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Abstract. Jakarta, the capital city of Indonesia, is the most populated area in Indonesia, with a population of 10.56 million people or around 3.91% of the total Indonesian population. Jakarta has also become an important city in Indonesia as around 80% of Indonesian economic activity is located in this area. No doubt, the urban activity caused the air pollution to infuriate its microclimate, including the urban heat island phenomena. During the Covid-19 pandemic, Indonesia applied the partial lockdown for several areas to decrease virus transmission. Most of the transportation and commercial areas were closed, and most people worked from home. This significant shifting will affect the temperature and urban heat island conditions. Thus the main objective of this research was to analyse the urban heat island during the early stage of the pandemic in Jakarta. We used Landsat 8 imagery to extract the land surface temperature (LST) and generated the urban heat island (UHI). The correlation was used to determine the relationship between the distribution of covid-19 cases with the UHI distribution. From the four different recording times (May, July, September, and December 2020) of Landsat 8 imagery, The highest UHI, 7.76^{0}C was found in December 2020 (the late first year of the pandemic). The lowest UHI, 4.910C was found in May 2020 (The early stage of the first year). Furthermore, the UHI hot spot moved from almost evenly in East Jakarta in May 2020, a tiny spot in East Jakarta in July and September 2020, and evenly distributed in Southeast Jakarta in December 2020. In addition, we found that the increase of covid-19 cases had a positive correlation with the UHI in Jakarta, which means the areas with the high UHI value have high new covid-19 cases.

1. Introduction

The population is one of the causes of climate change. But more than that, the activities carried out by the population have a major impact on climate change such as industrial activities that release greenhouse gases and population migration on a large scale [1] These activities can be found in urban areas. The World Population Data Sheet 2020 shows that 40% of twenty-six countries have urban populations of more than 1 million people. The reason why is many people choose to live in urban areas is that cities have a higher standard of living than villages so that residents can generate higher incomes to fulfill consumptive desires [2]. A large number of residents in urban areas will certainly be directly proportional to the burden borne by urban areas, especially on natural resources so that urban areas have the vulnerability to the risks and impacts of climate change [3]. One of the risks of climate change is the urban heat island (UHI) phenomenon. UHI is a condition where the city has a higher temperature in the surrounding area because the city experiences the fastest and most urbanization process [4,5]. UHI has 2 types, namely surface UHI which can be measured using Land Surface Temperature (LST), and atmospheric UHI which is measured based on air temperature [6].

In 2019, there was a new outbreak that attacked the world's population, namely the coronavirus disease (COVID-19), which was first reported to appear in Wuhan, China on December 31, 2019

(WHO, 2020). The outbreak has a rapid spread of cases, resulting in a rapid increase in COVID-19 cases even on a global scale. In May 2021, WHO reported that more than 170,000,000 cases of COVID-19 had occurred worldwide. Even in serious cases, COVID-19 can result in death. The process of spreading COVID is through small fluid particles from the mouth or nose of an infected person when they cough, sneeze, talk, sing or breathe (WHO, 2020). In addition, the WHO also reported that COVID-19 would have a very large risk of spreading in the interaction of several people at a distance of less than 1 meter if they were in a room with minimal ventilation. The risks and impacts of COVID-19 have caused many countries to take decisions to reduce the spread of COVID-19 more widely in their countries. One of the decisions taken was to impose a lockdown. The Lockdown in Wuhan, as the first place where COVID-19 emerged, was carried out by restricting travel to and from Wuhan, closing public places including schools and universities, banning social activities and having to adhere to strict quarantine at home [7]. The Lockdown was also carried out by several other countries, including Italy, Poland, Spain, England, France, Malaysia, and many other countries.

