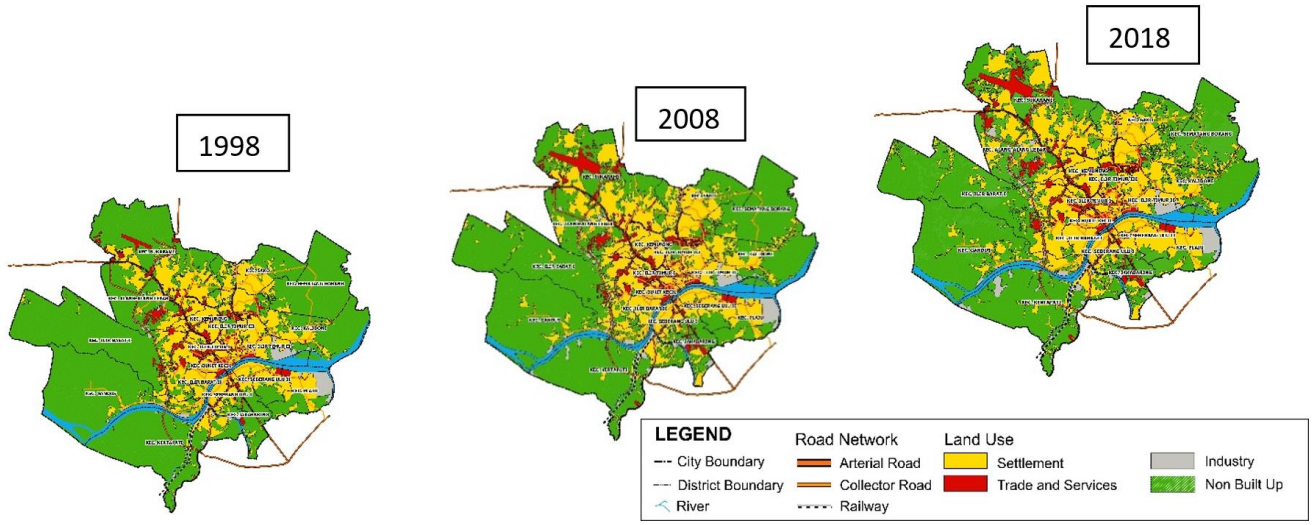
Alang-Alang Lebar and Kertapati Districts are the districts with the biggest land-use change for industrial area in Palembang City, supported by good accessibility. Alang-Alang Lebar District is located in northern Palembang, passed by arterial road and the location of Alang-Alang Lebar Type A Bus Station, and closed to Sultan Mahmud Badaruddin II International Airport. Kertapati District is located in southern Palembang, passed

by arterial road, and the location of Kertapati Type A Train Station, as well as located at the banks of Musi River. Figure 3 shows spatial distribution of land-use changes in Palembang City in 1998-2018.

Table 1. Land-use Changes in Palembang City in 1998-2018

No.	District	Settlement 1998-2018		Trade and Services 1998-2018		Industry 1998-2018		Non-Built Up 1998-2018	
		Ha	%	Ha	%	Ha	%	Ha	%
1.	Alang-Alang Lebar	547.62	124.22	87.24	42.50	125.74	173.20	-760.60	-47.68
2.	Bukit Kecil	25.73	22.53	0.00	0.00	0.00	0.00	-25.73	-69.51
3.	Gandus	796.99	251.51	0.00	0.00	14.17	16.35	-811.16	-10.46
4.	Ilir Barat I	1300.90	164.19	151.36	107.68	28.83	51.17	-1481.09	-32.21
5.	Ilir Barat II	83.95	30.83	0.00	0.00	0.00	0.00	-83.95	-61.89
6.	Ilir Timur I	13.34	4.73	19.82	11.32	0.00	0.00	-33.16	-69.29
7.	Ilir Timur II	120.72	27.82	28.45	40.73	70.00	77.39	-219.17	-39.58
8.	Ilir Timur III	68.00	19.72	114.87	161.99	0.00	0.00	-182.87	-62.48
9.	Jakabaring	243.84	106.41	78.68	115.57	31.54	106.02	-354.06	-45.16
10.	Kalidoni	744.57	210.69	14.05	13.83	1.80	4.04	-760.42	-29.97
11.	Kemuning	108.95	27.60	32.54	33.74	0.00	0.00	-141.49	-73.00
12.	Kertapati	339.93	94.32	10.33	202.15	208.63	158.85	-558.89	-14.67
13.	Plaju	191.15	79.64	0.00	0.00	100.00	61.50	-291.15	-30.99
14.	Sako	507.10	137.20	0.00	0.00	0.00	0.00	-507.10	-40.32
15.	Seberang Ulu I	117.32	47.34	13.87	24.79	0.00	0.00	-131.19	-48.73
16.	Seberang Ulu II	347.00	118.56	0.00	0.00	1.30	32.91	-348.30	-57.48
17.	Sematang Borang	482.83	403.76	0.00	0.00	0.00	0.00	-482.83	-19.00
18.	Sukarami	1714.20	343.76	347.74	98.76	15.00	32.38	-2076.94	-56.64
Palembang City		**7754.12**	**127.05**	**898.95**	**58.46**	**597.01**	**74.33**	**-9250.08**	**-29.26**

