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The Impact of COVID-19 Pandemic on Gross Regional Domestic Product Growth and Tropospheric Nitrogen Dioxide Pollution in South Sumatra Province, Indonesia

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Abstract

The objective of the study was to examine the spatial and temporal variation of the tropospheric NO_2 column compared with the economic growth during the COVID-19 pandemic. Therefore, the satellite based tropospheric NO_2 was acquired from the Aura Satellite during 2019-2021 over the South Sumatra region of Indonesia. The GIS analysis was conducted to produce the quarterly tropospheric NO_2 map over the study area. In this study, the gross regional domestic product (GRDP) was used as a benchmark for economic growth. The GRDP would relate to the air pollution to identify possible anthropogenically induced NO_2 pollution. The result indicated the GRDP growth significantly decreased when the tropospheric NO_2 concentration experienced a great reduction during 2020 (Quarters III-IV). The economic growth reduced from 5.79 to -1.58 during 2019-2020. It was noted that during the decline in GRDP, the variation of tropospheric NO_2 was decreased by about 33%.

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INTRODUCTION

Satellite-based measurement gave a chance to analyze air pollution on a large scale, daily monitoring and based on air quality standard (Rendana et al. 2021; Sathe et al. 2021; Vîrghileanu et al. 2020). The NO_2 is one of the most prominent air pollutants which can affect human health, environment, and the development of secondary pollutant such as ground ozone (O_3) (Luo et al. 2020). Several primary sources of NO_2 come from human activities such as biomass burning and fossil fuel combustion. The NO_2 studies using satellite-based measurement have been widely carried out. Platikaov et al. (2022) assessed hourly data for NO_2 and O_3 in Spain. Another study by Siddiqui et al. (2022) examined the annual, seasonal, and diurnal variation of the NO_2 in India. Some studies revealed the NO_2 increased more during heavy traffic in the morning as compared to evening (Keast et al. 2022; Zhao et al. 2022). Sunarsih et al. (2020) also analyzed the impact of NO_2 on health risk in the South Sumatra, Indonesia. Anugerah et al. (2021) revealed that the car-free-day program was useful to control the NO_2 pollutants from vehicle emissions. Another study by Praveen Kumar et al. (2022) investigated the NO_2 pollution during the christmas and new year events. By applying satellite-based measurement, some studies were carried out to evaluate the link between air pollutants and economic growth such as Zhu et al. (2019). Castellanos and Boersma (2012) examined the application of environmental policy resulted to 50% decline of NO_2 from 2004 to 2010. Bichler and Bittner (2022) studied the impact the economic growth by using the ozone monitoring insturment (OMI) NO_2 investigation in the northern Italy.

In addition, the 2020 year is the most challenging year as compared to previous years. The COVID-19 has made the change of human interaction, economic, and social activities (Rendana et al. 2022). The restriction policy has been applied to suppress the virus spread. Prunet et al. (2020) reported the COVID-19 restriction policy has contributed to decrease in daily NO_2 emission over Paris, Milan. Many studies have revealed a significant reduction in air pollutants concentration in China (Bao and Zhang, 2020), European (Grange et al. 2021), and Asian (Ghahremanloo et al. 2021) cities. The decline of economic growth can affect various sectors such as energy, industries, agricultures, and transportation (Rendana et al. 2016). However, the knowledge about how the economic growth affect the environment is still scarce and does not fully understand. Thus, the aim of our study is to analyze the impact of economic growth on the spatial and temporal distribution of the tropospheric NO_2 column. The output of the study is useful to provide a new insight in monitoring of national or global economic development using the NO_2 pollution that measured by the satellite.

METHOD

Study Area

The South Sumatra Province is one of the main provinces in Indonesia that situates in the southern part of the Sumatra Island (102°0′0″ E - 106°0′0″ E and 2°0′0″ E- 5°0′0″ E) (Figure 1). It covers a total area about 91,592.43 km^2 and consists of seventeen administrative districts. Palembang is a capital city of the province with total population almost 1.7 million people. The South Sumatra province is classified into the top ten rank of the populous provinces in Indonesia. Economic activities in the province comprises industries, commercial places, transportation, and agricultural sectors. The most important industries in the province are the fertilizer and coal sector, whereas oil palm cultivation is the biggest agricultural activity in the province. The land area is characterized by peatland which encompasses more than 50% of total area of the province. The air pollution in this province mainly comes from industries, vehicle emission, and biomass burning which contributes to NO_2 and other gases generation in the atmosphere. This statement needs to be elaborated clearly. As it is now its not eaasy to understand

