BIS HEALTH AND ENVIRONMENTAL SCIENCE

Volume 1 2024 | DOI: 10.31603/bishes.78
5th Borobudur International Symposium on Science and Technology (BIS-STE) 2023

UNIMMA PRESS
Universitas Muhammadiyah Magelang

Comparative analysis of land surface temperature before and during the large-scale social restrictions due to covid-19 in Jabodetabek, Indonesia

Y Priyana[1*], N S Firdaus[1,2], Jumadi[1], C Amin[1] and H Z Hadibasyir[1,2]

[1] Faculty of Geography, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia
[2] Geo-information and Data Analytics (GiDA) Research Group, Sukoharjo, Indonesia
*Corresponding author email: yp121@ums.ac.id

Abstract

Large-scale social restrictions (LSSR) have been implemented in various cities around the world, including in Jabodetabek (Jakarta, Bogor, Depok, Tangerang, Bekasi), Indonesia, to limit anthropogenic activities that involve social interactions to reduce the spread of Covid-19. Restrictions on anthropogenic activities might have an impact on land surface temperatures (LST) in Jakarta and its surrounding areas. This research aims to analyze the timeline of the Covid-19 policy and to analyze the impact of LSSR on LST in Jabodetabek. LST were derived using Landsat 8 imagery, then spatial and temporal analysis were conducted by comparing several images with different acquisition dates. In general, the policy phase of adjusting the intensity of human activity consists of total LSSR and transitional LSSR. At the time before the LSSR policy was implemented in Jakarta, there were relatively high LST in Jabodetabek concentrated in almost the entire Jakarta area, almost half of Bekasi and several other areas directly adjacent to Jakarta. LST were low in the south and southwest of Bogor where the area is mountainous, and the northern part of Bekasi. When entering total LSSR phase 1 (22 April 2020), the LST in Jabodetabek decreased quite drastically, then continued to decrease until total LSSR phase 3 (24 May 2020). Furthermore, the temperature began to increase when the LSSR transitional period reached phase 1 (13 September 2020). This study reveals the possibility of utilizing satellite images to monitor environment due to changes in human activities.

Published:
October 20, 2024

Selection and Peer-review under the responsibility of the 5th BIS-STE 2023 Committee

Keywords

Land surface, Temperature, Covid-19

Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is a new type of mutation of the corona virus that causes Coronavirus Disease 2019 (COVID-19), which was first identified in Wuhan City, Hubei Province, China in December 2019 (Kong et al., 2020). Due to the rapid spread of COVID-19, the Chinese Government decided to close Wuhan as the epicenter of the virus as a measure to prevent and control the spread of

the disease [1]. This policy is known as 'Lockdown' from 23 January 2020, until the next 76 days in Wuhan [2].

On March 11, 2020, the World Health Organization (WHO) or the World Health Organization (2020) classified COVID-19 as a pandemic. The government of DKI Jakarta responded to the outbreak which began to spread globally by issuing a Surat Edaran Dinkes18/SE/2020 concerning Precautions for Novel Coronavirus (nCoV) Pneumonia [3]. On March 1, 2020, the Governor of DKI Jakarta announced that as many as 115 Jakarta residents were under monitoring regarding the Covid-19 corona virus and were monitoring 32 people related to this virus. The monitoring status of monitored person (*orang dalam pengawasan*/ODP) was then confirmed at a press conference Monday, March 2, 2020, at the same time as the inauguration of the DKI Jakarta Provincial Covid-19 Response Team [4].

The President of the Republic of Indonesia announced the first 2 positive cases of Covid-19 in Indonesia on March 2, 2020, namely the case of a mother and her child. This is the result of a search after a Japanese citizen who had just returned from Indonesia tested positive for Covid-19 [5]. Several steps were taken by the government to anticipate the increasingly widespread spread of the virus, namely by limiting teaching and learning activities through Surat Edaran Disdik No. 26 Tahun 2020 (26/SE/2020) regarding Learning at Home During Implementation of School Examinations and/or National Examinations [6], calls for the temporary suspension of all religious worship activities in houses of worship through the Governor's Call No. 5 of 2020 concerning the Temporary Suspension of Worship and Religious Activities in Houses of Worship in the Context of Preventing the Spread of the Coronavirus Disease (Covid-19) outbreak ("Hindari Corona, DKI Jakarta Tiadakan Kumpul Keagamaan 2 Pekan," 2020, March 20), Termination of office activities through the Governor's Call Number 6 of 2020 concerning Temporary Suspension of Office Activities in the Context of Preventing the Spread of the Coronavirus Disease (Covid-19) Outbreak and Surat Edaran Dinas Perindustrian, Perdagangan, Koperasi, dan UKMNumber 81/SE/2020 (Prireza, 2020), Termination of tourism industry activities through the Surat Edaran Dinas Pariwisata dan Ekonomi Kreatif Nomor 160/SE/2020 concerning the Temporary Closure of Tourism Industry Operational Activities in Efforts to Be Vigilant Against the Transmission of Coronavirus Disease Infection (Covid-19) [7]. Apart from that, there are also restrictions on public transportation, namely Transjakarta, MRT, LRT and KRL through Press Release No. 1141 - Public Transportation Restrictions Effective Monday for Transjakarta, MRT, LRT, and KRL and Decree Number 71 of 2020 Concerning Instructions for Implementing Large-Scale Social Restrictions in the Transportation Sector [8].

It seems that these policies are not capable of reducing the transmission rate of Covid-19 with evidence that the number of cases is increasing rapidly to the point that the City of Jakarta is made the epicenter of the Covid-19 pandemic, so that finally the DKI Jakarta Provincial Government imposes Large-Scale Social Restrictions in DKI Jakarta by issuing Governor's Decree No. 380 of 2020 concerning Enforcement of Implementation of

Large-Scale Social Restrictions in Handling the 2019 Coronavirus Disease (Covid-19) in DKI Jakarta Province [9]. Based on the presentation of the government's policy timeline, this global pandemic has urged the government to maximally limit human activities outside the home which has resulted in a decrease in activities involving transportation and industrial operations.