Source: Analysis, 2022



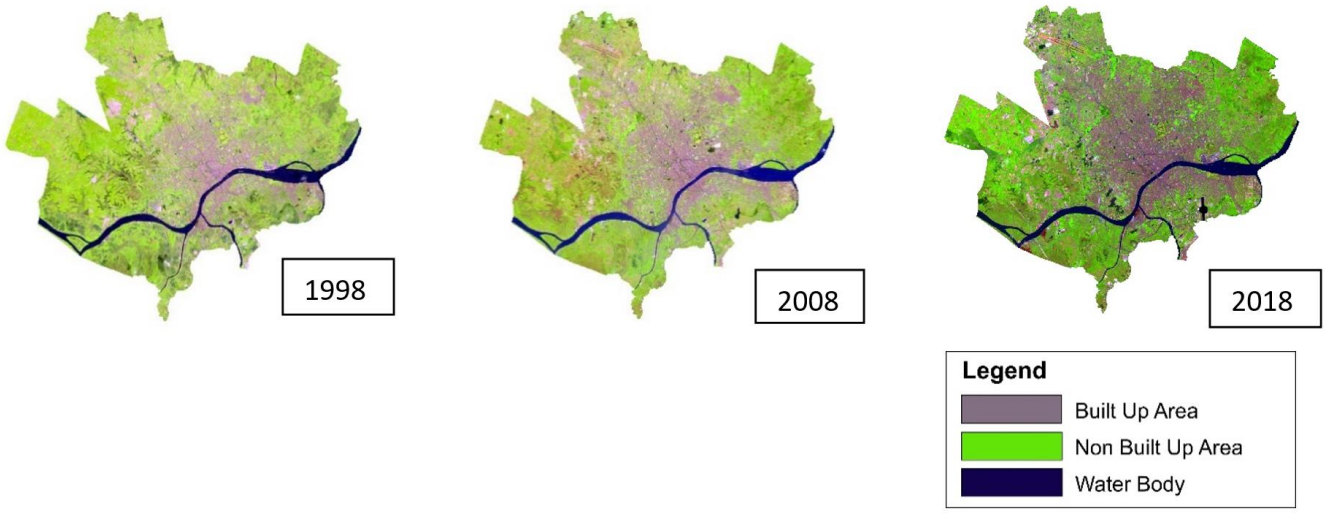
Source: Analysis, 2022

Figure 3. Land-use Changes in Palembang in 1998-2018

3.2. Urban Development of Palembang

The development of Palembang City and its direction can be determined based on the expansion of the built-up area in 1998-2018. The built-up area in Palembang City has been increasing in the period of observed years, documented at 8444.28 Ha (21.08%) in 1998, 12671.18 Ha (31.63%) in 2008, and 17694.35 Ha (44.17%) in 2018. Sukarami District is the district with the biggest built-up area, documented at 2974.03 Ha (16.81%). The growth has begun to occur in the suburban area because of the limited area and expensive land prices in urban area (Prihatin, 2016).

Spatially, built-up area in Palembang in 1998 was mostly observed in the center of Palembang City, along Musi River, in the following districts: Ilir Timur I, Bukit Kecil, Ilir Timur II, Ilir Timur III, and Seberang Ulu I. Boom Baru Port is located in Ilir Timur II District as the gate of distributions of goods and means of transportations in Palembang, and has a significant impact on the development of its surrounding area. In 2018, the built-up area had developed to the northern (Sukarami District) and western (Ilir Barat I District) suburbs of Palembang City. Figure 4. presents the built-up area in Palembang City in 1998, 2008, and 2018.



