Spatial Distribution of COVID-19 Vulnerable Areas in Tambora District, Jakarta Barat

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Informasi artikel	A B S T R A K
	Fenomena pandemi COVID-19 saat ini telah berjangkit di hampir seluruh negara dan menimbulkan banyak korban jiwa. Kota Jakarta sebagai ibukota negara termasuk wilayah dengan jumlah penderita COVID-19 terbanyak di Indonesia. Tujuan penelitian ini adalah menganalisis persebaran wilayah rawan pandemi COVID-19 di Kecamatan Tambora, Jakarta Barat. Variabel yang digunakan adalah kependudukan, sosial ekonomi, kesehatan, dan fisik wilayah. Hasil penelitian menunjukkan bahwa persebaran penderita COVID-19 di Kecamatan Tambora sejak awal pandemi menunjukkan bahwa keberadaan penderita COVID-19 mulai terdeteksi pada 7 kelurahan dari 11 kelurahan di wilayah Kecamatan Tambora. Jumlah penderita COVID-19 terbanyak pada bulan November 2020 berada di sisi barat, barat daya, dan tenggara, sedangkan jumlah penderita paling sedikit terdapat di sisi selatan dan timur laut. Kelurahan Jembatan Besi dan Roa Malaka menunjukkan kondisi yang kontras dibandingkan wilayah sekitarnya karena merupakan wilayah dengan jumlah penderita COVID-19 paling banyak dan paling sedikit. Hasil klasifikasi wilayah rawan COVID-19 menunjukkan bahwa wilayah dengan tingkat kerawanan sangat tinggi berada di sisi barat, barat daya, tengah, utara, dan tenggara Kecamatan Tambora. Selanjutnya, wilayah dengan tingkat kerawanan tinggi berada di sisi utara, tengah, dan selatan. Kemudian, wilayah dengan tingkat kerawanan sedang berada di sisi selatan dan timur, sedangkan wilayah dengan tingkat kerawanan rendah berada di sisi timur laut.
	A B S T R A C T The COVID-19 pandemic has spread in almost all countries and has caused many casualties. Jakarta is one of the areas with the highest number of COVID-19 sufferers in Indonesia. This study aimed to analyze the distribution of areas vulnerable to the COVID-19 pandemic in Tambora District, Jakarta Barat. The variables used are demographic, socioeconomic, health, and physical characteristics. Since the beginning of the pandemic, the distribution of COVID-19 sufferers in the Tambora District has been detected in 7 sub-districts out of 11 sub-districts. The highest number of COVID-19 sufferers in November 2020 was on the west, southwest, and southeast side, while the least number of sufferers was on the south and northeast side. Jembatan Besi and Roa Malaka sub-districts showed contrasting conditions than their surrounding areas because those were the areas with the most and the least number of COVID-19 sufferers. The results showed that the areas with a very high vulnerability to COVID-19 are located in the west, southwest, central, north, and southeast side of the Tambora District. Furthermore, areas with a high level of vulnerability are located in the north, center, and south. Then, the areas with a moderate level of vulnerability are located on the south and east sides. Simultaneously, the areas with a low level of vulnerability are located on the northeast side.

Introduction

The disease caused by a new type of coronavirus or COVID-19 phenomenon has now spread in various countries. This disease was originally discovered on December 31, 2019, in a market in Wuhan, China. The Chinese government managed to identify the cause of a new type of coronavirus or nCoV on January 7, 2020. A total of 41 cases of coronavirus infection were found in Wuhan and were reported by the Chinese government to the World Health Organization (WHO) on 11 and 12 January 2020. Incidents of people being exposed to the COVID-19 virus outside China began to be reported on January 20, 2020. The spread of the COVID-19 disease in April 2020 has become more widespread, and WHO has declared the status of this disease as a pandemic. People with COVID-19 are found in more than 200 countries and have resulted in more than 2 million deaths worldwide. Countries with the most positive cases include the United States, India, Brazil, Great Britain, and Russia.