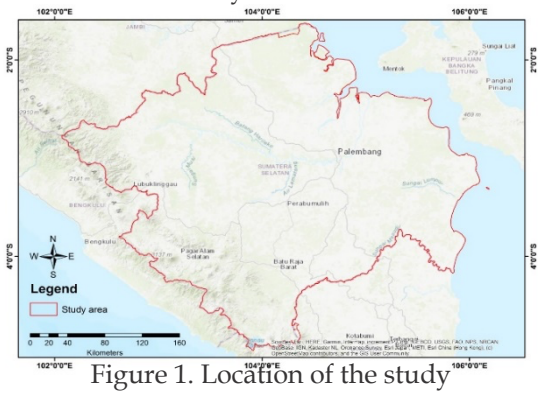


Figure 1. Location of the study area

Data Collection

Our study is based on the tropospheric NO_2 column density obtained by the ozone monitoring insturment (OMI) aboard in Aura Satellite during the period from 2019 to 2021. The satellite has begun the mission from 2014

until today with spatial resolution at 0.25˚ × 0.25˚. The tropospheric NO_2 column density data product was downloaded from Giovanni website (https://giovanni.gsfc.nasa.gov/giovanni/). The biggest share to gross regional domestic product comes from the eastern area especially the capital city, Palembang, where most of industries and service sectors located. The GRDP data was obtained from the Central Bureau of Statistics of Indonesia (https://www.bps.go.id/). Because the GRDP data are in the form of quarterly data, the tropospheric NO_2 data were also chosen in the same form.

GIS and Statistical Analysis

The downloaded tropospheric NO_2 column density data was in a Geotiff format. The data were then processed using ArcGIS software version 10. To produce a smooth raster map, we extracted the NO_2 values in each pixel/grid image, converting them to point features. The point features underwent a coordinate projection transformation process from WGS 1984 to UTM Zone 48S coordinate system. The ordinary kriging interpolation method was then carried out to produce NO_2 map in the study area. The last step, we clipped the raster map based on the study area border. For statistical analysis, we used the Pearson correlation analysis using the Microsoft Excel 2019.

RESULT AND DISCUSSION

The development in this research is an Android-based Interactive E-Booklet that can be used as

