ENVIRONMENT QUALITY IDENTIFICATION USING LANDSAT-8 IN THE PERIOD OF COVID-19 LOCKDOWN IN JAKARTA

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Abstract. This study explored Jakarta's environmental quality across different phases of the Covid-19 lockdown, leveraging Landsat-8 satellite imagery. The focus was on key environmental indicators: PM10, Land Surface Temperature (LST), and indexes like NDVI (vegetation), NDWI (water), and NDMI (moisture). Advanced techniques such as radiometric correction were employed to ensure accurate data extraction from satellite imagery. PM10 levels were estimated using linear regression with ground station data, while LST was derived from the satellite's brightness temperature data. NDVI, NDWI, and NDMI were calculated from reflectance band transformations, each providing insights into different aspects of the environment. The study developed an environmental quality index by weighting each variable differently: 50% for PM10, 31% for LST, and lower weights for the other indices. This index revealed significant findings. Prior to the lockdown, many Jakarta regions had poor environmental quality. During the lockdown, improvements were observed, although areas like the Cilincing industrial zone still struggled. Post-lockdown, environmental quality was mixed, with some areas not returning to pre-lockdown conditions. This research highlights the lockdown's impact on urban environmental quality and the utility of satellite data in environmental monitoring..

Keywords: *landsat-8, environment quality index, covid-19, lockdown, PM10*

1 INTRODUCTION

The decline in environmental quality continues to occur both from the land, air and water environment. This phenomenon occurs especially in urban areas due to human activities such as the use of motorized vehicles, industrial activities, household activities and limited green open space. This results in liquid waste, air waste, and solid waste. DKI Jakarta is no exception, as the nation's capital, which has various activities that have an impact on the environment. The DKI Jakarta Provincial Environmental Agency (DLH DKI Jakarta) calculates the environmental quality index based on the water pollution index, air pollution index, and land cover index based on Law Number 32 of 2009 about Environmental Management (DLH, 2020). In addition, the KLHK website http://iku.menlhk.go.id/aqms/arsip stated that the Air Pollutant Standard Index (ISPU) in Jakarta in 2019 showed 212 days (58% per year) which was a moderate condition and only 130 days (35% per year) in the good category.

The Covid-19 pandemic has infected 665 million people worldwide with the number of deaths reaching 6.72 million cases as of 31 January 2023 (https://covid19.go.id/id). The high spread of this disease has also hit Indonesia, especially in the capital city of DKI Jakarta with the highest cases of 1.5 million positive confirmations and the number of deaths reaching 15,941 as of 31 January 2023 (https://corona.jakarta.go.id/id).
Various efforts have been made by the government to overcome this problem. Creating a COVID-19 task force,

implementing health protocols, namely social distancing, washing hands and wearing masks, and making a lockdown policy called Pembatasan Sosial Berskala Besar (PSBB) through PERGUB No. 33 of 2020 as the legal basis implementation on 10 – 24 April 2020.

The Covid-19 lockdown is in the form of work from home (WFH), school form home (SFH), and pray from home. This policy was issued by the government as an effort to minimize the spread of the Covid-19 disease. The DKI Jakarta government implements the WFH policy in all sectors except health, food, transportation, etc. to limit the movement of its population. The implementation of this policy was considered successful in reducing public exposure to Covid-19.

In this study, the environmental quality of DKI Jakarta is the quality of the air environment and the quality of the land environment. Air quality is measured from PM10 which is a parameter of air pollution index (KLH, 1997). Driving force of air pollution is in the form of particles. Particulate Matter (PM10) are airborne particles in solid form with a diameter of less than 10 micrometers, the solid particles in this smoke will scatter sunlight so that it interferes with vision. (Haq & Vallack, 2002) mentions that PM10 is generated from motor vehicle and industrial activities. (Wijayanti, Sutrisno, & Budiharjo, 2014) studied transportation activities in the northern coast of Central Java as the main cause of air pollution from PM10. Based on these studies, the pressure that increases air pollution is the increase in the number of motorized vehicles and industrial activity. The condition of PM10 before the Covid-19 pandemic (state) in 2019 had an average of 39 μm/m3 which was included in the moderate category of ISPU (KLHK, 2020). This study examines the effect of reduced use of motorized vehicles due to the implementation of work from home during the lockdown period on air quality and land quality. Air quality is reflected by PM10 while land quality is described by land surface temperature and vegetation index.