Remote sensing data can be used for multitemporal monitoring of environmental conditions in a large area coverage. Therefore, the impact of a policy on environmental conditions can be analyzed with the help of remote sensing data [10-13]. Lockdown policies implemented in various countries have also had an impact on land surface temperature changes such as in the city of Wuhan, China. Research that has been conducted by Hadibasyir et al. [10] using MODIS imagery to observe multitemporal changes in temperature. The results of their research show that the temperature during the lockdown was lower than the average in the previous period, where the temperature difference in the city center was higher than in the suburbs. The difference in the intensity of anthropogenic activity could be one of the factors.

Taoufik et al. [12] also researched changes in land surface temperature in the city of Casablanca, Morocco during the lockdown. This study used Landsat 8 imagery for temperature extraction, which used a higher spatial resolution than the MODIS imagery used by Hadibasyir et al. [10], where a comparison was found that drastically reversed between before and after the pandemic. The results of research by Taoufik et al. [12] showed that in the pre-pandemic period the temperature tended to rise and during the ongoing pandemic (lockdown) temperatures tended to fall and rise again when easing was implemented. Based on these studies, it can be seen that the lockdown that has been imposed has an effect on decreasing anthropogenic activity. The decrease in anthropogenic activity has positive things for the environment in the form of decreasing land surface temperatures in these cities.

Transportation, industry, households, and urbanization are the main activities that have the potential to increase land surface temperature (LST) [14, 15]. Thus, if an increase in anthropogenic activity can increase LST, then there is a possibility that a decrease in anthropogenic activity can also cause a decrease in LST. Population mobility between the City of Jakarta and its satellite cities, namely Bogor, Depok, Tangerang and Bekasi (Bodetabek) is very high. The growth of areas on the outskirts of Jakarta and the change in the function of Jakarta which was originally a residential area to an office area resulted in population movements and a shift in city functions from the city center to the suburbs. Even though the residents of Jakarta have moved to Bodetabek, some of them still depend on the Jakarta area for their economic life. The growth of residential areas and industrial activities to the outskirts of the city center is caused by the need for land for settlement locations and industrial activities [16].

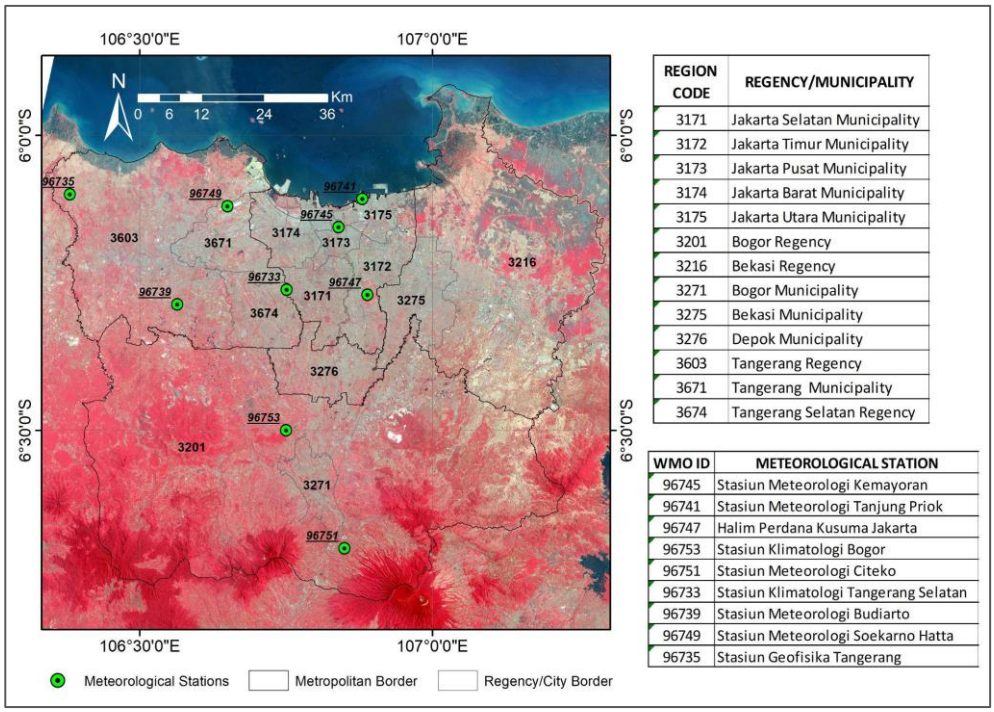
With restrictions on public activities, public transportation and temporary suspension of industrial activities in Jabodetabek (Jakarta Bogor, Depok, Tangerang, Bekasi) as long as the PSBB policy is enforced by the Government it will have an impact on changes in

the value of LST, where LST will be lower than before. The mobility of residents between cities is also strictly limited so that a drastic reduction in the use of inter-city transportation means a decrease in CO2 gas produced, so that cities around Jakarta, namely Bogor, Depok, Tangerang and Bekasi are also expected to experience a decrease in land surface temperatures. The LST dynamics can be analyzed spatially and temporally using remote sensing satellite data that has a thermal band [17,18]. Based on this background, this study aims to analyze the Covid-19 policy timeline in Jabodetabek and to analyze the impact of PSBB on land surface temperature in Jabodetabek.