The State of Indonesia, especially in Jakarta, has also implemented restrictions on activities for its people to reduce the spread of COVID-19 with the existence of Large-Scale Social Restrictions (PSBB). PSBB includes restrictions on religious activities, schools, workplaces, public facilities, socio-cultural activities, modes of transportation, and other activities specifically related to defense and security aspects, but in terms of essential services and public transportation, there are no total restrictions but only capacity reduction and strict implementation of health protocols (Ministry of Health of the Republic of Indonesia, 2020). The PSBB, which restricts Jakarta residents from doing activities outside the home, will certainly make a difference, not only in terms of habits but also environmental effects. Anugerah et al., 2021 in their research showed that PSBB can reduce the concentration of air pollution, namely CO, NO2, and SO2. Another thing that can be predicted by PSBB is the impact of the urban heat island phenomenon. Previously, several studies showed that Jakarta experienced an urban heat island. Jakarta had temperatures reaching 31 – 34 oC in 2013 and 34.1 oC in 2014 [8,9].While the UHI comparison research in Putra et al., (2021) shows that the 3 sample years studied, namely 2008, 2013, and 2018, have several areas with temperatures over 30 oC.

In this study, researchers aimed to examine the relationship between UHI and COVID-19 in Jakarta. This study uses surface UHI as a parameter to determine UHI so that image data for obtaining LST values is carried out using LANDSAT-8. Several studies of the same study have also been carried out, such as Hadibasyir et al [10] showing that the average LST value in built-up areas experienced a significant difference in the form of a decrease in the LST value of 1.19 oC. Research in the United Arab Emirates on the implementation of lockdown was able to reduce the value of the surface urban heat island intensity (SUHII) by 19.2% [11].

2. Methods

The study area is located in DKI Jakarta, the capital city of Indonesia. The data that was used in this research was taken in May, July, September and December of 2020. Those selected months represent two seasons in Indonesia. July & September is the dry season, while May & December is the wet season. The use of remote sensing imagery gives an excess to actual comprehensive in the case of the city region [12]. This research uses imagery remote sensing of Landsat 8 thermal infrared sensors (TIRS). Data (for the first 4 months of 2020) was obtained from the United States Geological Survey (USGS) website. There is no radiometric and geometric correction because this research uses data type L1TP that is already corrected by the system. The Covid 19 data case in Jakarta was obtained by the government website of DKI Jakarta. The data used cumulative cases of covid 19 in 1 district in 1 month.

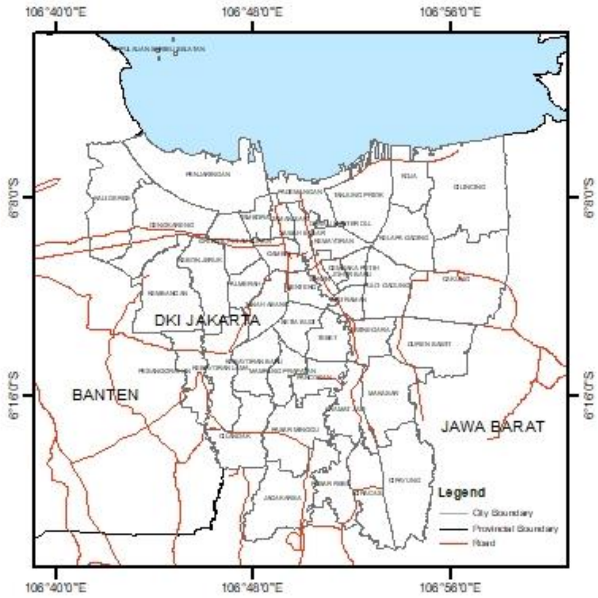

Figure 1. Map of District DKI Jakarta

The data process to generate the urban heat island (UHI) use derivatives from land surface temperature (LST) value. Then, UHI value in every district has been correlated with cumulative cases Covid 19. Here is the method process:

2.1. Radiance (Lλ)

Land surface temperature value got by process that refers to landsat 8 data handbook [13]. Digital value or digital number (DN) pixel changed to radiance value (Lλ) with algorithm

$$L\lambda = (ML)*(DN) + AL - Oi \quad (1)$$

ML & AL is factor value radiance from metadata; DN is pixel value; Oi is constant value band 10 viz 0.29.