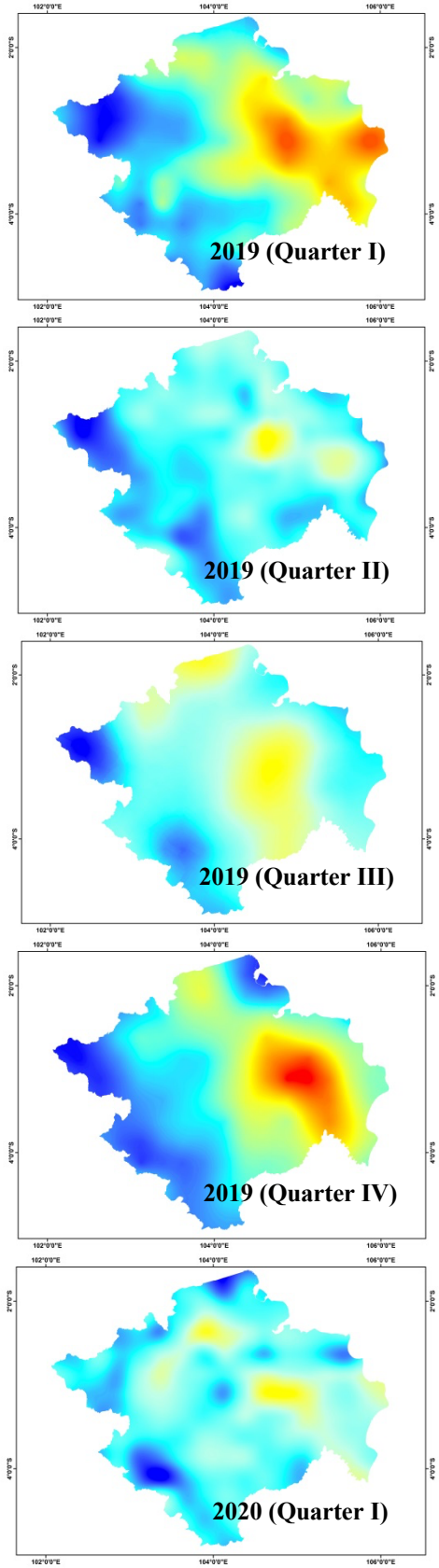
Tropospheric NO_2 Distribution

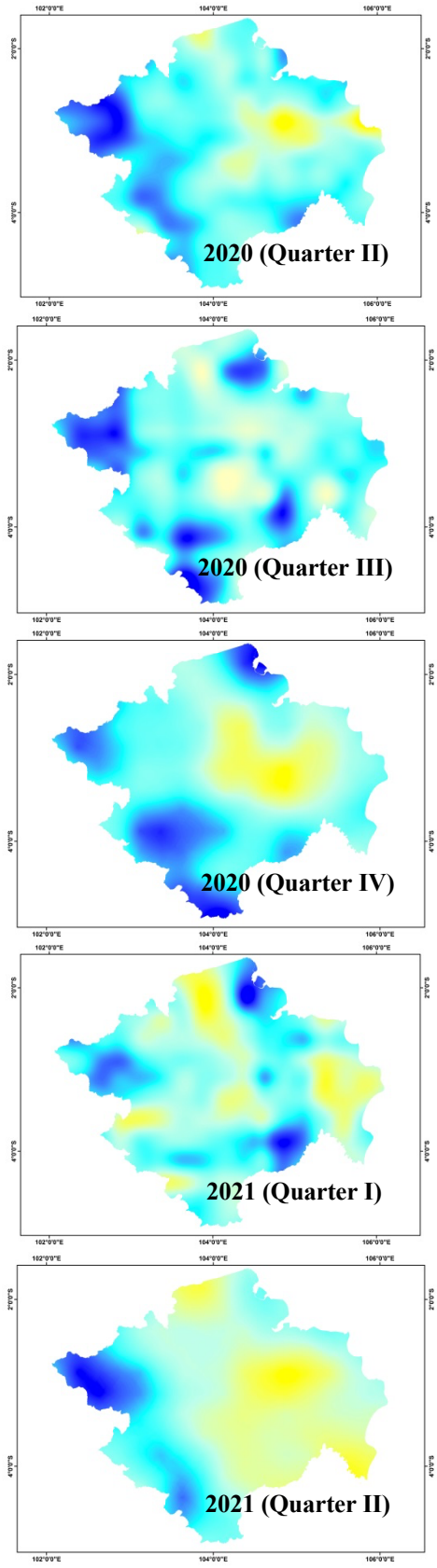
According to Figure 2, this study produced the quarterly tropospheric NO_2 by using data from the Aura satellite. This satellite has been applied to quantify the tropospheric NO_2 data product from 2019 to 2021 over the South Sumatra region. The tropospheric NO_2 was distinguished by a short-term decreasing trend. The lowest mean tropospheric NO_2 over the study area was recorded in 2020 (Quarter III) at around 0.49×10^{15} molecule cm^{-2}. This value decreased by about 18% as compared with the same quarter in 2019. Figure 2 shows a quarterly distribution with a higher value in 2019 and a lower value in 2020. The average of tropospheric NO_2 over the study area was about 0.61×10^{15} molecule cm^{-2} during the study period. This value was still lower than in India with an average value of 2.14×10^{15} molecule cm^{-2} (Biswal et al. 2020). The highest mean tropospheric NO_2 over the study area was observed at about 0.73×10^{15} molecule cm^{-2} during 2019 (Quarter IV). It was also found that quarter tropospheric NO_2 fluctuated across the study period.

The trend in tropospheric NO_2 predicted from 2019 to 2021 for the Palembang city area in the eastern province indicated a reduction of the mean tropospheric NO_2 by around 33% during 2019-2020. 2020 was known as "the COVID-19 year", For the South Sumatra Province , the COVID-19 restriction policy was first applied in 2020 (Quarter II), but the impact of this policy was apparently seen in 2020 (Quarters III-IV). This was in line with the findings of our study, which found the low tropospheric NO_2 over the study area. In addition, this result was consistent with another study by Santoso et al. (2021) that found a significant reduction of tropospheric NO_2 over Jakarta, Indonesia. The fluctuation did not constantly exist in the whole period of 2019-2020; a gradual increase was observed from 2020 (Quarter IV) to 2021 (Quarter II). The increase might be the result of the loosening of the COVID-19 restriction measure; thus, the transportation and industrial sectors have again contributed NO_2 emissions to the atmosphere.