WHO defines COVID-19 as an infectious disease caused by the SARS-CoV-2 virus, which is the cause of respiratory disease. Common symptoms of COVID-19 are fever, dry cough, fatigue, inability to recognize the taste and/or smell, nasal congestion, conjunctivitis, sore throat, headache, sore muscles and joints, skin rash, dizziness and vomiting, diarrhea, chills, and dizziness. Symptoms in the development of more severe disease include difficulty breathing, loss of appetite, chest pain, and high fever exceeding 38°C. People aged 60 years and over and people with health problems such as hypertension, heart and lung disorders, diabetes, obesity, and cancer are among the population groups at risk of serious illness if exposed to COVID-19.

The Indonesian government has responded to the development of the COVID-19 transmission situation by establishing a policy of working, studying and worshiping at home for all people since March 15, 2020. This policy is outlined in Peraturan Pemerintah Nomor 21 Tahun 2020 tentang Pembatasan Sosial Berskala Besar Dalam Rangka Percepatan Penanganan Corona Virus Disease 2019 (COVID-19) and Peraturan Menteri Kesehatan Republik Indonesia Nomor 9 Tahun 2020 tentang Pedoman Pembatasan Sosial Berskala Besar dalam Rangka Percepatan Penanganan Corona Virus Disease 2019 (COVID-19). In line with the development of the situation, the number of COVID-19 sufferers in Indonesia as of May 6, 2020 has totaled 12,438 people and 38.35 percent of them are located in Jakarta. Jakarta's position as the national capital and economic center of Indonesia has resulted in the highest number of COVID-19 sufferers.

The number of COVID-19 sufferers is increasing from time to time. The distribution covers 263 sub-districts from 267 sub-districts in the DKI Jakarta Province. The cumulative number of cases as of October 12, 2020 reached 88,174 people, with the number of people who recovered reaching 72,540 people, and the deaths were 1,914 people. Based on data from the DKI Jakarta Provincial Government, the highest number of COVID-19 sufferers are located in Jakarta Timur and Jakarta Barat, while the least number of sufferers is in the municipality of Jakarta Utara and the Kepulauan Seribu Regency. This condition is proportional to the largest population in DKI Jakarta, located in the municipalities of Jakarta Timur and Jakarta Barat. The characteristics of the majority of COVID-19 sufferers in Jakarta are men and women aged 20-39 years.

This study aims to analyze the distribution of COVID-19 sufferers and to classify areas vulnerable to COVID-19 in Tambora District, Jakarta Barat. Tambora District is part of the administrative area of the municipality of Jakarta Barat, DKI Jakarta Province. This district consists of 11 sub-districts covering 96 Rukun Warga and 1,083 Rukun Tetangga. The Tambora District area is 542.09 hectares, with Kali Angke and Penjaringan District in the north and Kali Krukut and Taman Sari District in the east. The district also shares a border with Gambir District in the south and West Flood Canal and Grogol Petamburan District in the west. Tambora District also has a population density figure that is far above the average population density of Jakarta Barat's municipality and the province of DKI Jakarta. During the COVID-19 pandemic, this sub-district was one of the ten sub-districts with the highest number of positive COVID-19

cases in Jakarta until early September 2020. This condition also affected Jakarta Barat's municipality, making it one of the municipalities with the highest number of COVID-19 sufferers in the province of DKI Jakarta.

In the study of health geography, the risk is often defined as an aspect of the physical or social environment that poses a danger to human health. Risks can arise from a combination of exposure to environmental hazards and human exposure to these exposures (Crooks et al., 2018). Each type of disease is influenced by three factors, namely genetics, environment, and behavior. Genetics refers to the biological characteristics of humans. Environment refers to the geographical context of where people live. Behavior refers to people's choices, activities, and interactions. Based on the context of residence, the environment can be a major factor in the spread of disease, thus emphasizing the vulnerability of place. (Brown *et al.*, 2009)

Disease susceptibility is generally related to location, in addition to other things such as risky behavior, population conditions, or regional characteristics. Behaviors and choices made by society create a vulnerable environment that undermines people's resilience or health. Place of residence affects disease susceptibility so that environmental components in the ecology of the disease need to be combined with physical, social, economic, and other factors to explain the characteristics of the spatial variations regarding disease susceptibility and to consider the vulnerability of places and places that are vulnerable (Oppong and Harold in Brown *et al.*, 2009).