Previous research regarding air quality during the Covid-19 pandemic included (Baldasano, 2020) in Spain, (Griffith et al., 2020) in East Asia, (Zheng et al., 2020) in Wuhan, China. In Indonesia, Umara et al, 2020 studied air quality from Jakarta station data. The research stated that PM2.5 and PM10 values decreased when work from home was implemented in March 2020 compared to 2019. Related to environmental quality from land and air aspects (Ghosh et al., 2020) studied in big Indian cities. The variables used are the land environment from LST, NDVI, NDWI, and NDMI as well as PM10 air quality.

Jakarta as the capital city of Indonesia which high environmental changes need to be studied about the environmental condition. The lockdown covid-19 will have influenced the environmental condition. However, the study is limited. Weighted linear method which has been used to model the EQI in the India will be applied in Jakarta, Indonesia in tropical country. From the research gap and hypothesis, this study aims to identify environment quality using Landsat-8 in Jakarta when Covid-19 lockdown.

2 MATERIALS AND METHODOLOGY

In this part described location, data, and methodology of the study.

2.1 Location and Data

This research was conducted in DKI Jakarta Province except Kepulauan Seribu which includes 5 administrative cities i.e. West, North, Central, East and South Jakarta (Figure 2-1). The exclude of Kepulauan seribu since it has different physical characteristic which will have different environmental condition. The exclude of Kepulauan seribu since it has different physical characteristic which will have different environmental condition. The study area located in 6°12’ S and 106°48’ E. The region has tropical rainforest climate with annual air temperature ranging from 20 - 30°C. the relative humidity is high, typically ranging from 70% – 90%. There are two season i.e. rainy and dry season (Dai et al, 2023). The landforms is dominated with plain with relatively flat terrain which consist of rivers and lake. Southern part is alluvial landform, northern part is marine-origine, northwest and northeast is beach ridge, swap and mangrove in the coastal fringe

(Abidin et al, 2008). The LULC is dominated with antropogenic development such as built up area of settlement, office building, factory.

The data used are Landsat 8 OLI and TIRS Level 1TP path/row 122/64 images on 25 July 2019, 22 April 2020, and 27 July 2020. 25 July 2019 represent condition before lockdown years ago which free from cloud cover. Also, in the same day of 25 July 2019 gathered PM10 data to build the model of PM10 using Landsat-8. 22 April 2020 is recorded time image that show the lockdown period and 27 july 2020 is after lockdown. Table 2-1 shows the specifications of Landsat-8 imagery

Figure 2-1: Landsat-8 Imagery of DKI Jakarta Province as study location

Tabel 2-1 Specification of Landsat-8 Imagery

Sensor	Spectral Bands	Wavelength (nm)	Spatial Resolution (m)
OLI	Band 1 – Coastal/Aerosol	433 – 453	30
	Band 2 – Blue	450 – 515	30
	Band 3 – Green	525 – 600	30
	Band 4 – Red	630 – 680	30
	Band 5 – Near Infrared	845 – 885	30
	Band 6 – SWIR1	1560 – 1660	30
	Band 7 – SWIR2	2100 – 2300	30
	Band 8 - Panchromatic	500 – 680	15
	Band 9 - Cirrus	1360 – 1390	30
TIRS	Band 10 – Thermal	10600 – 11190	100
	Band 11 – Thermal	11500 – 12510	100

PM10 concentration data were obtained from observations at 6 air quality measurement stations at the DKI Jakarta Provincial Environmental Agency (DLH DKI Jakarta) and the Ministry of Environment and Forestry (KLHK) which are evenly distributed in each administrative city, specifically for Central Jakarta there are 2 station locations, namely at the Bundaran HI and Gelora Bung Karno Stadium. PM10 concentrations are expressed in units of µg/m3 which is observation data for 24 hours on July 25 2019. The observation

date is adjusted to the time of recording of Landsat-8 imagery.