Method

Research location

The astronomical location of Jabodetabek is at 106° 33' 5.17" - 1070 17' 44.31" East Longitude, and 5° 55' 17.95" - 6° 47' 16.27" South Latitude (Figure 1). The Jakarta Metropolitan Area (Jabodetabek) is in the northern part of Java Island, whose territory is covered by 3 provinces, namely DKI Jakarta Province, West Java Province (Bogor, Depok and Bekasi), and Banten Province (Tangerang). Jakarta is the main city, while Bogor, Depok, Tangerang and Bekasi are the satellite cities around it. The central to northern parts of the Jabodetabek area, namely Jakarta, Depok, Tangerang and Bekasi are dominated by plains that have a flat to gentle slope topography. The southern part which is included in the Bogor area has very varied slopes from flat to very steep. This is because most of the Bogor area is mountainous and there are two volcanoes.



REGION CODE	REGENCY/MUNICIPALITY
3171	Jakarta Selatan Municipality
3172	Jakarta Timur Municipality
3173	Jakarta Pusat Municipality
3174	Jakarta Barat Municipality
3175	Jakarta Utara Municipality
3201	Bogor Regency
3216	Bekasi Regency
3271	Bogor Municipality
3275	Bekasi Municipality
3276	Depok Municipality
3603	Tangerang Regency
3671	Tangerang Municipality
3674	Tangerang Selatan Regency

WMO ID	METEOROLOGICAL STATION
96745	Stasiun Meteorologi Kemayoran
96741	Stasiun Meteorologi Tanjung Priok
96747	Halim Perdana Kusuma Jakarta
96753	Stasiun Klimatologi Bogor
96751	Stasiun Meteorologi Citeko
96733	Stasiun Klimatologi Tangerang Selatan
96739	Stasiun Meteorologi Budiarto
96749	Stasiun Meteorologi Soekarno Hatta
96735	Stasiun Geofisika Tangerang

Figure 1. Jabodetabek as the research location is displayed with 543 composite Landsat 8 imagery

Geographically, Jabodetabek borders the Java Sea to the north, Karawang Regency to the east, Sukabumi Regency to the south, and Lebak Regency to the west. The Jakarta Metropolitan Area (Jabodetabek) has a total area of 6421.71 km^2, of which Jakarta is

653.83 km^2, Bogor is 2829.12 km^2, Depok is 200.29 km^2, Tangerang is 1312.98 km^2, and Bekasi is 1431.49 km^2. The northern part of Jabodetabek has a climate type C based on the Schmidt-Ferguson climate classification which has a slightly wet nature. The central part of Jabodetabek has a climate type B which has a wet nature, and in the south the climate has a type A which has a very wet nature.

Data used and method

This study uses Landsat 8 image data for the Jabodetabek area for recording July 2019, September 2019, April 2020, May 2020 and September 2020. The choice of image recording time is based on minimal cloud cover and the selected time can represent conditions before the pandemic, lockdown, and PSBB transition.

1. Analysis of the covid-19 pandemic policy timeline

In addition, researchers dig up information on government policies in each province, to support an analysis of the implications of government policies during a pandemic for changes in LST. Changes in the intensity of anthropogenic activities that trigger LST dynamics in a region during a pandemic are highly dependent on government policies in a given location. The policies implemented are the authority of each province led by the governor, so that between provinces can have different policies which can later have implications for anthropogenic intensity. The difference in anthropogenic intensity can have an impact on LST dynamics. In the research area, there are 3 Provinces consisting of DKI Jakarta (which includes the Jakarta Metropolitan area), Banten Province (which includes the Tangerang Metropolitan area), and West Java Province (which includes the Bogor, Bekasi, and Depok Metropolitan areas). Data related to government policies were obtained from the official website of the local government. After the multitemporal policy data is obtained, data recapitulation is then carried out to facilitate the analysis of the policy timeline and its implications for the permitted levels of anthropogenic activity intensity.

2. Image processing for LST extraction

The first stage of image processing was pre-processing Landsat 8 images for the entire recording time. DN Band 10 (thermal) is converted to top of atmoshpere (TOA) radiance by Eq. (1).

$$L\lambda = ML * Qcal + AL \quad (1)$$

Where,

$L\lambda$ = TOA spectral radiance
ML = band-specific multiplicative rescaling factor
Qcal = Digital Number
AL = band-specific additive rescaling factor

Furthermore, TOA radiance band 10 was processed into brightness temperature (BT) with Eq. (2).

$$BT = K2 / (\ln (K1 / L\lambda) + 1) \quad (2)$$

Where,

BT = brightness temperature (K)
K1 = calibration constant 1
K2 = calibration constant 2
Lλ = TOA radiance of band 10

Next, DN B4 (Red) and B5 (NIR) were converted to TOA reflectance. After obtaining the TOA reflectance for B4 and B5, then the atmospheric correction process was carried out using the Dark Object Substraction (DOS) 1 algorithm (Eq. (3)- Eq. (4)).

$$Rc = R - RSi \quad (3)$$

$$RSi = (\text{Mean Rw} - (2 \times \text{StDev Rw})) \quad (4)$$

Where,

Rc = Surface reflectance
R = ToA reflectance
Rw = Reflectance of dark object
StDev = Standard deviation

The next step is to calculate the Normalized Difference Vegetation Index (NDVI) value using the NIR band and the Red band (Eq. (5)).

$$NDVI = (\text{Band 5} - \text{Band 4}) / (\text{Band 5} + \text{Band 4}) \quad (5)$$

Band 5 and band 4 are the at surface reflectance for bands 5 and 4, respectively. Note that the calculation of NDVI is important because, furthermore, the proportions of vegetation (Pv), which is strongly related to NDVI, and emissivity (ε), which is related to Pv, must be calculated. Then, the calculation of the proportion of vegetation is done by Eq. (6).

$$Pv = ((NDVI - NDVImin) / (NDVImax - NDVImin))^2 \quad (6)$$

After knowing the Pv, the emissivity is calculated using Eq. (7).

$$\varepsilon = 0.004 * Pv + 0.986 \quad (7)$$

The final stage of image processing is LST processing by considering BT and Pv (Eq. (8)).

$$LST = (BT / (1 + (0.00115 * BT / 1.4388) * \ln(\varepsilon))) \quad (8)$$

BT was used in K units, so the resulting LST is also in K units. In order to simplify the analysis, the LST unit that is K is changed to Celsius by reducing the LST value (K) with a value of 273.15.