Research methods

This study uses variables consisting of population, socioeconomic, health, and physical characteristics. The population variable consists of the number of elderly people and population density, while the socioeconomic variable consists of the number of casual daily laborers and education level. Furthermore, the health variable is the number of people who have comorbid diseases (comorbid), then the physical characteristics variables consist of building density and land

use. The choice of variables is based on studies related to the COVID-19 pandemic in various countries.

In a mapping conducted by de Kadt *et al.* (2020) in Gauteng Province, South Africa, they used six risk factors that could hinder people's efforts to maintain physical distancing and personal hygiene in the COVID-19 pandemic. The six factors are crowded living conditions, shared or inadequate sanitation, no access to clean running water in-dwelling or yard, reliance on public health facilities, lack of access to electronic communication, and reliance on public transportation. Snyder and Parks (2020) examined vulnerability to COVID-19, particularly in the spatial variation of socio-ecological vulnerability to COVID-19 in the United States. They used 18 variables grouped into four dimensions: ecology, social, health, and economy. Ecological variables include age, sex ratio, population density, air quality, temperature, humidity, and connectivity. Social variables include the availability of hospital beds, health insurance/insurance participants, education level, and race. Health variables include obesity, smoking, hypertension, and diabetes. Economic variables include the type of work and industry, poverty, and the Gini coefficient.

Pathak *et al.* (2020) examined the socioeconomic vulnerability to COVID-19 in India. They found variables that were positively and significantly related to the risk of COVID-19 in India. These variables are the proportion of the elderly population, the prevalence of disease, interregional migration, international migration, bringing water from outside the household premise, health infrastructure, population density, proportion of the urban population, the proportion of non-agricultural daily workers, and extended family. Areas with a high number of COVID-19 sufferers are characterized by high population density, the high population in urban slum areas, and many people living in the same room.

Morocco *et al* (2020) examined centers of COVID-19 spread in New York and Chicago and compared them to social inequalities. They found that areas with many people with COVID-19 had the opposite condition, such as fewer college graduates and more people of

color. The number of family members living in the same house is also more related to the high number of people with COVID-19 than the population density as a whole.

Ramirez and Lee (2020) examined the spatial pattern of the emergence of COVID-19 in Colorado, United States, by using social and health factors. The factors used include, among others, the number of people with asthma, diabetes, flu, poverty levels, per capita income, unemployment, education levels, and health insurance. Their research results showed areas with the highest number of COVID-19 sufferers and areas with the largest increase in cases. There are social and economic factors that are dominant in urban areas in the form of population density and the number of people with asthma. On the other hand, the dominant factors in rural areas are poverty and unemployment.

The data used in this study consisted of spatial data and tabular data. The spatial data consists of land use and building data in the Tambora District area per 2018. The tabular data used were population data per 2019, consisting of population density, the number of elderly people, the number of casual daily laborers, and the number of people with an educational level equal to junior high school level and below and not yet/not attending school. Also, this study also uses data on the population with comorbidities per 2020 and the number of COVID-19 sufferers in the Tambora District from March 2020 to November 2020. All data in this study were sourced from the DKI Jakarta Provincial Government.

The analysis unit used is 11 sub-districts in Tambora District. Data processing was carried out using a spatial multi-criteria analysis approach and geographic information systems. First, the density of building data in Tambora District is calculated using the ArcMap application's Calculate Density tool. The result is then converted into vector-based maps and classified into four classes based on equal intervals. This building density map is then overlaid with the land use map that has been scored based on the type of land use to obtain an overlay map of building density on land use. Furthermore, the map is overlaid on the administrative map of the Tambora District area, which has been combined with attribute data of population density, the number of elderly people, the number of casual daily laborers, the number of people with junior high school education, and below, and the number of people with comorbidities. After the results map was obtained, the scores for all variables were calculated, and the results were classified into four vulnerability classes based on natural breaks, namely low, medium, high, and very high. The explanation for the scoring of each variable is described in the following table.