Source: Analysis, 2022

Figure 4. Built-up Area in Palembang City in 1998, 2008, and 2018

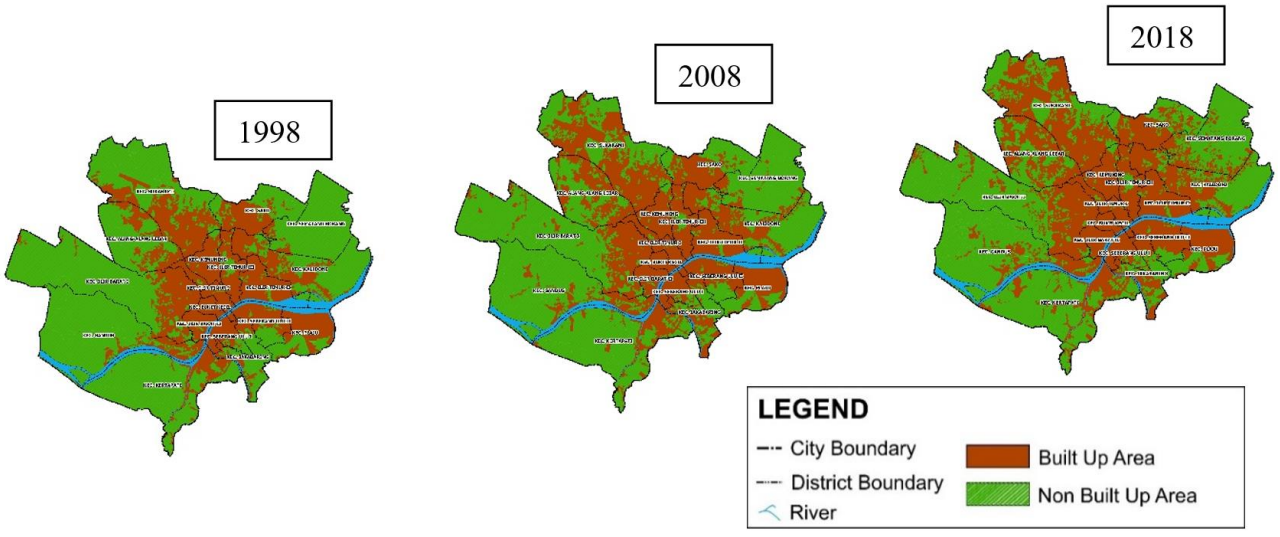
The built-up area in Palembang City in 1998-2018 was documented at 4202.34 Ha (10.49% of the area of Palembang City). The built-up area continued to increase to 35.51% in 1998-2018 which mostly located in Sukarami District, recorded at 1091.85 Ha (64.07%). The percentage of changes in built-up area is presented in Table 2,

The area with the largest changes to built-up areas was located in the northern Palembang (Sukarami District, which borders Banyuasin Regency). The changes in built-up area were a result of initial built-up area. In some areas, a sprawling was observed in the surrounding area of initial built-up area (in 1998), like in Sematang Borang District. Changes in built-up areas is irregular and unplanned. The result of overlaying built-up areas in 1998 and 2018 confirms the development of built-up areas on non-built-up areas. It shows that the development of built-up areas goes in line with the decrease of non-built-up areas (Subasinghe et al., 2016). Figure 5 shows changes in built-up area in Palembang in 1998-2018.

Table 2. Built-up Area and Non-Built-up Area in Palembang City in 1998-2018

No.	District	Built Up		Change		Non-Built Up		Change	
		1998	2018	Ha	%	1998	2018	Ha	%
1	Alang-Alang Lebar	718.72	1479.32	760.60	105.83	1595.28	834.68	-760.60	-47.68
2	Bukit Kecil	184.99	210.71	25.73	13.91	37.01	11.29	-25.73	-69.51
3	Gandus	405.60	1216.76	811.16	199.99	7751.40	6940.24	-811.16	-10.46
4	Ilir Barat I	989.24	2470.32	1481.09	149.72	4597.77	3116.68	-1481.09	-32.21
5	Ilir Barat II	276.35	360.30	83.95	30.38	135.65	51.70	-83.95	-61.89
6	Ilir Timur I	457.15	490.31	33.16	7.25	47.85	14.70	-33.16	-69.29
7	Ilir Timur II	594.28	813.45	219.17	36.88	553.72	334.55	-219.17	-39.58
8	Ilir Timur III	425.32	608.19	182.88	43.00	292.68	109.81	-182.88	-62.48
9	Jakabaring	326.98	681.04	354.06	108.28	784.02	429.96	-354.06	-45.16
10	Kalidoni	499.50	1259.91	760.42	152.24	2537.51	1777.09	-760.42	-29.97
11	Kemuning	497.18	638.67	141.49	28.46	193.82	52.34	-141.49	-73.00
12	Kertapati	496.84	1055.73	558.89	112.49	3809.16	3250.27	-558.89	-14.67
13	Plaju	453.41	744.56	291.15	64.21	939.59	648.44	-291.15	-30.99
14	Sako	444.24	951.34	507.10	114.15	1257.76	750.66	-507.10	-40.32
15	Seberang Ulu I	303.80	435.00	131.19	43.18	269.20	138.01	-131.19	-48.73
16	Seberang Ulu II	354.02	702.31	348.30	98.39	605.99	257.69	-348.30	-57.48
17	Sematang Borang	119.58	602.41	482.83	403.76	2541.42	2058.59	-482.83	-19.00
18	Sukarami	897.09	2974.03	2076.94	231.52	3666.91	1589.97	-2076.94	-56.64
Palembang City		**8444.28**	**17694.35**	**9250.07**	**109.54**	**31616.72**	**22366.65**	**-9250.07**	**-29.26**