2.2. Convertion radiance (Lλ) to Brightness Temperature (BT)

Radiance value is not represented temperature value so it needs to convert to Brightness Temperature (BT) value. Brightness Temperature is real temperature recorded by remote sensing. BT value obtained by equation 2. K1 & K2 obtain from metadata Landsat imagery is constan value. The result of equation is minus by value -273.15 to get Celsius temperature.

$$BT = K2/\ln(K1L\lambda + 1) - 273{,}15 \quad (2)$$

2.3. Land surface emisivity (LSE)

Emisivity is capacity of city material that influenced thermal condition to determine solar energy reflectance and absorption[14]. Land emisivity value are varied by heterogeneity of vegetation, land humidity, roughness, view angle with energy. LSE value evaluation by Normalized Difrence Vegetation Index (NDVI) and Proportion Vegetation (PV) method [14].

$$E = 0.004 * Pv + 0.98 \quad (3)$$

PV is proportion vegetation value. If pv value show lower it is built land or open land and value upper show the vegetation. Pv equation use the relation betweeen NDVI and percent covered land [14].

$$Pv = ((NDVI- NDVImax)/(NDVImax-NDVImin))^{2} \tag{4}$$

NDVI give green vegetation ilustration in raster pixel and give land composision to get emissivity value. NDVI calculated by Equation 5. NDVI result value from -1 to 1, value near -1 showing less density vegetation, water or soil and near 1 showing more density vegetation.

$$NDVI\ (NIR\ band - Red\ band)/(NIR\ band+ Red\ band) \tag{5}$$

2.4. Land Surface Temperature (LST)

Land surface temperature (LST) calculated by use of corrected land emissivity value [15] use Equation 6 to calculated.

$$LST = BT/ (1+\lambda*BT/c2)*\ln(\varepsilon) \tag{6}$$

BT is Brightness temperature value from Equation 2 ; λ is effective wavelength (Band Thermal); C2 is h*c/s= 1.4338*10-2mK = 14338MK; s is Boltzmann constant value (1,38 ×10− 23JK− 1); h is Planck constant value (1,38 ×10− 23JK− 1); and c is light speed in vacuum (2,998 × 10− 8 ms− 1).

2.5. Urban Heat Island (UHI)

UHI phenomenon is divided into two namely Land UHI & atmospheric [14]. Remote sensing will result only the land UHI. Land UHI is used for visualization difference temperature condition cause land temperature related with air temperature [16]UHI value calculated from LST value used threshold calculation [17].

$$UHI=Ts- (\mu+0,5\ \alpha) \tag{7}$$

UHI is urban heat island; Ts is land surface temperature value; μ is mean value Ts; α is standar deviation value Ts. UHI calculated used threshold calculation if positive value so represented the UHI and if lower than 0 represented no UHI in area [17].

2.6. Corelation Analysis

Pearson correlation is used in this research to know the relation among two variable between UHI value at district in DKI Jakarta and cumulative increase positive cases covid 19 in one month. The pearson value result can represent the relation value of the variables.

3. Results and Discussions

3.1. Land Surface Temperature (LST)

Land surface temperature calculation in DKI Jakarta generates a different value each month. This result is affected by the cloud cover that covers the land, so it has become the main problem with LST calculation. The maximum LST value in December is 34.36 oC and the minimum value looks similar every month between 13 – 14 oC. It is due to the cloud cover in imagery being less clean, so some areas in study location have a noise value from that. Figure 2 shows that the dry season (July & September) looks hotter than the wet season (May & December). From that, we know that the LST depends on the season. The great temperature of LST occurred in July, which shows that almost the whole area in DKI Jakarta is yellow to red, which shows the high symbol of LST. But July is not the hottest month of the year. The hottest month is September. In September, the temperature reached

35,73 oC. Otherwise, May may become the coldest month in which the temperature is 30,65 oC. Most of the LST results show the same pattern of each area which has the higher temperature each month. But the temperature is dynamically shown depending on each month, such as in northeast DKI Jakarta in May, September, and December show the green color which shows the lowest temperature, but in July it shows the yellow to orange color that fits with the fact that July has a larger area of high temperature.