Field survey data in the form of land cover and temperature information. The field survey was taken using the stratified random sampling (STR) method by dividing the population into several groups based on environmental quality classes and then randomly taking from each of these groups. This method has been used in this study since STR gives results by strata which environment quality has its strata. It accommodates more sample to strate with higher variability or importance. The STR shows higher estimation accuracy and more economical cost (Lu et al., 2023).

2.2 Methods

(Landsat 8 level 1TP image is pre-processed with radiometric correction to improve image pixel values from distortion so that they match object reflections (Danoedoro, 2012). USGS, 2016 has explained this pre-processing technique to top of atmosphere (TOA)

correction for reflectance and radian values. It is used metadata file which contains reflectance and radiance rescaling coefficient.

$$L_\lambda = M_L Q_{cal} + A_L \quad (1)$$

Where Lλ is TOA spectral radiance, ML is the band-spesific multiplicative rescalling factor from the metadata, AL is band specific additive rescalling factor from the metadata and Qcal is DN of the image.

LST variable extraction uses the mono window brightness temperature (BT) band 10 methods because band 11 has stray light disturbances (Utomo, Suprayogi, & Sasmito, 2017). Equation 2 is a brightness temperature calculation (2016).

$$T = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda}+1\right)} \quad (2)$$

K1 and K2 are band 10 thermal constants, while is TOA radians.

The index transformations used include the Normalized Difference Vegetation Index (NDVI) (Myneni & Williams, 1994), Normalized Difference Moisture Index (NDMI) (USGS, 2018), and Normalized Difference Water Index (NDWI) (Xu, 2006). NDVI is a ratio index that combines the near infrared and red bands to determine the density of vegetation in a land cover. NDMI is a ratio index to identify soil surface moisture with the near infrared band and the SWIR band. While NDWI is an index to distinguish objects based on their wettability using the ratio of the green band and the near infrared band. Here are the equations:

$$NDVI = \frac{Band5 - Band4}{Band5 + Band4} \quad (3)$$

$$NDMI = \frac{Band5 - Band6}{Band5 + Band6} \quad (4)$$

$$NDWI = \frac{Band3 - Band5}{Band3 + Band5} \quad (5)$$

The PM10 variable was constructed using a regression model between observation station data and pixel values. A number of sample observation values are adjusted to the Landsat-8 image recording time. The pixel value is a combined value of band 2 – band 5 which has been corrected by TOA whose equations match (U.S. Geological Survey, The spectral band was chosen which represents the best PM10 (Ghosh et al., 2020).

The weighting of land and air environmental quality variables follows previous research (Ghosh et al., 2020). Table 2-2 shows the weight value of each variable.

Table 2-2. Weight factor of environment quality variable

Environment quality variable	Weight
PM10	0,492
LST	0,3136
NDVI	0,1093
NDWI	0,0553
NDMI	0,0298

Table 2-3: Data used in this study

No	Type of Data	Date	Source
1.	Landsat-8 Path/row 122/64	25072019 22042020 27072020	BRIN ex. LAPAN http://landsat- catalog.lapan.go.id/
2.	PM10 stations: DKI1 DKI2 DKI3 DKI4 DKI5 KLHK-GBK-JAKARTA	25072019	DLH DKI Jakarta 2019 and 2020 https://data.jakarta. go.id/dataset/indeks - standar- pencemaran- udara-ispu-tahun-2020 KLHK 2019 http://iku.menlhk.go .id/aqms/arsip
3.	Field survey	21112020 22112020	Own data collection