Table 1. Classification and scoring for each research variables

Variable	Classification	Score
Building density	Very high	4
	High	3
	Moderate	2
	Low	1
Land use	Occupancy	4
	Effort	3
	Religious	2
	Socio-cultural	2
	Other uses	1
	Special	1
Population density	Very high	4
	High	3
	Moderate	2
	Low	1
Number of people with comorbidities	Very high	4

Variable	Classification	Score
	High	3
	Moderate	2
	Low	1
Number of the elderly population	Very high	4
	High	3
	Moderate	2
	Low	1
Number of casual daily laborers	Very high	4
	High	3
	Moderate	2
	Low	1
Total population with education level equals to junior high school and below	Very high	4
	High	3
	Moderate	2
	Low	1

The scoring of land use types is based on assumptions about the duration of use and likelihood of crowding. Residential type land use is given a score of 4 because residents live and do activities in the residential area for 24 hours per day. During this duration, there may be crowds because residents interact and socialize with each other, despite calls for physical distancing. Furthermore, land use for this type of business is given a 3 because human activities occur during working hours for companies or government agencies or shop opening hours for entrepreneurs/traders. The average working hours or shop opening hours range from 10-12 hours. There is also a high probability of crowds occurring in markets, businesses, and offices serving the public interest during this duration.

On the other hand, religious and socio-cultural types of land use are given a score of 2 because the duration of the activity and the number of people within the premises are not as long and many as in residential or business places. An example of the socio-cultural land use that is likely to create crowds is health facilities, while others, such as educational facilities, have been closed since the pandemic. Finally, other uses and specific use types are scored 1. Specific uses type are related to defense and security interests so that crowds are less likely to occur. This condition is almost similar to other types of vacant land, former buildings, or green open spaces. The overall research workflow can be seen in the following figure 1.
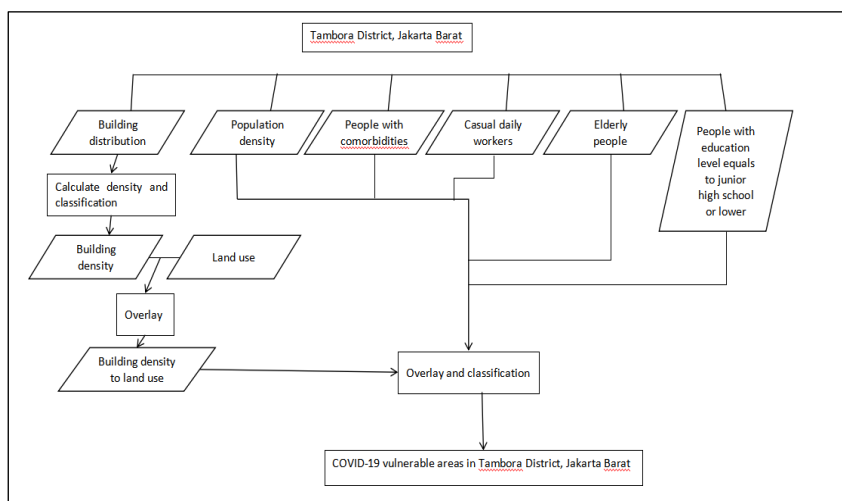

**Figure 1.** Research workflow

Results and discussion
Characteristics of the Tambora District area

The population density in Tambora district varies. Areas with high population density are located in the middle, west, and southwest, while areas with low population density area on the northeast side. The population density increases as we move to the west and south. The area with the highest population density in Tambora District is Kali Anyar sub-district with 95,078 people/km^2. The area with the lowest population density is in Roa Malaka sub-district with 7,625 people/km^2. Compared to the number of COVID-19 sufferers in each of these areas, Roa Malaka sub-district has the lowest population density and the lowest number of COVID-19 sufferers. On the other hand, Kali Anyar sub-district has the highest population density in Tambora District, but the number of COVID-19 sufferers is lower than Jembatan Besi sub-district.