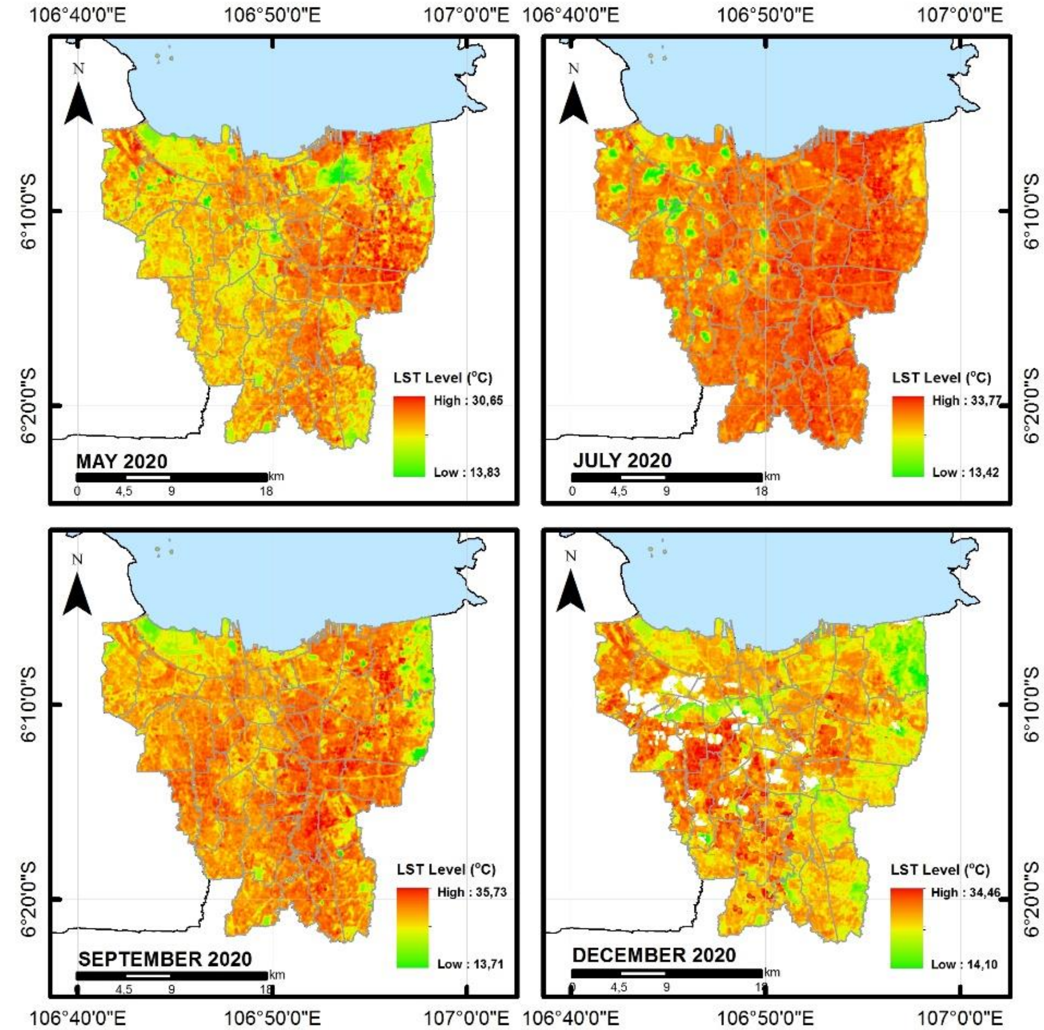

Figure 2. Land Surface Temperature in DKI Jakarta

3.2. Urban Heat Island (UHI)

The urban heat island value is calculated from the land surface temperature value. The UHI value represents the LST value in each area. UHI detected in the east area of DKI Jakarta in May, July, and September, while in December there is a high UHI value detected in the east area of DKI Jakarta. The UHI value in each month has increased from May, which has a maximum value of 4.92 ºC, July at 5.64 ºC, September at 6,97 ºC and December at 7,76 ºC. UHI spatial distribution can be related to a lot of people's activities in that area. The more people who have activity outside, the more it will affect the expansion of spatial distribution and increase the UHI value in that area. The result of this research has applied to Pembatasan Sosial Skala Besar (PSBB) that limits people's activities outside. May is the early month of PSBB in DKI Jakarta. The rules must be people decrease the activity outside. PSSB affected schools, companies, public facilities, and shopping centers to reduce activity. This factor represented UHI value with UHI distribution due to people's activity. May is the first PSBB and UHI that can be affected by human activity. May shows the lowest UHI value compared to the other 3 months. Figure 3 shows that May, July, and September have the same UHI pattern that shows that the UHI value is mostly in the east area of DKI Jakarta. Whereas the UHI pattern in December is very different compared to the other 3 months, where December has many larger UHI phenomenon. In December, most of UHI is in the west area of DKI Jakarta, which is mostly the urban areas of this city. Related to the lowest and highest UHI value, this research shows that each month the UHI value always increases. The increase in UHI value can be affected by the first PSBB in May, but the next month, the PSBB is loosened up so that people do activities outside and increase the cause of the UHI phenomenon. Figure 3 also shows that not all areas of DKI Jakarta have a UHI value, although the LST value in figure 2 shows that DKI Jakarta mostly has high LST. But, the different patterns of LST and UHI mainly in July that have the larger area of LST do show the larger area of UHI. The larger area of UHI occurred in September, which has the higher LST. Those results mean that the larger area of LST does define the UHI phenomenon, but the higher LST can define the larger UHI phenomenon.