3. LST Analysis

LST was analyzed using descriptive statistical techniques so as to produce output in the form of information in the form of tables and graphs to present multitemporal measures of central tendency (mean) and dispersion (standard deviation).

Results and Discussion

Government policy timeline for the covid-19 pandemic

Large-Scale Social Restrictions (LSSR) as a local government policy that limits mobility between spaces to reduce the spread of Covid-19. The PSBB implementation center is in Jakarta which is the epicenter of the spread of Covid-19, which will be followed by other regions whose provisions refer to the Governor Regulation (Pergub) of each province. As in DKI Jakarta Governor Regulation Number 33 of 2020 which decided to implement PSBB in the Jakarta area, West Java Governor Regulation Number 27 of 2020 which decided to procure PSBB in the Bodebek area (Bogor, Depok, Bekasi) in harmony with LSSR in Jakarta, and Banten Governor Regulation Number 25 of 2020 which stipulates LSSR in the entire Tangerang area.

The results of the study in the form of land surface temperature data were generated from Landsat 8 OLI-TIRS images with image acquisition times that are within the PSBB policy date range in Jakarta, which has the least cloud cover. The time of image acquisition before the PSBB policy was implemented in Jakarta used was the 2019 image on the same date as the PSBB policy that was implemented in Jakarta in 2020. Information regarding the time of image acquisition used in this study can be seen in Table 1.

Table 1. The time of image acquisition used in this study

LSSR Policy Date in Jakarta		Acquisition Date	
		During the Outbreak (2020)	Before the Outbreak (2019)
April 10 – 23	Full-scale LSSR phase 1	22-Apr	*Cloud-covered study area*
April 24 – May 22	Full-scale LSSR phase 2	*Cloud-covered study area*	*Cloud-covered study area*
May 22 – June 4	Full-scale LSSR phase 3	24-May	*Cloud-covered study area*
June 5 – July 2	Transition Period LSSR phase 1	*Cloud-covered study area*	*Cloud-covered study area*
July 2 – 16	Transition Period LSSR phase 1; 1st extension period	*Cloud-covered study area*	*Cloud-covered study area*
July 16 – 30	Transition Period LSSR phase 1; 2nd extension period	*Cloud-covered study area*	25-Jul
July 30 – August 14	Transition Period LSSR phase 1; 3rd extension period	*Cloud-covered study area*	*Cloud-covered study area*
August 14 – 27	Transition Period LSSR phase 1; 4th extension period	*Cloud-covered study area*	*Cloud-covered study area*
August 27 – September 13	Transition Period LSSR phase 1; 5th extension period	13-Sep	11-Sep

The impact of the LSSR on land surface temperatures in Jabodetabek

The study area named Jabodetabek consists of three metropolitan areas and 11 districts/cities (Table 2). The metropolitan area in Jabodetabek consists of Jakarta (West Jakarta, Central Jakarta, South Jakarta, and East Jakarta), Bogor (Bogor and Bogor City), Depok, Tangerang (Tangerang City, Tangerang, South Tangerang), and Bekasi (Bekasi and Bekasi City)). In general, Jabodetabek experienced an average increase in temperature from 25 July 2019 to 11 September 2019 of 4.01 °C. A significant decrease in temperature began to occur on 22 April 2020 (LSSR volume 1) to 25.49 °C, then decreased again to 25.03 °C on 24 May 2020 (LSSR volume 3). After that, there was an increase in temperature on September 13 2020 (transitional LSSR). The standard deviation value also experiences up and down dynamics with the same pattern as the average temperature. The standard deviation shows a relatively low value among all periods on 22 April 2020 and 24 May 2020 of 2.30 °C and 2.03 °C, respectively. The low standard deviation of temperature in LSSR volumes 1 and 3 indicates that the spatial variations in temperature in Jabodetabek tend to be more homogeneous during LSSR volumes 1 and 3. The pattern of temperature dynamics and standard deviation for each district/city in the study area generally has a similar pattern where there is a decrease temperature and standard deviation during LSSR volume 1 to LSSR volume 3, which then increased during LSSR transition.

Table 2. Mean and Stdev for LST in each city district on a multi-temporal basis

No	District/City	Metropolitan Area	7/25/2019		9/11/2019		4/22/2020		5/24/2020		9/13/2020	
			MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV
1	Tangerang City	Tangerang	30.99	1.32	35.47	1.75	28.36	1.38	26.39	1.17	29.58	1.61
2	Tangerang		28.28	1.74	32.42	2.33	26.21	1.33	24.74	1.23	27.26	1.82
3	Tangerang Selatan		30.57	1.42	34.74	1.56	27.92	1.19	26.45	1.03	29.46	1.38
4	Jakarta Barat	Jakarta	31.32	1.07	35.83	1.39	28.79	1.15	27.03	0.98	29.85	1.13
5	Jakarta Pusat		31.20	1.12	35.91	1.51	28.93	1.11	27.16	1.03	30.10	1.20
6	Jakarta Selatan		31.55	1.18	35.80	1.48	28.30	1.07	26.95	0.92	30.24	1.22
7	Jakarta Timur		31.80	1.30	36.81	1.81	28.36	1.41	27.74	1.26	30.60	1.43
8	Jakarta Utara		30.57	1.80	35.31	2.67	28.14	1.74	26.95	1.51	29.21	1.94
9	Bekasi	Bekasi	28.77	2.20	33.17	3.33	25.37	1.73	25.76	1.67	26.91	2.10
12	Bekasi City		31.30	1.15	36.14	1.51	27.76	1.19	27.43	1.48	29.47	1.28
10	Bogor	Bogor	26.37	2.78	30.04	3.60	23.91	1.81	23.81	1.84	25.98	2.34
13	Bogor City		29.34	1.43	33.03	1.74	25.98	1.49	27.04	1.60	26.94	1.44
11	Depok	Depok	30.60	1.50	34.80	1.96	27.46	1.32	26.89	1.19	29.71	1.34
	JABODETABEK		28.17	2.90	32.18	3.75	25.49	2.30	25.03	2.06	27.22	2.51