Source: Analysis, 2022

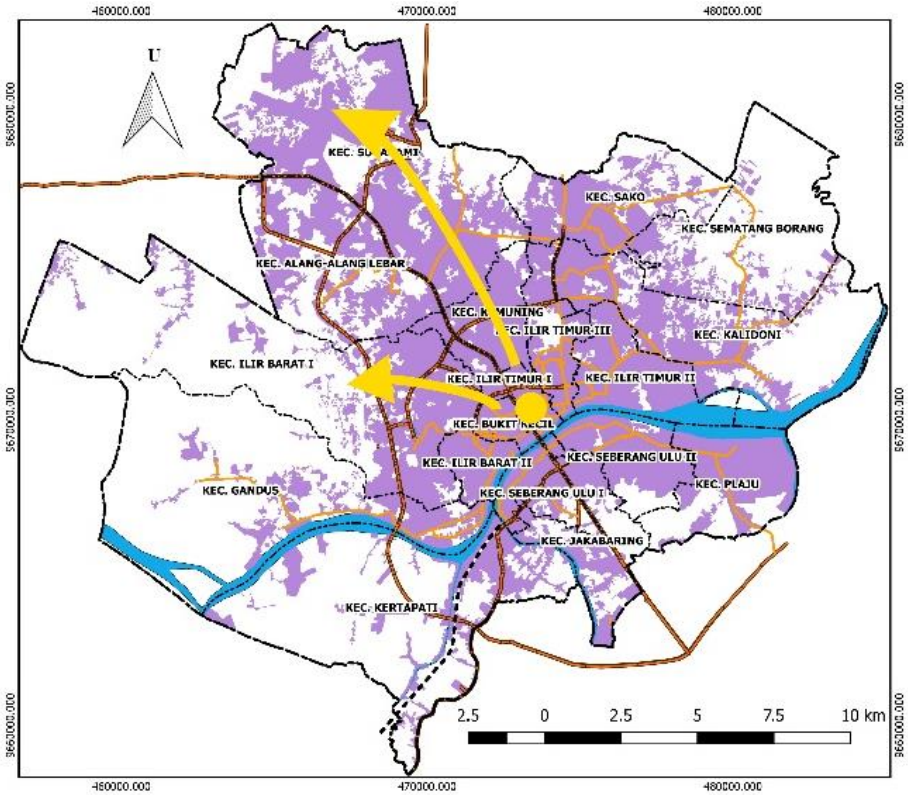


Source: Analysis, 2022

Figure 5. Changes in Built-up Area in Palembang in 1998-2018

The growth of Palembang City can be measured from the size of built-up areas and the areas that experiencing an increase in built-up areas. All areas have experienced an increase in their built-up areas but the district with the largest change was observed in Sukarami District 2076.94 Ha (231.52%) and Ilir Barat I District 1481.09 Ha (149.72%). While the district experiencing the most rapid growth is Sematang Borang, where the size of built-up area was documented as 482.83 Ha (403.76%).

Sukarami District is located in northern Palembang, direct border with Banyuasin Regency. The district has good accessibility, passed by arterial and collector road, location of Sultan Mahmud Badaruddin II Type A Airport, and close to Type A Bus Station in Alang-alang Lebar District. All those factors support the growth of built-up areas in Sukarami District. Furthermore, Ilir Barat I District has extensive growth because its strategic location, close to the center of activities in Palembang City that are Ilir Timur I and Bukit Kecil Districts. The usage of built-up areas in the city center causing the extension of activities to its surrounding areas, Ilir Barat I District. Next, the growth of Sematang Borang District is influenced by collector roads that increase the accessibility in the area. Based on the table of built-up area development, it can be concluded that Palembang City has developed to many directions, yet the areas having the biggest growth are the north and the west of Palembang. Figure 6 shows the direction of urban development in Palembang in 1998-2018.