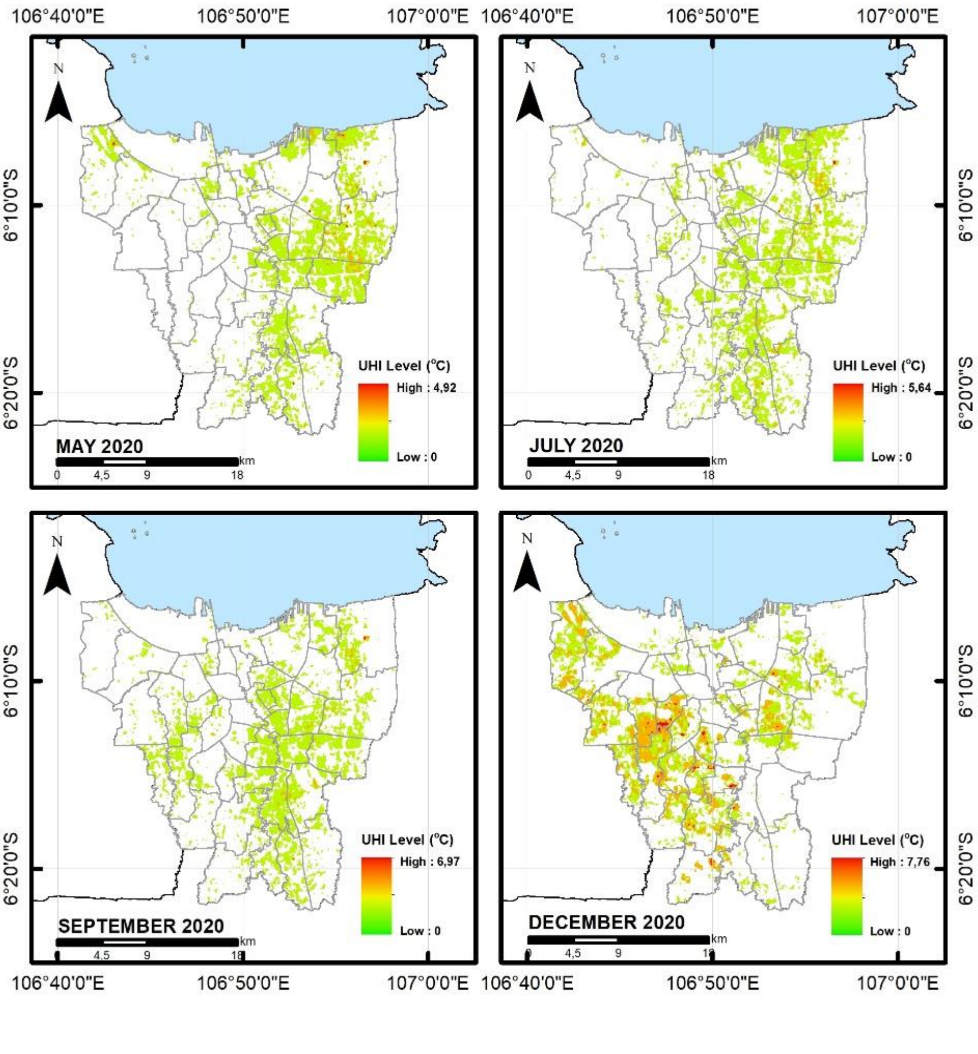

***Figure 1**. Urban Heat Island in DKI Jakarta*

3.3. Correlation of UHI and COVID-19 Cases

The correlation results between urban heat islands and cumulative cases covid 19 show that there is a positive relationship between them. It means that higher UHI value will have higher positive cases of covid-19 in that area. The Pearson correlation value shows that it increased every month from May at 0,147, July at 0,228 and December at 0,514. Yet, the correlation in September doesn't have a significant result because the calculated UHI in September has over cloud cover.