The presence of elderly people in Tambora District occupies a proportion of 9.6 percent of the total population. The area with the highest number of elderly people is Tanah Sereal sub-district, 3,627 people or 11.2 percent of the total population in that sub-district. The area with the second largest number of elderly people is Pekojan sub-district, amounting to 3,485 people. The proportion of the elderly population to the total population in Pekojan sub-district is 12.3 percent. On the other hand, the area with the least number of elderly people is Roa Malaka sub-district. The number of elderly residents is 828 people, or 20.5 percent of the total population. Compared to the total population in each sub-districts, the largest proportion of the elderly to the total population is in Roa Malaka sub-district. The smallest proportion is in Jembatan Besi sub-district.

Residents in Tambora District also have comorbid conditions or comorbidities that can exacerbate the impact of COVID-19. These diseases include diabetes, hypertension, pneumonia, heart disease, and chronic obstructive pulmonary disease. The area with the least number of comorbid sufferers is in the Roa Malaka sub-district, which is 68 people. On the other hand, the area with the highest number of comorbid sufferers is Jembatan Besi, 1,100 people. Besides, the area with the second-highest number of comorbid sufferers is in the Kali Anyar sub-district, with a total of 759 people. This condition has similarities with the variation in the number of COVID-19 sufferers in the Tambora District.
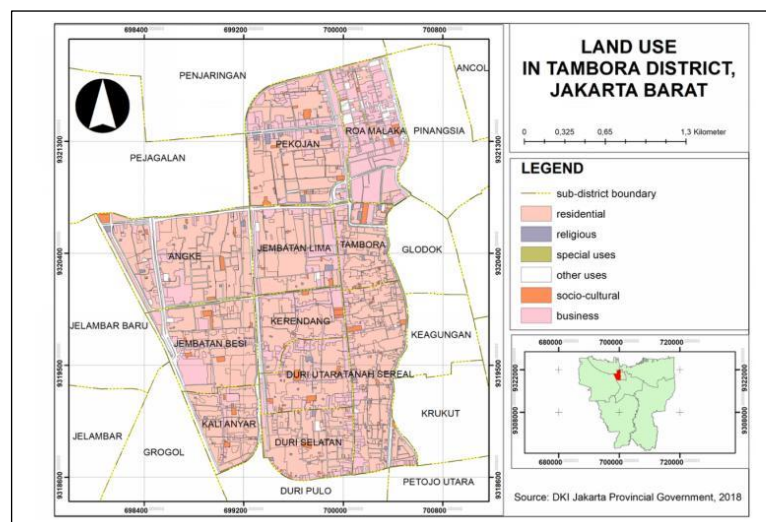
Figure 2. Land use in Tambora District, Jakarta Barat

There are various types of land use in Tambora District. However, they can be grouped into six types, namely residential, religious, special uses, other uses, socio-cultural, and business. The business type is the type of land use with the largest proportion, namely 46 percent of Tambora District's total area. The residential type ranks second with a proportion of 24 percent. The smallest proportion of land use is special uses

type, which is 0.2 percent of the total area. The residential land use includes various types of houses and settlements.

In contrast, the business land use includes various types of shops, industries, warehouses, private offices, government offices, hotels, markets, restaurants, and banks. Besides, socio-cultural land use includes, among others, educational facilities, health facilities, museums, and waste processing sites. Other uses include vacant land, green open space, and former buildings, while special uses are intended for regional defense and security purposes.