Source: Analysis, 2022

Figure 6. The Direction of Urban Development of Palembang in 1998-2018

3.3. Land-cover Changes in Palembang

Land-cover classification system consists of agricultural areas, water bodies, built-up areas, vegetation, and open spaces. In 1998, land cover in Palembang was dominated by agricultural areas. In 2008 and 2018, it was dominated by built-up areas. Built-up area in Palembang was recorded at 17,694.35 Ha (44.17%) in 2018. Most of the area was located in Sukarami District that is 2,974.03 Ha (16.61%).

Palembang City has experienced significant land-cover changes. During 1998-2018, built-up areas and water bodies were increasing, while agricultural areas, vegetation, and open spaces were decreasing. Built-up area covered up to 9,250.07 Ha (109.54%), whereas vegetation decreased to 4,014.67 Ha (34.97%).

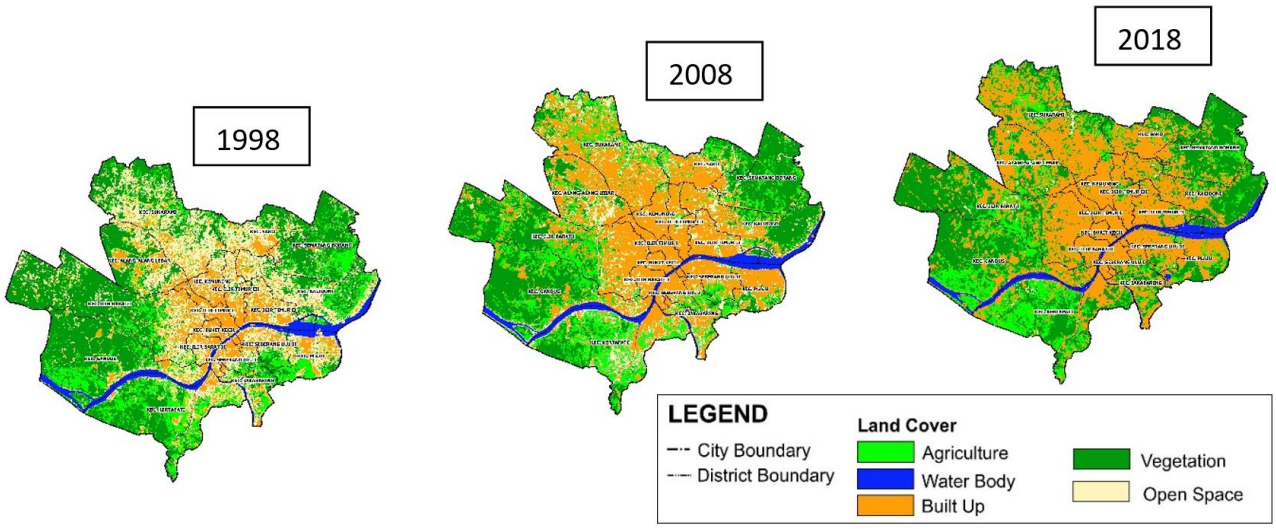
The biggest change in built-up area was observed in Sukarami District which was recorded at 2,076.94 Ha (231.52%), whereas the area having the least change in built-up area was Bukit Kecil District, 25.73 Ha (13.91%). The area with the largest decrease in vegetation was Gandus District, 1,724.11 Ha (51.01%), while the area with the least decrease in vegetation was Ilir Timur I District 1.80 Ha (53.63%). Table 3 presents percentage of land-use change in Palembang City.