Table 1. Correlation UHI Value with Covid 19 Data Cases May

		UHI	DATA COV19
UHI	Pearson Correlation	1	**,147***
	Sig. (2-tailed)		,016
	N	268	268
DATA COV19	Pearson Correlation	,147*	1
	Sig. (2-tailed)	,016	
	N	268	268

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2. Correlation UHI Value with Covid 19 Data Cases July

		UHI	DATA COV19
UHI	Pearson Correlation	1	**0,228***
	Sig. (2-tailed)		0,000
	N	263	263
DATA COV19	Pearson Correlation	0,228**	1
	Sig. (2-tailed)	0,000	
	N	263	263

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3. Correlation UHI Value with Covid 19 Data Cases September

		UHI	DATA COV19
UHI	Pearson Correlation	1	**0,069**
	Sig. (2-tailed)		0,265
	N	81	81
DATA COV19	Pearson Correlation	0,069	1
	Sig. (2-tailed)	0,265	
	N	81	81

Table 4. Correlation UHI Value with Covid 19 Data Cases December

		UHI	DATA COV19
UHI	Pearson Correlation	1	**,514***
	Sig. (2-tailed)		,000
	N	265	265
DATA COV19	Pearson Correlation	,514**	1
	Sig. (2-tailed)	,000	
	N	265	265

*. Correlation is significant at the 0.05 level (2-tailed).

Significancy of the correlation can be affected by the data quality of imagery. On September cases of covid 19 keep increase in every month but avability of remote sensing imagery cannot be found in good imagery because its depend on the temporal radiometric of Landsat-8 that in each month may only have 2 recorded imagery so that in this research use the best recorded imagery but still have the cloud cover that affected the result. Table 1, Table 2, Table 3 and Table 4 show that the correlation result is based on the district data in Jakarta that was selected only at the area wich have UHI phenomenon to look the relation between UHI and covid 19 cases. December has the higher value of correlation related to figure 3 that show that UHI phenomenon is also larger and higher than the other 3 months. It means that on December, when PSBB is loosened up and most of people back to do activity outside, the covid 19 cases is also increase because the spread of covid 19 is based on the people activity. From that correlation, it can be conclude that rules is not affective in Jakarta at 2020.

Signify the LST results of Hadibasyir et al [10] research, this result found the similar phenomena in Wuhan China, although they used different resolution of satellite imagery. During the lock down policy both areas, Wuhan and Jakarta, experienced the same phenomena. The LST of both areas decreased significantly. This condition led to the shifting of urban heat island phenomena which usually occur in industrial area to the settlement area. During the pandemic, the government force the lock down policy in particular area in Jakarta. Most of workers work from home and used more electricity to support their activity at home. As a result, the LST also affect the distribution of UHI. In term of Covid transmission, we found high positive correlation of Covid-19 accumulative case with the UHI value in several observed months. We assumed that the area which has high UHI value has more activities, therefore the transmission of covid increase as the developing country tend to have more problem in maintaining the social distancing or partial lock down in particular area [18].

4. Conclusions

During the implementation of partial restriction or lockdown policy, there were shifting of population concentration in Jakarta. In normal time people tend to concentrated in central business district and industrial area. Meanwhile, during the lock down policy, most of people were work from home. As a result, there were shifting of LST temperature. The results showed that the LST decreased significantly on industrial area and increase in settlement area. Furthermore, the UHI pattern also match with the LST pattern. In addition, we found that the prone areas to covid-19 (have high accumulative covid-19 case) were have positive correlation between the high UHI value. Further research need to be conduct in different places signify this result.

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