Each sub-district in Tambora District has various types of land uses. The sub-district with the largest residential land-use area is Kali Anyar, while the smallest is Krendang sub-district. Moreover, the smallest area of business land use is also found in Krendang sub-district, while the largest is in Roa Malaka sub-district. Special land uses are only found in Roa Malaka and Duri Selatan sub-districts. Furthermore, the largest socio-cultural land use area is located in Angke, while the smallest is in Roa Malaka. The largest area of religious land use is located in Pekojan sub-district, while the smallest is in Roa Malaka sub-district. The largest land-use area for other uses is in Roa Malaka sub-district, while the smallest is in the Duri Selatan sub-district.

Data processing results showed that the building density in Tambora District is in the range of very high, high, medium, and low. Areas with very high building densities are located in the Jembatan Lima, Pekojan, Kali Anyar, and Angke sub-districts. Furthermore, the areas with high building density are located in Pekojan, Roa Malaka, Tambora, Jembatan Lima, Angke, Jembatan Besi, Kali Anyar, and Krendang sub-districts. Finally, areas with medium and low building densities can be found in all sub-districts in Tambora District.

Based on the type of occupation, most of the population in Tambora District are private employees. This can be seen from the proportion of 27 percent of the total population. Meanwhile, the second-largest type of occupation is the student who has a proportion of 22 percent. Caretakers of household occupy the third rank by 21 percent. Apart from these three types of work, there are also a number of residents who are not/not

working yet. This group has a proportion of 17 percent of the total population. Besides, there are also people who work as entrepreneurs as much as 8 percent of the total population and casual daily laborers as much as 3 percent of the total population.

Based on the location, employees' population is mostly found in Angke sub-district, while the most casual daily laborers are located in Tanah Sereal sub-district. The population who was not/not working yet is mostly at Jembatan Besi sub-district, while residents who are students are mostly found in Angke sub-district. In addition, the caretakers of households are also mostly found in Angke sub-district, while residents who work as entrepreneurs are mostly found in Jembatan Besi sub-district.

Most of the Tambora district population has a high school education level or equivalent, with a proportion of 43 percent of the total population. The second largest group is the population with an education level of junior high school/equivalent, namely 22 percent of the total population. In addition, there is also 3.8 percent of the total population who have not/do not attend school. The population group with higher education or equivalent to bachelor's degree to Ph.D. is only 6 percent of the total population. Based on the sub-district, the population with an education level equal to high school/ equivalent is mostly in Jembatan Besi sub-district. The least is in Roa Malaka sub-district. Likewise, other population groups have an education level equivalent to junior high school/equivalent, and those who have not/are not attending school are found in those two sub-districts. The population with bachelor's degrees and master's degrees are mostly found in the Tanah Sereal sub-district, while the Ph.D. graduates are mostly found in Pekojan and Jembatan Besi sub-districts.

The development of the number of COVID-19 sufferers in Tambora District

Based on data released by the DKI Jakarta provincial government on the *corona.jakarta.go.id* website, the whereabouts of COVID-19 sufferers in Tambora District began to be recorded in April 2020. The COVID-19 sufferers identified that month were from 7 sub-districts of 11 sub-districts in

Tambora District, namely Angke, Jembatan Besi, Jembatan Lima, Kali Anyar, Krendang, Pekojan, and Tanah Sereal. Sub-districts that have not shown the number of COVID-19 sufferers was in the south, northeast, and east sides of Tambora District, namely Duri Utara, Duri Selatan, Roa Malaka, and Tambora. The number of COVID-19 sufferers in all sub-districts in Tambora District continued to increase from July to November during its development. The sub-district with the most COVID-19 sufferers is Jembatan Besi, which was 298 people.