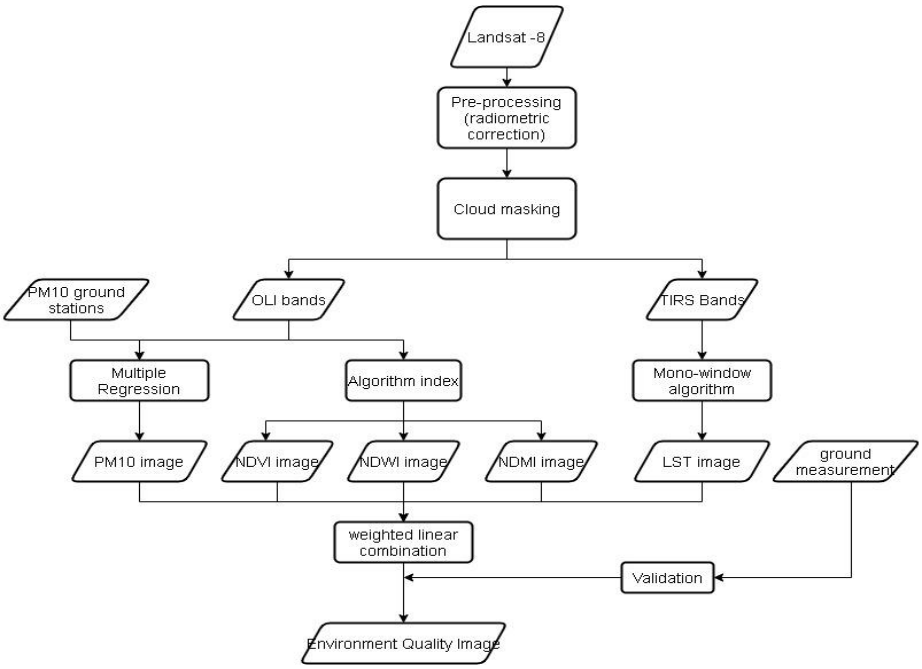


Figure 2-2: Flowchart of the study

A field survey using the started random sampling method was applied to this study to test the LST and NDVI variables. LST checking using an infrared thermometer with an average temperature in an area of 100 x 100 m. Observation of land cover in an area of 30 x 30 to check the quality of the environment in general. Figure 2-2 shows the flowchart of this study.

3 RESULTS AND DISCUSSION

PM10 concentration based on observations at 6 stations has a value of 56 – 79 µg/m3. The stations are spread spatially in Figure 3-1(a) in each administrative city in locations that have high pollutants, including: Bundaran HI, Gelora Bung Karno, Kebon Jeruk, Jagakarsa, Lubang Buaya, and Kelapa Gading. This value is included in the category of moderate ISPU which affects the decrease in visibility (KLHK, 1997). Observation data is point data then processed into spatial data based on the linear regression method with bands 2, 3, 4, and 5. Figure 3-1(b) shows a graph of the observed PM10 values with visible and near infrared reflectance band values. Based on the graph, the visible band reflectance value shows a positive trend, the higher the PM10 value, the higher the reflectance value. On the other hand, the near infrared band has a negative trend, the higher the PM10, the lower the reflectance.

The PM10 and Landsat8 algorithm models in DKI Jakarta Province are Y = 57.23 - 6.26*B2 + 5.64*B3 + 3.01*B4 - 0.77*B5. The regression results have a coefficient of determination R2 = 0.95 with a standard error of 4.19. It has high determination especially of each variable. Positive correlation is performed by band3, band 4 while negative correlation is performed by band2 and band5. From the chart (Figure 3(b)), it is shown the linear line between pm10 observation and reflectance bands. The band 5 has most influenced among other bands (R=0.64) which is near infrared. It gives new insight from other study. Previously, Mozafari et al., 2019 studied that aerosol band (Band 1) Landsat-8 has significant influence of PM10 estimation in Tehran, India. While Saraswat et al., 2017 studi that visual band has strong correlation in Delhi, India. From this regression also resulted good RMSE with only 4.19. This value is good and can be applied to PM10 modeling at other recording times.