Table 3. Land Cover Changes in Palembang in 1998-2018

No.	District	Agriculture 1998-2018		Water Body 1998-2018		Built Up 1998-2018		Vegetation 1998-2018		Open Space 1998-2018	
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
1.	Alang-Alang Lebar	-406.66	-66.32	1.70	1700.00	760.60	105.83	-330.94	-47.46	-24.70	-8.68
2.	Bukit Kecil	-3.33	-90.23	0.00	0.00	25.73	13.91	-3.10	-79.35	-19.30	-94.70
3.	Gandus	946.54	35.55	0.00	0.00	811.16	199.99	-1724.11	-51.01	-33.59	-2.62
4.	Ilir Barat I	-1324.96	-68.46	0.00	0.00	1481.09	149.72	-124.54	-5.80	-31.59	-6.19
5.	Ilir Barat II	-38.81	-82.10	0.00	0.00	83.95	30.38	-26.51	-92.63	-18.62	-61.44
6.	Ilir Timur I	-3.72	-80.64	0.00	0.00	33.16	7.25	-2.30	-67.25	-27.14	-95.46
7.	Ilir Timur II	-88.82	-73.49	0.00	0.00	219.17	36.88	-89.99	-56.82	-40.34	-65.28
8.	Ilir Timur III	-71.05	-67.87	0.94	12.70	182.88	43.00	-53.11	-61.80	-59.65	-63.02
9.	Jakabaring	-271.20	-59.98	0.00	0.00	354.06	108.28	-20.13	-14.67	-62.73	-46.65
10.	Kalidoni	-201.28	-19.20	0.00	0.00	760.42	152.24	-327.16	-39.60	-231.98	-66.17
11.	Kemuning	-57.78	-73.92	0.90	200.00	141.49	28.46	-41.08	-78.25	-43.52	-69.41
12.	Kertapati	-135.19	-6.12	0.00	0.00	558.89	112.49	-328.74	-31.15	-94.95	-40.99
13.	Plaju	-277.80	-48.29	31.62	18.93	291.15	64.21	-13.39	-21.79	-31.58	-23.25
14.	Sako	-250.52	-54.12	0.18	100.00	507.10	114.15	-118.30	-25.97	-138.46	-40.83
15.	Seberang Ulu I	-109.86	-70.38	0.00	0.00	131.19	43.18	-12.49	-47.21	-8.85	-23.27
16.	Seberang Ulu II	-214.63	-65.24	7.80	8.60	348.30	98.39	-117.98	-80.64	-23.49	-58.82
17.	Sematang Borang	-385.43	-31.63	0.32	1270.19	482.83	403.76	-67.67	-5.70	-30.04	-22.25
18.	Sukarami	-936.68	-54.00	2.97	471.43	2076.94	231.52	-613.11	-59.81	-530.13	-58.47
Palembang City		**-3831.18**	**-27.85**	**46.43**	**2.74**	**9250.07**	**109.54**	**-4014.67**	**-34.97**	**-1450.65**	**-30.95**

Source: Analysis, 2022

The image of land cover in 1998 which was overlayed with land cover in 2018 shows that there is a noticeable increase of built-up areas in Palembang City. Land cover which was recorded as agricultural areas, vegetation, and open spaces in 1998, has changed into built-up areas in 2018. It indicates that land-cover changes occurred in Palembang City in1998-2018. Figure 7 shows spatial distribution of land-cover changes in Palembang Cities in 1998-2018.