Land surface temperature is affected by the flow or transfer of heat energy to the soil (land) from the environment on the surface by conduction and convection, because soil heat flow is the sum of the flux due to conduction and convection. Anthropogenic activities, especially in the industrial and transportation sectors, produce waste heat, where thermal and mechanical processes from industrial activities and electronic equipment operating inside buildings release waste heat into the environment [19]. The soil temperature which is relatively cooler than the environment on the surface causes heat to move or be absorbed into the soil, so that by conduction, waste heat causes the temperature of buildings and asphalt roads to be higher than the soil temperature so

that heat in these buildings moves, is absorbed by the soil [20]. This theory supports the reason why the land surface temperature in Jabodetabek dropped dramatically when the Total PSBB was implemented in Jakarta and rose again gradually when the Transitional PSBB policy was implemented. Yoo et al. [15] in previous research proved that anthropogenic activity contributed to changes in land surface temperature in Daegu City, Korea.

The average temperature dynamics for each metropolitan area is presented in Figure 2. In 2019 (before LSSR) the land surface temperature in the Jakarta metropolitan area in general, seen from the average temperature data, experienced a significant increase from 37.96 °C on 25 July 2019 to 45.05 °C on 11 September 2019. In 2020 (period LSSR) land surface temperature in Jakarta decreased significantly during the initial period of the Total LSSR, namely to 33.76 °C on April 22, 2020, and continued to decrease until the end of the Total LSSR period, which was 32.61 °C on May 24 2020. The land surface temperature increased again to 37.63 °C on 13 September 2020, at which time the Transitional LSSR policy was being implemented in Jakarta.

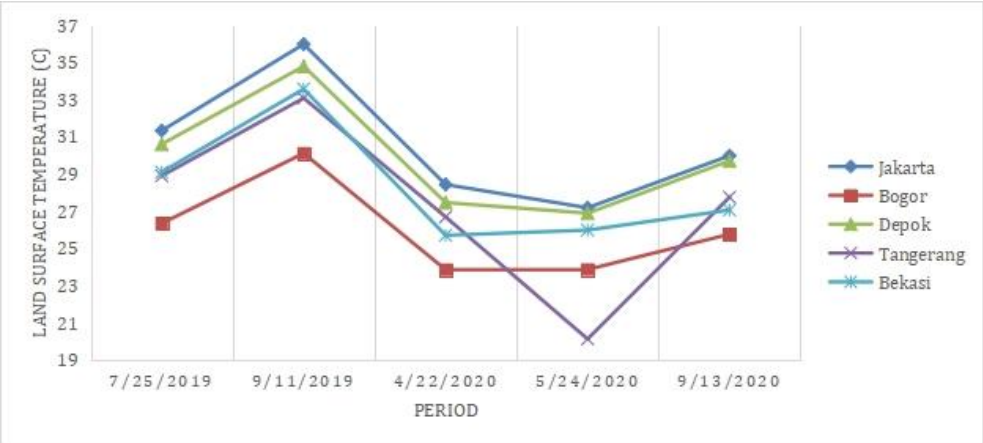


Figure 2. Average temperature dynamics for each metropolitan area

The Total LSSR policy, which massively limits anthropogenic activities in Jakarta, also has a direct impact on reducing the amount of heat waste, so that the amount of heat absorbed by the soil decreases and land surface temperatures in Jakarta decrease compared to before. One of the total LSSR policies regulated in Pergub Number 33 of 2020 is holidaying activities at work except for 11 strategic agencies, namely health companies, food businesses, energy, telecommunications and information technology, finance, logistics, hotels, construction, industry strategic, and basic services or public and industrial utilities that are designated as national vital objects and certain objects, fulfilling daily needs [7]. Based on data from the DKI Jakarta Central Statistics Agency (2021) in the DKI Jakarta Manufacturing Industry Statistics publication, there were 1,792 large and medium manufacturing industries that were actively operating in 2019. Meanwhile, in the detailed data it was stated that there were 222 industries operating in the food sector, 17 industries beverages, 9 energy industries, and 44 industries engaged in the pharmaceutical sector, which means that there were 292 industries or

16.29% of the 1,792 industries that were still operating during the initial period of the total LSSR.

There was an incident where several industries or companies in the Jakarta metropolitan area temporarily stopped operating in the second timeframe for image acquisition, namely April 22 – May 24 2020. On April 22 2020, there were 52 companies that violated the LSSR rules, causing the DKI Jakarta Provincial Government to temporarily close 52 the company [11]. Furthermore, on April 27 2020, there were 543 companies and workplaces that violated the LSSR regulations which resulted in the sealing of 76 of them [21]. A decrease in land surface temperature when restrictions and bans on social activities were imposed due to the Covid-19 Pandemic also occurred in Wuhan City, China, in a previous study conducted by Hadibasyir et al. [10] who compared the surface temperature of the land between before the Covid-19 pandemic hit the city and when the lockdown policy involving social activities including industrial and transportation activities was enforced, where the result was that the surface temperature of the land during the lockdown period in Wuhan was lower than in previous years. at the same timeframe.