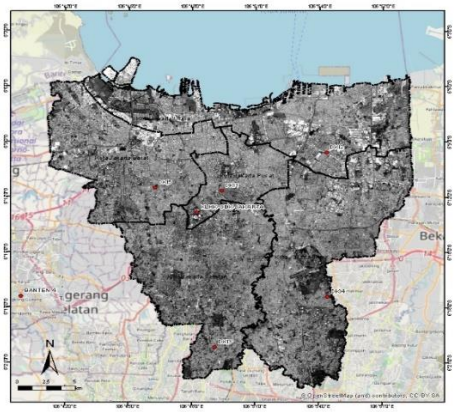


Figure 3-1(a): Spatial distribution of stations

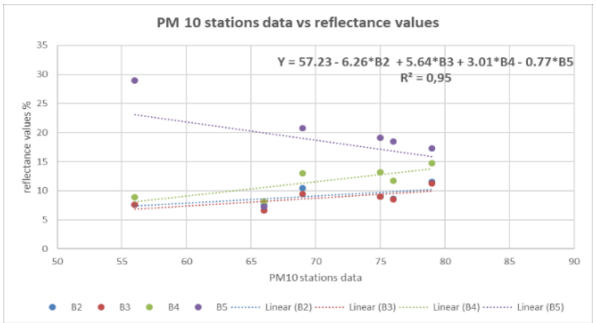
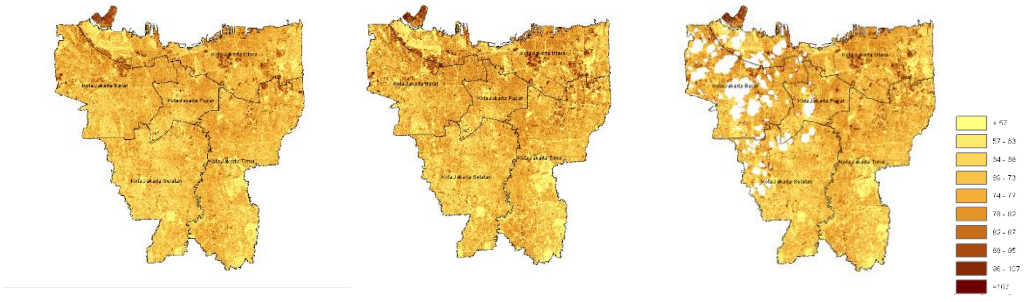


Figure 3-1(b): Multiple linear regression between PM10 stations data and reflectance values bands.

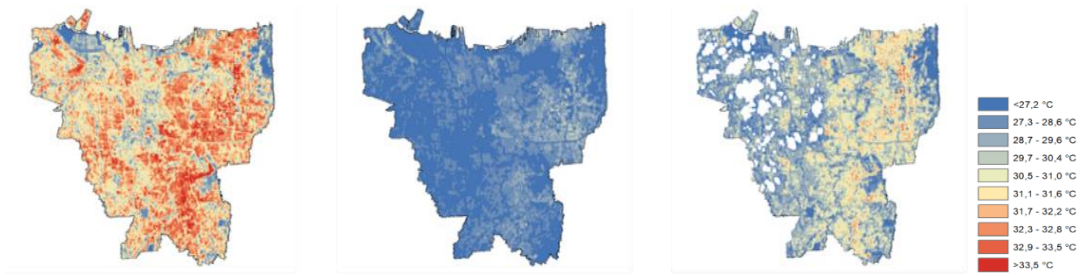
During the Covid-19 pandemic, the PM10 range was 10-150 µg/m3. Based on the Ministry of Environment and Forestry, 1997 this value included ISPU in the good (0-50 µg/m3) and moderate (50-150 µg/m3) categories. Figure 3-2(a)(b)(c) shows the concentration of PM10 in DKI Jakarta Province at 3 recording times i.e. before, during and after the lockdown. Overall, Jakarta Province is dominated by PM10 <100 µg/m3 which is shown in yellow to light brown. Some areas with higher values (> 100 µg/m3) are visualized in dark brown color, which are widely spread in the city of North Jakarta, including reclamation islands and industrial areas. The area is an area with high dust pollutant levels due to construction and industrial activities.