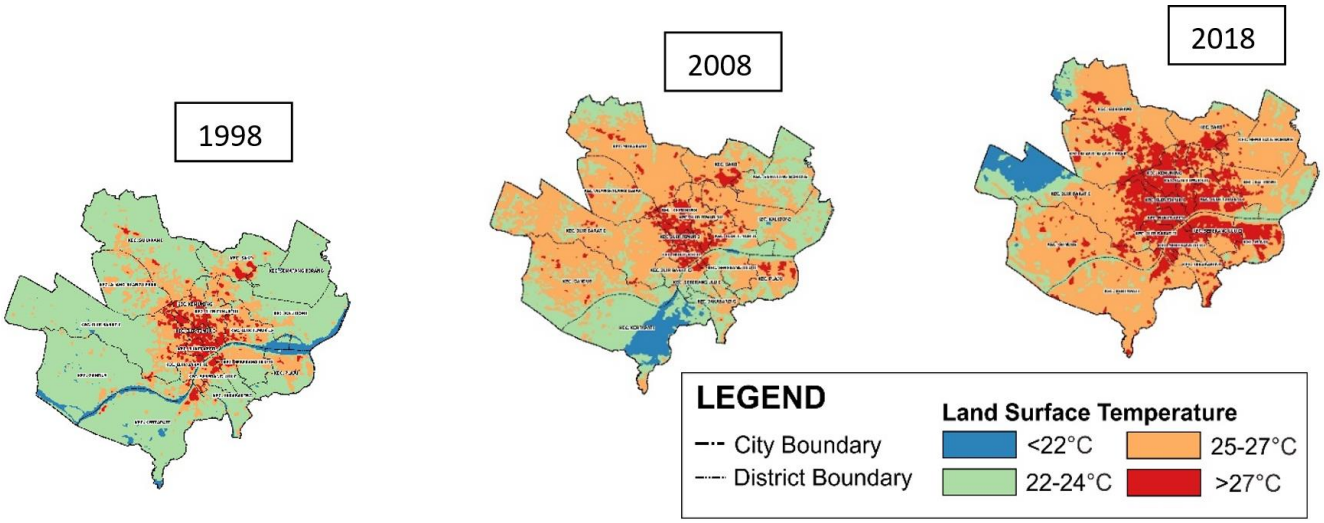
Source: Analysis, 2022

Figure 7. Changes in Built-up Area in Palembang in 1998-2018

3.4. Land Surface Temperature Change in Palembang City

Land surface temperature is categorized into four groups, namely <22°C, 22-24°C, 25-27°C, and >27°C. In 1998, the largest distribution of land surface temperature was reported in the category of 22-24°C, documented as 26,760.08 Ha (66.80%). While in 2008 and 2018, the largest distribution was reported in the category of 25-27°C, documented as 22,977.80 Ha (57.36%), which mostly located in Gandus District, documented as 3,502.47 Ha (15.24%). In the category of highest temperature, >27°C, the area was documented as 7,160.67 Ha (17.87%) which mostly located in Ilir Barat I District, documented as 795.95 Ha (11.12%).

Land surface temperature distribution in Palembang City had changed during 1998-2018. The noticeable decrease in land surface temperature distribution was in the following categories: <22°C and 22-24°C. The largest decrease in land surface temperature distribution was in the category of 22-24°C, documented as 21,580.30 Ha (80.64%) which mostly located in in Ilir Barat I District, documented as 3,485.20 Ha (75.90%).



Source: Analysis, 2022

Figure 8. Changes in Land Surface Temperature in Palembang in 1998-2018

Land surface temperature categories that had noticeable increase were 25-27°C and >27°C. The largest increase was in the category of 25-27°C, documented as 16,346.98 Ha (246.53%) which mostly located in Sematang Borang District, 3,428.11 Ha (1668.42%). During 1998-2018, in the category of >27°C, an increase of 5,478.90 Ha (325.78%) was documented and mostly located in Sukarami District, 701.30 Ha (1508.17 %). Figure 8 shows spatial distribution of land surface temperature in Palembang City in 1998-2018.

The average land surface temperature increased during the observation period in 1998-2018. The average land surface temperature in 1998 was 23.29°C while in 2018, the average was recorded at 25.41°C, confirming an increase at 2.12°C. According to Howard (1820), average city temperature in 1797-1816 was considered normal at 15-20°C, which means that land surface temperature in Palembang is 5°C higher than normal temperature in cities in 1797-1816. Temperature increase, which was documented at 2.12°C, is higher than allowed temperature increase based on Paris Agreement that is 1.5-2°C. An intervention on temperature increase is needed to reduce the impact of climate changes in Palembang City. Table 4 shows the average Land Surface Temperature in Palembang City in 1998, 2008, and 2018.

Table 4. Average Land Surface Temperature in Palembang City in 1998, 2008, and 2018 (°C)

No.	District	The Average of Land Surface Temperature (°C)		
		1998	2008	2018
1.	Alang-Alang Lebar	23.85	25.45	26.19
2.	Bukit Kecil	28.43	27.78	28.99
3.	Gandus	21.29	22.39	23.01
4.	Ilir Barat I	23.60	25.31	23.95
5.	Ilir Barat II	26.20	25.39	28.39
6.	Ilir Timur I	28.65	27.94	29.22
7.	Ilir Timur II	24.74	25.21	27.45
8.	Ilir Timur III	26.06	26.55	28.15
9.	Jakabaring	23.64	24.24	26.88
10.	Kalidoni	23.12	24.52	25.79
11.	Kemuning	26.86	27.36	28.88
12.	Kertapati	22.92	21.89	25.88
13.	Plaju	23.59	25.19	26.82
14.	Sako	24.02	25.55	26.20
15.	Seberang Ulu I	25.15	24.50	27.91
16.	Seberang Ulu II	24.06	24.78	27.72
17.	Sematang Borang	23.01	23.93	25.74
18.	Sukarami	23.57	25.28	25.98
	Palembang City	**23.29**	**24.26**	**25.41**

Source: Analysis, 2022

3.5. The Correlation Between Urban Development and Land Surface Temperature Change in Palembang City

The analysis on correlation between urban development and land surface temperature was aimed to observe the impact of urban development to the changes in land surface temperature in Palembang City in the period of 1998-2018. Data obtained for the analysis were the built-up area as the independent variable and land surface temperature as the dependent variable. The data were documented in 1998-2018. The data were analyzed using simple linear regression on SPSS to determine the correlation between urban development and land surface temperature in Palembang City in 1998-2018.