On the other hand, the sub-district with the least COVID-19 sufferers was Roa Malaka, with 20 people. The distribution of COVID-19 sufferers per sub-district showed that the highest concentration of sufferers was in the west, center, and southeast side of Tambora District. The areas with the least COVID-19 sufferers were in the northeast and south side. Sub-districts that have recorded the presence of positive residents of COVID-19 since April continued to show a higher number of positive cases compared to other sub-district until November.
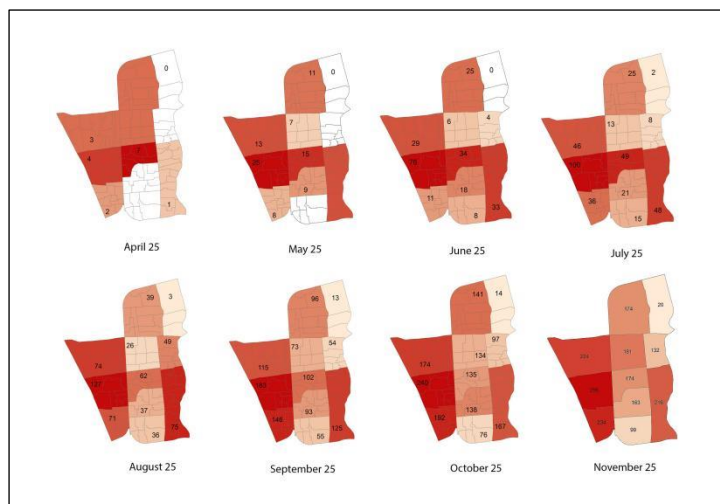
Figure 3. Development of COVID-19 positive cases in Tambora District, Jakarta Barat

Two areas showed the distinct number of COVID-19 sufferers in Tambora District, namely Roa Malaka and Jembatan Besi sub-districts. Roa Malaka is the sub-district with the lowest number of COVID-19 sufferers, and the highest is in Jembatan Besi sub-district. In terms of land use, Jembatan Besi is dominated by residential places, while Roa Malaka is dominated by land use for business. In terms of the elderly population, Jembatan Besi has a greater number of elderly people than Roa Malaka. However, the proportion of the elderly to the overall population is greater in Roa Malaka than Jembatan Besi.

The population density at Jembatan Besi sub-district is the second-highest in Tambora District, while the population density in Roa Malaka sub-district is the lowest. Because the Jembatan Besi population is bigger than Roa Malaka, Jembatan Besi had a larger number of various employment than Roa Malaka such as

unemployed, employees, casual daily laborers, and self-employed. The population at Jembatan Besi sub-district is greater than the population in Roa Malaka sub-district from various aspects, including education levels and the number of sufferers of comorbid diseases.
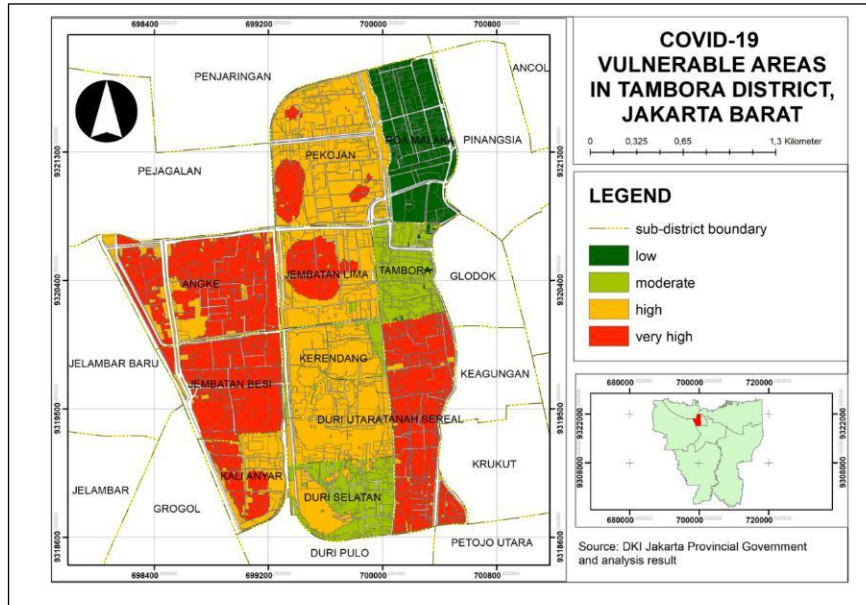
Distribution of COVID-19 vulnerable areas in Tambora District