The land surface temperature variable (LST) during the pandemic has a temperature range of 27 – 35°C. Figure 3-3 shows the spatial distribution of the LST. Before the lockdown the surface temperature was relatively higher than during and after the lockdown. High temperatures (> 32°) are in dense residential areas and airports, industrial areas. It simbolyzed with yellow, orange and red pixel in the picture. Then, significantly decreased by an average of 4°C during the lockdown. In Figure 3-3(b) the area dominated with blue pixels which is colder than before the lockdown. Only some part in eastern part is yellow pixel. After lockdown the temperature is increasing into yellow pixel (30-31°C) in the average area but not reach the red pixel (>32°C). After lockdown not much higher than before Covid-19. Less vechicle is used after the lockdown since some office still WFH and school is SFH at 27 Juli 2020.



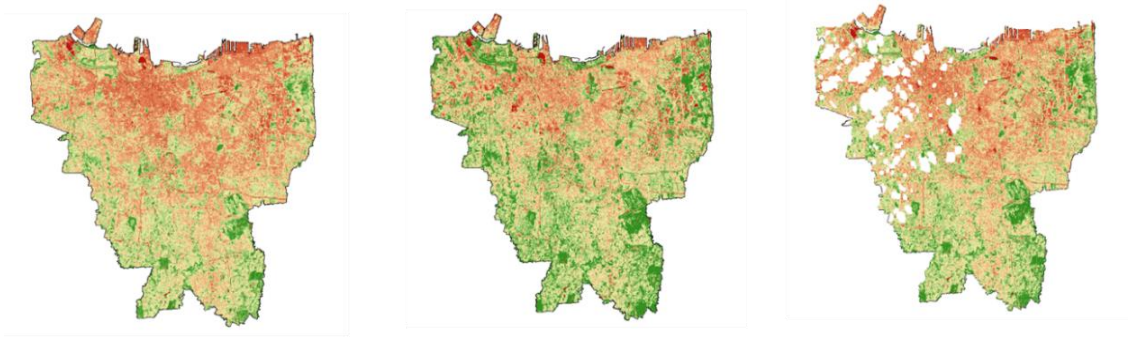
a. 25072019 b. 22042020 c. 27072020

Figure 3-2: Spatial distribution of PM10 (a) before (b) during and (c) after Covid-19 Lockdown



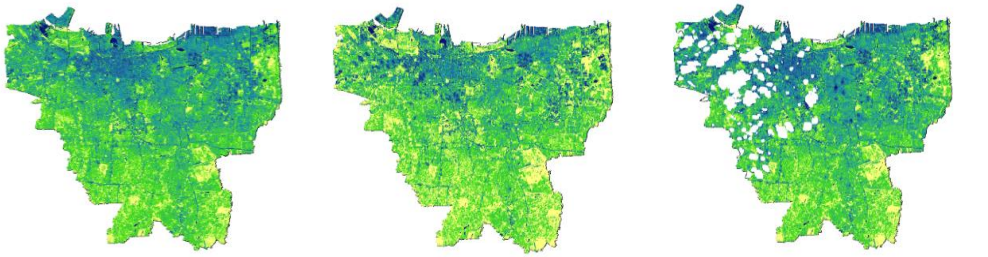
25072019 22042020 27072020

Figure 3-3: Spatial distribution of land surface temperature (LST) before, during and after Covid-19 lockdown



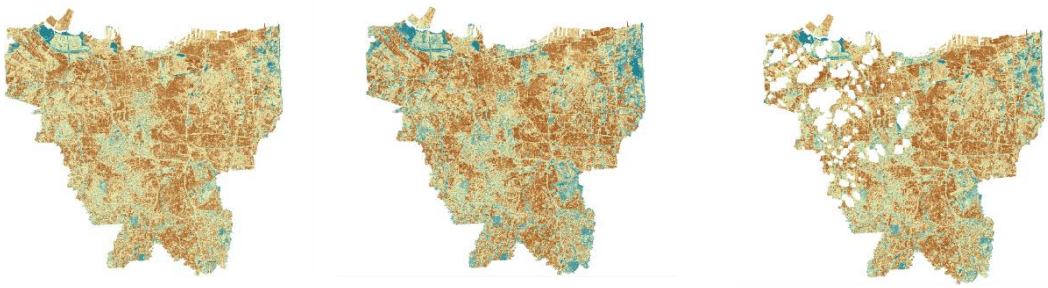
25072019 22042020 27072020

Figure 3-4: Spatial distribution of NDVI before, during and after Covid-19 lockdown