The land surface temperature in Jakarta was rising again based on the results of the image acquisition of 13 September 2020, which is the final date of the Transitional PSBB. On the previous June 5, the Governor of DKI Jakarta, Anies Baswedan, issued Governor Decree No. 563 of 2020 Regarding the Implementation of Stages and Implementation of LSSR Activities during the Transitional Period. In general, during the Transitional LSSR period, almost all forms of activity were relaxed, including industrial activities with a legalized quota of 50% [22], September 11). The LST value in Jakarta in the image acquisition on September 13 has increased by 2.8 ℃, bringing the land surface temperature to 29.96 ℃ with the lowest temperature being 20.51 C and the highest temperature being 29.96 ℃. With the resumption of industrial and transportation activities, heat waste is also produced and released into the environment so that the surface temperature of the land is also increasing again. Something similar happened in the City of Casablanca, Morocco, in a study conducted by Taoufik et al. [12] where in the face of the Covid-19 outbreak in the city, the local government imposed a lockdown and there was an easing of activities afterwards, with the result that the surface temperature of the land in the City decreased drastically when compared to the year before the lockdown, and again experienced an increase during the relaxation opened.

The impact of the LSSR on land surface temperatures in the Bogor, Depok and Bekasi metropolitan areas

Jabodetabek is not an administrative area under one regional government, but part of 3 Provinces, namely Jakarta as part of the DKI Jakarta Province, Bodebek (Bogor, Depok and Bekasi) which is part of the Province of West Java and Tangerang which is part of the Province of DKI Jakarta. Banten. Therefore, the policies implemented in Jabodetabek may differ from one region to another because they depend on the Governor's Decree (Kepgub) from each province. As in West Java, as a preventive

measure to prevent the worsening impact of the Covid-19 pandemic in the Bodetabek area and to break the chain of transmission, especially from Jakarta which is the epicenter of the Covid-19 pandemic in Indonesia in 2020, the Governor of West Java issued West Java Governor Regulation Number 27 of 2020 which stipulates that the PSBB will also be implemented in all areas of Bogor, Depok and Bekasi from 18 April to 3 May 2020, which will be extended in line with the PSBB policy from the DKI Jakarta Government.

In 2019 (before the LSSR was implemented in Jakarta) the land surface temperature in the Bogor metropolitan area in general, taken from the average temperature data, has increased, namely 39.04 ℃ on 25 July 2019 to 43.28 ℃ on 11 September 2019. In 2020 (when the PSBB was implemented in Jakarta) the land surface temperature in Bogor decreased quite drastically during the initial PSBB Total to 34.21 ℃ on April 22, 2020, then increased again to 36.09 ℃ on May 24, 2020, at which time the Total LSSR is in phase 3, and continues to increase until the Transitional LSSR policy is enforced in Jakarta to 38.87 ℃ on 13 September 2020.

In 2019 (before the PSBB was implemented in Jakarta) the land surface temperature in Depok in general, seen from the average temperature data, experienced a significant increase from 35.86 ℃ on July 25, 2019, to 40.83 ℃ on September 11 2019. In 2020 (when the PSBB was implemented in Jakarta) the land surface temperature in Depok decreased significantly during the initial period of the Total LSSR, namely to 31.64 C on April 22, 2020, and continued to decrease to 30.94 ℃ on May 24, 2020, at which time the Total LSSR is in phase 3. The land surface temperature has increased again to 34.03 ℃ on 13 September 2020, at which time the Transitional LSSR policy was being implemented in Jakarta.

In 2019 (before LSSR was implemented in Jakarta) land surface temperatures in Bekasi in general, seen from the average temperature data, experienced a significant increase from 39.88 ℃ on July 25, 2019, to 47.03 ℃ on September 11, 2019. In 2020 (when the LSSR was implemented in Jakarta) the land surface temperature in Bekasi experienced a significant decrease during the Total PSBB Volume 1, namely to 34.98 ℃ on April 22, 2020, and slightly decreased to 34.89 ℃ on May 24, 2020, at which time the LSSR policy Total Volume 3 in Jakarta is being implemented. The land surface temperature in Tangerang increased again to 37.53 ℃ on September 13, 2020, at which time the Transitional LSSR policy was being implemented in Jakarta.

Based on West Java Governor Regulation Number 27 of 2020 concerning guidelines for Large-Scale Social Restrictions (LSSR) in the Bodebek area (Bogor, Depok, and Bekasi), things that are restricted are school activities, work at work, religious activities in houses of worship, activities in public facilities, socio-cultural activities, as well as the mobility of people and goods using modes of transportation. Learning activities and work are carried out remotely. Temporary suspension of activities at work is excluded for all government agencies, BUMN, and business actors operating in 11 certain sectors as in the policy applied to the Jakarta LSSR, as well as both local and international NGOs

working in the disaster and/or social sectors. The use of all modes of transportation is restricted except for fulfilling basic needs, security, and other permitted activities. Public transportation with 50% capacity and limited operating hours.

As a result of the restrictions on anthropogenic activities, of course, the mobility rate in Bodebek has dropped drastically, where the decrease in mobility is not only within Jakarta but also in the surrounding areas, especially Bodetabek (Bogor, Depok, Tangerang, Bekasi). KRL is one of the transportation fleets whose travel route coverage is in the Jabodetabek area and is often used by commuters, with the achievement of a total number of passengers of 15,349,716 from April to September 2019. This number decreased by 87.12% in April - September 2020 to 1,976,762. So that, like in Jakarta, anthropogenic activities, especially in the industrial and transportation sectors, in Bodebek experienced a drastic decline during the LSSR period. The LSSR in Bodetabek was subsequently extended in the West Java Governor Decree (Kepgub) Number 443/Kep.304-Hukham/2020 concerning the Enforcement of Large-Scale Social Restrictions (LSSR) proportionally which is valid for 28 days or four weeks, starting from Friday 5 May to Thursday 2 July, 2020. Secretary of the West Java Task Force for the Acceleration of Handling COVID-19 Daud Achmad in his written statement said that the extension of the LSSR was aligned with the policy of the DKI Jakarta government which began entering the transitional PSBB throughout June [23].