The classification of COVID-19 vulnerable areas shows that the Tambora District area with a very high vulnerability area is on the west and southeast side and partly on the central side, and somewhat to the north. Areas with high vulnerability can be found extending from the north, center, south, and west and southwest. Furthermore, areas with moderate vulnerability are located on the south and east sides, while areas with low vulnerability are located on the northeast side of Tambora District. Based on the administrative area, sub-districts that are

included in very high vulnerability areas are Angke, Jembatan Besi, Jembatan Lima, Kali Anyar, Pekojan, and Tanah Sereal. Subsequently, sub-districts that are included in high vulnerability areas are Duri Utara,

Jembatan Lima, Kali Anyar, Krendang, and Pekojan. After that, there are areas of moderate vulnerability in Tambora and Duri Selatan sub-districts. Finally, areas of low vulnerability are only found in the Roa Malaka sub-district.

Figure 4. Areas vulnerable to COVID-19 in Tambora District, Jakarta Barat

The classification of the COVID-19 vulnerable areas was then compared with the data on the number of positive sufferers of COVID-19 on November 25, which have been grouped into four classes, namely very high, high, medium, and low. Based on this comparison, the results of the classification of the COVID-19 vulnerable areas are in accordance with the actual number of sufferers. For example, the Roa Malaka sub-district has a

low class of COVID-19 sufferers, and the classification of vulnerable areas is also low. The Jembatan Besi sub-district area has a very high number of COVID-19 sufferers, and in the classification of vulnerable areas is also classified as very high. Some areas have two types of vulnerability classifications: Pekojan, Kali Anyar, and Jembatan Lima sub-districts ranging from very high to high. This condition is under the class of the number of sufferers in each region in the very high to high class.

Table 2. Comparison of the results of the classification of COVID-19 vulnerable areas to the number of COVID-19 sufferers in Tambora District, Jakarta Barat

Sub-district	Number of COVID-19 sufferers as of November 25, 2020	Classification of the number of COVID-19 sufferers	Results from the classification of areas vulnerable to COVID-19
Angke	224	High	Very high
Duri Selatan	99	Moderate	Moderate
Duri Utara	163	High	High
Jembatan Besi	298	Very high	Very high
Jembatan Lima	181	High	Very high to high
Kali Anyar	234	Very high	Very high to high
Krendang	174	High	High
Pekojan	174	High	Very high to high

Sub-district	Number of COVID-19 sufferers as of November 25, 2020	Classification of the number of COVID-19 sufferers	Results from the classification of areas vulnerable to COVID-19
Roa Malaka	20	Low	Low
Tambora	132	Moderate	Moderate
Tanah Sereal	216	High	Very high

Conclusion

The distribution of COVID-19 sufferers in Tambora District since the beginning of the pandemic showed that the presence of COVID-19 sufferers was detected in 7 sub-districts of 11 sub-districts in Tambora District, which are located in the central, north, southeast, southwest, and west side. The number of sufferers in the seven sub-districts continued to increase until the other four sub-districts also showed the number of positive sufferers of COVID-19 with an increasing trend to the south, north, and northeast. After that, in November 2020, the highest number of people with COVID-19 was in the west, southwest, and southeast, while the least number of sufferers was in the south and northeast. Among the 11 sub-districts in Tambora District, Jembatan Besi and Roa Malaka sub-districts show contrasting conditions than other areas because those are the areas with the most and the least number of COVID-19 sufferers.

The classification of areas vulnerable to COVID-19 showed that the areas with a very high level of vulnerability are located in the west, southwest, central, north, and southeast side of the Tambora District. Furthermore, areas with a high vulnerability level are located in the north, center, and south. The areas with a moderate level of vulnerability are in the south and east, while the areas with a low level of vulnerability are in the northeast. The results of the classification of areas vulnerable to COVID-19 were under the classification of the number of COVID-19 sufferers in the Tambora District as of November 25, 2020.

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