25072019 22042020 27072020

Figure 3-5: Spatial distribution of NDWI before, during and after Covid-1



25072019 22042020 27072020

Figure 3-6: Spatial distribution of NDMI before, during and after Covid-19 lockdown

through NDVI, NDWI, and NDMI. Figure 3-4, 3-5, and 3-6 shows the spatial distribution of each variables i.e. NDVI, NDWI, and NDMI. These variables did not change much during, before and after the lockdown because they were static objects that needed time to change. Overall before the lockdown the NDVI value was lower than during and after the lockdown. This condition was affected by the reduced traffic density during the PSBB period and decreased disturbance to vegetation during this period. Likewise, for the NDWI and

NDMI indices which experienced improvements during the lockdown period.

Environmental quality index (EQI) has been sucsessfully map in the Jakarta city, Indonesia using weighted linear combination which has been used in India. The weighted factor is same which used PM10 as the most influenced factor. Landsat-8 especially visual bands and infrared band gives the best result for PM10 estimation through multi linear regression. Remote sensing technology give efficiency measurement of spatial needs for air quality identification to overcome the limitation of ground station spatial distribution. However, there is limitation in this tropical country which is come from cloud disturbance. There are missing information if the area is covered by cloud. The radar imagery could be used which could penetrate cloud in the further research.

Environmental quality index (EQI) has changed before, during and after the lockdown. Figure 3-7 shows the spatial distribution of EQI in DKI Jakarta. Before the lockdown, some areas in Jakarta had moderate and poor environmental quality indexes. When lockdown, there are improvements to good quality, only a few areas were still of moderate quality, including on the reclamation island and the Cilincing Industry Area, North Jakarta. After the lockdown or during the relaxation period, the environmental quality index decreased again to the good, medium and bad categories but the distribution was not as wide as before the lockdown. Good quality index show in green and light green pixels, moderate quality shows in yellow pixels while the poor quality shows in orange and red pixels.

Field survey had been conducted in area that experience changes in the environmental quality index. Samples of them is describe in Figure 3-8. There are 5 samples area which had changes. First, Mampang Prapatan is a residential area and office building, before the lockdown the environmental quality index was moderate, during the lockdown was good, and moderate again after the lockdown. Kramat Jati is a market area with dense transportation when the lockdown experienced an improvement in environmental quality, which continued until after the lockdown. In Kalisari, which was a densely populated area during the lockdown, it improved but the quality of the environment declined again after the lockdown.

The quality of the environment become decline since the public is back to routinity. When the community is back to being active as before, causing the use of vehicle is increasing. It leads to decresing environment quality but not as poor as before Covid-19. Also, it is influenced by the dominant factor which is the concentration of PM10 in the form of dust particulates and an increase in land surface temperature. These two variables are the most influential variables on environmental quality according to their weights which reach 50% and 31%.

Obstacles were encountered when collecting field data during a pandemic. The field check process is limited in time and movement. There are several areas that cannot be accessed and the researchers also limit not taking samples in crowds and not too many for the sake of health, so that only the locations above can be surveyed for environmental conditions. This condition lead to the lack of field data collection.

EQI condition of Jakarta has been changed through pandemic covid-19. Because of the lockdown, the quality index is improved from 2019 to lockdown time, which is positive indication in the era of urbanization and environmental change. Before covid, the world is experiencing rapid population growth and increase human intervion on natural environment. Especially in the worsening of air quality and land surface temperature. In the lockdown period, restriction on human movement, industrial production, and vehicle movement results in the reduction of PM10 concentration in the atmosphere; on the other hand, less anthropogenic heat flux in the near-surface atmosphere resulting from human movement has also reduced LST, which helps to minimize the natural increase of LST from its previous year (Muhammad et al., 2020).