The rise in land surface temperatures on September 13, 2020, in Bogor, Depok and Bekasi is the same as what happened in Jakarta. The LSSR, which was also implemented in Bodebek, has reduced anthropogenic activities, especially those that release large amounts of waste heat into the environment, such as industrial and transportation activities. However, with the easing, the anthropogenic activity which had stopped was resumed although gradually and there were still several other restrictions so that waste heat was again produced and released into the surrounding environment, which caused the soil which had a lower temperature to absorb heat in the environment and caused an increase in temperature. land surface in Bodebek.

LSSR impact on land surface temperature in the Tangerang metropolitan area

In 2019 (before the LSSR was implemented in Jakarta) the land surface temperature in the Tangerang metropolitan area in general, seen from the average temperature data, experienced a significant increase from 39.68 ℃ on July 25, 2019, to 44.63 ℃ on September 11, 2019. In 2019 2020 (when the PSBB was implemented in Jakarta) land surface temperatures in Tangerang experienced a significant decrease in LSSR Total Volume 1, namely to 34.22 ℃ on 22 April 2020 and continued to decrease to 31.23 ℃ on 24 May 2020, at which time the LSSR Total was at phase 3. Land surface temperatures in Tangerang increased again to 36.58 C on September 13, 2020, at which time the Transitional LSSR policy was being implemented in Jakarta.

Tangerang is an area directly adjacent to Jakarta which is the epicenter of the spread of the Corona virus. Tangerang is also one of the areas that has a high level of inter-regional

mobility in Jabodetabek. Based on published data for Jakarta Transportation Statistics 2019 [24], the number of train passengers bound for Jabodetabek was 336,048,369 passengers in 2019 with 938 total trips, of which 291 trips were the Jakarta - Tangerang route, namely the Train Station route Tangerang – Duri and Rangkas/Maja/Parung Panjang/serpong Stations – Tanah Abang. Based on data published by Badan Pusat Statistik Provinsi Banten [25] here were 2,439 large and medium manufacturing industries in Tangerang as of 2019. Based on data on the number of motorized vehicles in 2019 in the Tangerang area published by Badan Pusat Statistik Provinsi Banten [26], it is known that there are 683,018 passenger cars, 2,025 buses, 137,529 trucks, and 3,219,574 motorbikes in Tangerang. The data shows the massive anthropogenic activity which is the biggest contributor to waste heat in Tangerang, which can cause land surface temperatures to rise in the region.

On April 22, 2020, as in the Bodebek area, the Tangerang area is also in the LSSR period based on Banten Governor Regulation Number 25 of 2020 which stipulates LSSR in the entire Tangerang area which takes place from April 18 to May 3. The Pergub mentions that activities outside the home are restricted including learning activities, work activities at work, religious activities in houses of worship, activities in public places or facilities, social and cultural activities, as well as the movement of people and goods using modes of transportation. The decrease in anthropogenic activity causes a decrease in the production of waste heat, which is released into the environment, so it is natural that there will be a decrease in land surface temperature.

Conclusion

Policies related to the adaptation of anthropogenic activities depend on the decision of the regional head, which in this case is held by the governor. In general, the policy phase of adjusting the intensity of human activity consists of total LSSR and transitional LSSR. The total LSSR limits all outdoor activities except activities from vital sectors such as health and energy. As for the transitional LSSR, there is an easing of activities, such as the public transportation and offices and industry sectors, but they are still limited.

Jabodetabek experienced an increase in land surface temperatures in 2019 or at the time before the PSBB policy was implemented in Jakarta. In 2020, when the LSSR in Jakarta was implemented due to the Covid-19 pandemic, the Jakarta area, and other areas outside Jakarta both experienced a drastic decrease in land surface temperatures, at which time LSSR Total volume 1 was enforced, then continued to decrease until PSBB Total volume 3. Furthermore, the temperature began to increase when the PSBB transition period reached phase 1 (13 September 2020).

In 2020 (the LSSR period) land surface temperatures in Jakarta decreased significantly during the initial PSBB Total period, namely to 33.76 °C on April 22, 2020, and continued to decrease until the end of the Total PSBB period, which was 32.61 °C on May 24, 2020. Land surface temperature This increased again to 37.63 °C on 13 September 2020, at which time the Transitional PSBB policy was being implemented in Jakarta.

Acknowledgments

The authors would like to thank the USGS for providing free Landsat imagery. In addition, the authors also thank the reviewers and editors who have contributed and provided input for the improvement of this article.