The average land surface temperature and built-up area in Palembang City had increased steadily in 1998, 2008, and 2018. The districts which experienced consistent increase of average land surface temperature and built-up area were Alang-Alang Lebar, Gandus, Jakabaring, Kalidoni, Sako, Seberang Ulu I, Seberang Ulu II, Sematang Borang, and Sukarami. Sukarami district were the district with the highest average land surface

temperature, which were recorded at 29.22°C in 2018, while Gandus District was the lowest, recorded at 23.01°C in 2018. Table 5 presents the average land surface temperature and built-up area in Palembang City.

Table 5. Average Land Surface Temperature and Built-up Area in Palembang City in 1998, 2008, and 2018

The Average of Land Surface Temperature (°C)			Built Up Area (Ha)		
1998	**2008**	**2018**	**1998**	**2008**	**2018**
23.29	24.26	25.41	11833.43	14079.76	16035.77

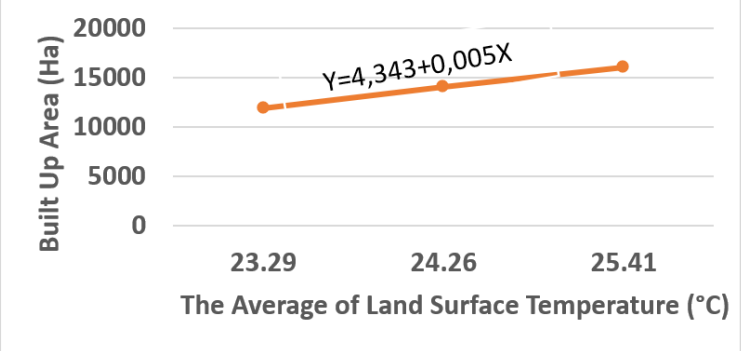
Source: Analysis, 2022

Data obtained for analysis were considered as abnormal, so that data pre-processing step was conducted by data transformation. Data transformation is conducted so that the data achieve normality prior to regression (Priguno & Hadiprajitno, 2013). The hypotheses were:

H_0 : There are no correlations between urban development and land surface temperature changes in Palembang City in 1998, 2008, dan 2018

H_1 : There is a correlation between urban development and land surface temperature changes in Palembang City in 1998, 2008, dan 2018

The analysis using simple linear regression method resulted in an equation where Y= 4.343+0.005 X. The analysis resulted in positive value with significance level 0.029 or less than 0.05 (probability), indicating a correlation between urban development and land surface temperature changes. R value at 0.999 shows that the correlation is strong. R-square value or Coefficient of Determination at 0.998 or 99.8% shows that the variable of built-up area contributes 99.8% to the variable of average land surface temperature while 0.02% is determined by other factors. It can be established that urban development correlates with land surface temperature. Figure 9 presents the result of linear regression analysis on the correlation between urban development and land surface temperature changes in Palembang City.



Source: Analysis, 2022

Figure 9. Result of Simple Linear Regression on The Correlation Between Urban Development and Land Surface Temperature in Palembang City in 1998, 2008, and 2018

The results of this study are in accordance with land surface temperature studies that have been conducted at the locations of Semarang Metropoliran Region, Asansol-Durgapur Development Region and San Salvador. (Choudhury et al., 2019; Sejati et al., 2019; Son et al., 2020) So that the results of this study are able to show the correlation between urban development and land surface temperature in Palembang City.

4. Conclusion

Palembang City is expanding in all directions. The largest increase in built up areas occurred in Sukarami District and Ilir Barat I District. During period of twenty-years (1998-2018) the development of Palembang City towards the North and West (Sukarami District and Ilir Barat I District). The decrease in the area of vegetated

land is significant with the reduced built-up area. In Palembang, there was an increase in land surface temperature of 2.12°C in a twenty-years (1998-2018). This indicates that Palembang City has exceeded the threshold for land surface temperature increase based on the terms of the 2015 Paris Agreement (1.5-2°C). The results of this study indicate that there is a correlation between urban development and land surface temperature change in Palembang City. The correlation is positive with a significance of 0.029, R is 0.999 and the coefficient of determination is 0.998 or 99.8%. This research was conducted on a regional scale, it would be better if further research could be analyzed with a detailed scope

5. Acknowledgments

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