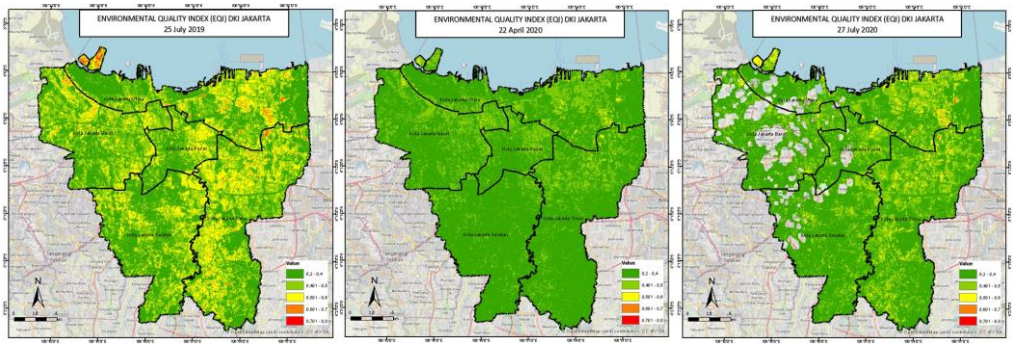


Figure 3-7: Spatial distribution of Environment Quality Index (EQI) before, during, and after the Lockdown Covid-19.

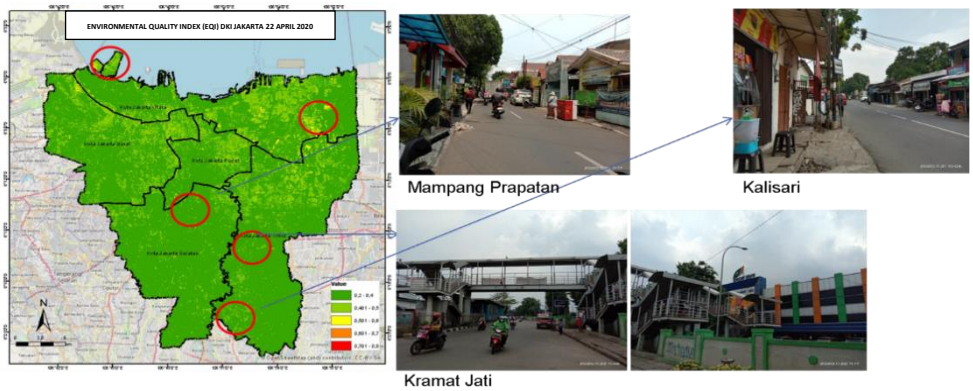


Figure 3-8: Field survey photos after the lockdown Covid-19.

4 CONCLUSION

1. The environmental quality variables extracted from Landsat 8 are PM10, LST, NDVI, NDWI, and NDMI. During the Covid-19 pandemic, the PM10 range of 10 – 150 µg/m3 included ISPU in the good and moderate categories. PM10 concentrations >100, among others, on reclaimed islands and industrial areas. The surface temperature of the land at the time of the study was 27 – 35°C, before the lockdown the surface temperature was relatively higher than during and after the lockdown. Vegetation, water and humidity indices did not change much during the pandemic because they were static objects.
2. The quality of the environment has changed before, during and after the lockdown. Before the lockdown, some areas in Jakarta had moderate and poor environmental quality indexes. When lockdown underwent improvement to become of good and very good quality, only a few areas were still of moderate quality, including on the reclamation island and the Cilincing industrial area, North Jakarta. After the lockdown or during the relaxation period, the environmental quality index decreased again to the good, medium and bad categories but the distribution was not as wide as before the lockdown. This shows that the community is back to being active as before, causing the quality of the environment to decline again, but not to the extent that it was before the lockdown.

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