Tropospheric NO_2 pollution is primarily generated by fossil fuel combustion activities. Generally, the dry season could lead more to the development of tropospheric NO_2 than the wet season (Phung et al. 2016). Additionally, the other sources of NO_2 were industry, transportation, biomass burning, lightning, and soil microbial activities (Wang et al. 2007). In the South Sumatra region, the source of NO_2 was predominantly industry and vehicle emissions. There was also the shorter-scale distribution of NO_2 pollution that originated from biomass burning; this event often occurred in the dry period (especially in Quarter IV). Since the south Sumatra was encompassed by peatland, it made the area vulnerable to wildfire. As we found in Figure 3, the mean tropospheric NO_2 varied across the years. This could be affected by the transport process. The air mass, through which a high amount of NO_2 could be transported from one area to another and also has a downward transport effect (Bichler and Bittner, 2022). This process needed time, thus

affecting the temporal fluctuation of NO_2 in the atmosphere.





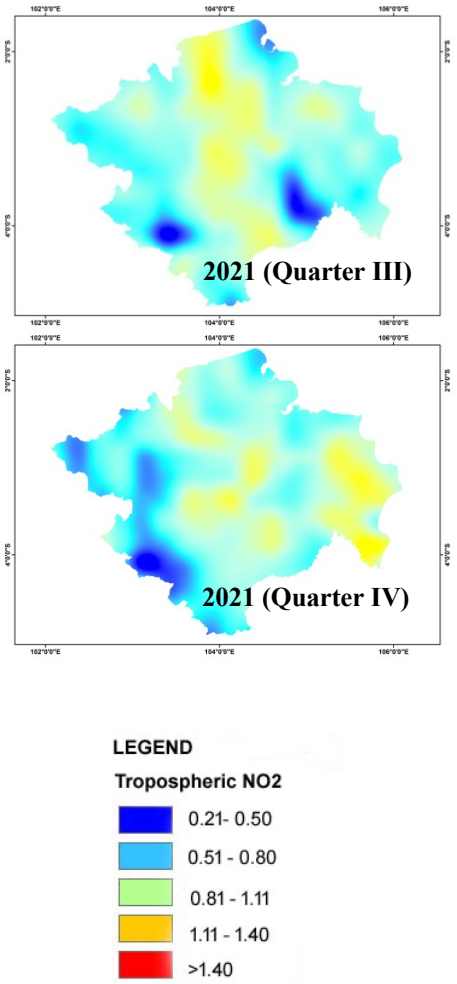


Figure 2. Quarterly tropospheric NO_2 column variation from 2019 to 2021 in the South Sumatra Province measured by OMI instrument on board of Aura satellite. (Unit: Tropo NO_2 × 10^{15} molecule cm^{-2})

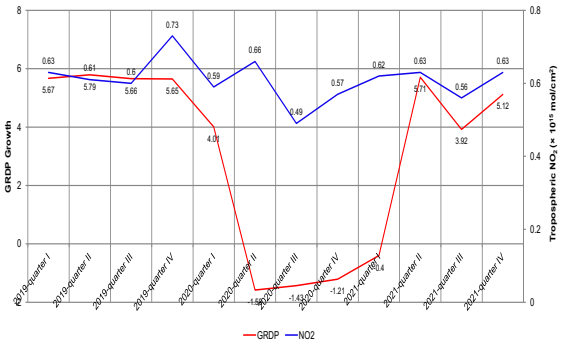


Figure 3. Comparison between quaterly GRDP growth and tropospheric NO_2 from 2019 to 2021.

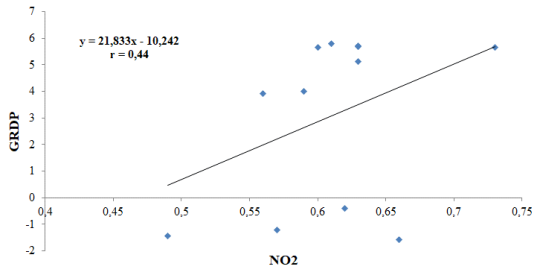


Figure 4. Correlation test between GRDP and NO_2.

CONCLUSION

This study concludes a short-term reduction of the temporal development of the tropospheric NO_2 of around 33% between the middle of quarter-II 2020 to middle of quarter-I 2021, the COVID-19 restriction policy during 2020 (Quarter II) which suspended the NO_2 sources from human activities. The variability of tropospheric NO_2 then increased again in 2021 (Quarter I-IV), this value was almost similar wih a previous year in 2019. Moreover, the study assumed there was a positive association between the GRDP growth and the tropospheric NO_2 values over the study area (Fig. 4). Although the decerease in NO_2 pollution has a good impact for the environment, however by, this is not a good way to develop the economy level of a nation. But, if the development of industries grew together with zero emission, it will achieve a sustainable economy. Our study recommends the use of satellite-based measurement of NO_2 data because it can cover large coverage areas and temporal data. Based on this study, the NO_2 data can be used to assess economic development in a region or a country.

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