References

[1] Kuo, L.. Coronavirus: China bars 11m residents from leaving city at centre of outbreak. The Guardian 2020. Retrieved from https://www.theguardian.com/world/2020/jan/22/coronavirus-china-measures-rein-spread-mutate-disease-death-toll
[2] McNeil, S. Wuhan Celebrates the End of Its 76-Day Coronavirus 2020 Lockdown Retrieved. TIME. https://www.aa.com.tr/en/asia-pacific/covid-19-china-opens-wuhan-after-76-day-lockdown/1796205
[3] Antara. Corona di Jakarta, DKI Sebar Surat Edaran Cara Penanganan Pasien. tempo.co. 2020, March 6 Retrieved from https://metro.tempo.co/read/1316156/corona-di-jakarta-dki-sebar-surat-edaran-cara-penanganan-pasien
[4] Nafi'an, M. I. Anies: 115 Orang di Jakarta dalam Pemantauan Terkait Virus Corona. 2020 detiknews. From https://news.detik.com/berita/d-4920457/anies-115-orang-di-jakarta-dalam-pemantauan-terkait-virus-corona
[5] Candra, S. A. Jokowi Umumkan Dua Kasus Pertama Positif Corona di Indonesia. REPUBLIKA.co.id. 2020, March 2 Retrieved from https://www.republika.co.id/berita/q6jur3409/jokowi-umumkan-dua-kasus-pertama-positif-corona-di-indonesia
[6] Fajri, F. A. Disdik DKI Terbitkan Surat Edaran Soal Pelajar Belajar di Rumah Akibat Wabah Corona. WARTAKOTAlive.com. 2020, March 15)Retrieved from https://wartakota.tribunnews.com/2020/03/15/disdik-dki-terbitkan-surat-edaran-soal-pelajar-belajar-di-rumah-akibat-wabah-corona
[7] Azhari, J. R. 6 Larangan dan 4 Hal yang Diperbolehkan Selama PSBB Total Kembali Berlaku di Jakarta. KOMPAS.com. 2020, September 10 Retrieved from https://megapolitan.kompas.com/read/2020/09/10/09210521/6-larangan-dan-4-hal-yang-diperbolehkan-selama-psbb-total-kembali-berlaku?page=all
[8] Andri, Y. Mulai Senin, Pembatasan Transportasi Umum Di Jakarta Berlaku. JAKARTA. 2020, March 21. Retrieved from https://jakarta.bisnis.com/read/20200321/77/1216430/mulai-senin-pembatasan-transportasi-umum-di-jakarta-berlaku
[9] Siddiq, T. Selain Pergub Anies Baswedan Juga Terbitkan Kepgub PSBB, Isinya. TEMPO.CO. 2020. Retrieve from https://metro.tempo.co/read/1330108/selain-pergub-anies-baswedan-juga-terbitkan-kepgub-psbb-isinya
[10] Hadibasyir, H. Z., Rijal, S. S., & Sari, D. R. . Comparison of Land Surface Temperature During and Before the Emergence of Covid-19 using Modis Imagery in Wuhan City, China. Forum Geografi,2022. 34, 1-15. doi:10.23917/forgeo.v34i1.10862
[11] Sari, N. UPDATE: Langgar PSBB Jakarta, 52 Perusahaan Ditutup Sementara. Kompas.com. 2020. Retrieve from https://pemilu.kompas.com/read/2020/04/22/20355121/update-langgar-psbb-jakarta-52-perusahaan-ditutup-sementara
[12] Taoufik, M., Laghlimi, M., & Fekri, A. Comparison of Land Surface Temperature Before, During and After the Covid-19 Lockdown Using Landsat Imagery: A Case Study of Casablanca City, Morocco. Geomatics and Environmental Engineering, 2021 .15, 105-120.
[13] Hidayati, I. N., Suharyadi, R., A Comparative Study of Various Indices for Extraction
[14] Urban Impervious Surface of Landsat 8 OLI. Forum Geografi, 2019. 33, 162-172. DOI:
[15] 10.23917/forgeo.v33i2.9179
[16] Wang, Y., Zhan, Q., & Ouyang, W. Impact of Urban climate landscape patterns on land surface temperature in Wuhan, China. Sustainability (Switzerland), 2017. 9. doi:10.3390/su9101700
[17] Yoo, C., Im, J., Park, S., & Cho, D.. Thermal Characteristics of Daegu using Land Cover Data and Satellite-derived Surface Temperature . 2017, 33, 1101-1118. doi:10.7780/kjrs.2017.33.6.2.6
[18] Warsida, R. Y., Adioetomo, S. M., & Pardede, E. Pengaruh Variabel Sosio-Demografis terhadap Mobilitas Ulang-Alik di Jabodetabek. Jurnal Ekonomi dan Pembangunan Indonesia,2013, 13, 159-176. doi:10.21002/jepi.v13i2.489

[19] Buyantuyev, A., & Wu, J. Urban heat islands and landscape heterogeneity: Linking spatiotemporal variations in surface temperatures to land-cover and socioeconomic patterns. Landscape Ecology,2010, 25, 17-33. doi:10.1007/s10980-009-9402-4
[20] Li, X., Li, W., Middel, A., Harlan, S. L., Brazel, A. J., & Turner, B. L. Remote sensing of the surface urban heat island and land architecture in Phoenix, Arizona: Combined effects of land composition and configuration and cadastral-demographic-economic factors. Remote Sensing of Environment, 2016, 174, 233-243. doi:10.1016/j.rse.2015.12.022
[21] Johnson,I.,Choate, Davidson .West Hot Recovery, tehnology and opprtuties in US Industry. Enveronmental science, 2008 DOI:10.2172/1218716
[22] Avena, G., Jonsson,E, Model for evaporation, moisture and temperature of bare soil: calibration and sensitivity analysis, Agricultural and Forest Meteorology 1997, 88. Pp 47-56.
[23] Wibisono, G. 543 Perusahaan di Jakarta Langgar PSBB, 76 Sudah Disegel. JawaPos.com.2020. Retrieve from https://www.jawapos.com/nasional/28/04/2020/543-perusahaan-di-jakarta-langgar-psbb-76-sudah-disegel/
[24] Yuliana.. Timeline PSBB Jakarta dari April hingga September, Apa Penyebabnya? rukita. 2020. Retrieved from https://www.rukita.co/stories/timeline-psbb-jakarta/
[25] VOI. Giliran Bodebek yang Perpanjang PSBB Hingga 2 Juli Mendatang. 2020 Retrieved from https://voi.id/berita/6847/giliran-bodebek-yang-perpanjang-psbb-hingga-2-juli-mendatang
[26] Badan Pusat Statistik Provinsi DKI Jakarta. Statistik Transportasi DKI Jakarta 2019. 2020.
[27] Badan Pusat Statistik Provinsi Banten. STATISTIK INDUSTRI BESAR DAN SEDANG DI PROVINSI BANTEN 2019. Serang, Indonesia: Badan Pusat Statistik Provinsi Banten. 2021.
[28] Badan Pusat Statistik Provinsi Banten. Jumlah Kendaraan Bermotor Menurut Kabupaten/Kota dan Jenis Kendaraan di Provinsi Banten (unit), 2015– 2019. Badan Pusat Statistik Provinsi Banten. 2020.