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Mapping the Vulnerability of DHF Cases as a Basis for Health Intervention Strategy in Batam City

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ABSTRACT

Batam City is one of the areas with the highest level of Dengue Fever (DHF) cases in Riau Islands Province in 2022. With a total of 902 DHF cases and a mortality rate of 45% among other districts/cities in Riau Islands Province. Factors that contribute to the distribution of cases can be influenced by environmental factors such as regional altitude and population density distribution. This study aims to analyze the level of vulnerability of DHF cases in Batam City using Geographic Information System using Secondary Data from the Batam City Health Office in 2022 and data from the Central Bureau of Statistics in 2022. This research uses a quantitative descriptive study with an ecological design using data clustering and mapping methods by utilizing the QGIS application. From the mapping results, it is known that areas with medium density experience high cases and areas with low altitude experience more cases. High vulnerability cases cover 37.5% of the entire Batam City area with a vulnerability score of 2 out of 3. With this mapping, health workers can create a health intervention strategy using the priority level of vulnerability ranging from preparing resources, manpower to additional prevention such as awareness campaigns and mosquito nest eradication movements according to the level of vulnerability of the area.

Keywords *: DHF ; Population Density ; Area Altitude; Geographic Information System*

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INTRODUCTION

Every year dengue virus is one of the arboviruses with 96 million cases and causes about 20,000 deaths worldwide. Worldwide, two main vector species, Aedes aegypti and Aedes albopictus, are responsible for virus transmission. Both species are geographically widespread in many countries across a wide ecological gradient, including urban, peri-urban, rural and forest areas where they breed in a variety of natural and artificial containers (1)

Elevation is an important factor that can affect the presence of dengue vector mosquitoes. High population density contributes to dengue transmission by increasing contact between infected mosquitoes and human hosts. In areas with a certain altitude, mosquitoes are less likely to transmit the virus, and at higher altitudes, mosquitoes are unable to breed. Variations in altitude affect the ecological conditions required by disease vectors, such as temperature, humidity and habitat availability (2). Population density affects the incidence of DHF every year with a strong relationship. This is due to the tendency of people to group and gather in one location. This is in line with research conducted by Norjanah in South Kalimantan, Indonesia, which found that DHF cases were generally distributed in densely populated areas (3).

One of the conditions determining the increased frequency of dengue fever has been its spread and contact with larger groups of human populations as cities in tropical climates have grown regularly. Dengue studies around the world use several different spatial definitions. Many studies do not define spatial descriptors and use a variety of definitions including population size, population density, agriculture and distance from urban areas (4).

Geographic Information System is a tool that allows for the analysis and visualization of spatial data to understand disease distribution and identify clusters of cases (5). Ongoing

public health problems can be aided by Geographic Information Systems to support decision-making on public health measures (6).

In Indonesia, the distribution of DHF cases was first reported in 1968 in the Jakarta and Surabaya areas which then spread to other regions throughout Indonesia until now with the number of cases and deaths continuing to increase (7). Throughout 2022 until the 22nd week in Indonesia there were 45,387 cases of DHF with a total of 432 deaths (8).

The incidence of DHF cases in Riau Islands Province in 2022 was recorded at 2,237 cases, in 2022 11 deaths were reported with 45% of cases occurring in Batam City out of 7 districts / cities in Riau Islands Province (9). Batam City alone had 902 cases of DHF in 2022 with 5 deaths. Therefore, through the utilization of geographic information system, this research aims to determine the level of vulnerability of DHF cases in developing health intervention strategies in Batam City.

METHODS

This study is a quantitative descriptive study with ecological design that aims to map dengue cases as a basis for health intervention based on the density and altitude of the area in Batam City. This study covers 12 sub-districts consisting of Batam Kota, Batu Aji, Batu Ampar, Belakang Padang, Bengkong, Bulang, Galang, Lubuk Baja, Nongsa, Sagulung, Sei Beduk, and Sekupang sub-districts in Batam City with a total population of 1,269,413 people. The average population density is 1,227/Km2 with an average height of 20 meters above sea level. The data used in this study are secondary data on the distribution of Dengue Fever Cases obtained from the Health Profile data of the Batam City Health Office in 2022 (10) and data related to the Percentage Distribution of Population Density and Area Height by Subdistrict obtained from the data of the Central Bureau of Statistics (11).

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Data mapping using Geographic Information System to show the areas affected by dengue cases and the level of vulnerability to be the basis of health intervention strategies. The application used was QGIS version 3.34 prizren.

To minimize the average deviation of each class group of DHF cases and vulnerability levels, the natural breaks jeans classification method was used to determine a good arrangement of values according to the class (12). The natural breaks jeans method is an optimization process that finds the best way to organize values into different classes. Unlike other clustering methods such as k-means, hierarchical clustering this method is useful for clustering one-dimensional data and for analyzing data that is not evenly distributed (13).

The stages carried out in this research include:

1. Secondary data collection
2. Making data classification and inputting variable attributes (DHF cases, population density and area height)
3. Data was analyzed using scoring and overlay techniques, which is an analysis that combines two or more variables in a map (14).
4. Classification score using natural breaks jeans with a score of 1 to 3 where 1 is low criteria and 3 is high criteria.

Table 1

Classification of data on dengue cases, population density and area elevation

No	Classification	Dengue Cases	Population Density /Km2	Elevation of Area/ mdpl	Score
1	Low	<4	<952	<6	1
2	Medium	4 – 135	952-5612	6-15	2
3	High	>135	>5612	>15	3

Source : natural breaks jeans QGIS

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From the variables of DHF cases, population density and altitude, the classification of DHF vulnerability level was then carried out using the sum of the criteria of low vulnerability with a score of less than six, moderate vulnerability with a score of six and high vulnerability with a score of more than six using the QGIS application.

RESULTS

Distribution of DHF cases

The distribution of DHF cases in Batam city in 2022 occurred in 11 (91.7%) out of 12 sub-districts (11) with a total of 902 cases (10). After clustering the case data using the natural breaks jeans classification method, 3 categories of cases were obtained (low, medium, high). The highest cases were found in Batam Kota sub-district (>135 cases) with 32.8% of the total cases followed by 8 sub-districts with moderate category (4-135 cases) namely Batu Aji, Batu Ampar, Bengkong, Lubuk Baja, Nongsa Sagulung, Sungai Beduk and Sekupang, while 3 more sub-districts recorded less than 0.3% of cases (<4 cases) namely Belakang Padang, Galang, and Bulang sub-districts.

This can be seen in Figure 1 which shows a map of the distribution of DHF cases per sub-district where the areas with bright red color are the areas with the highest cases followed by medium areas with orange color and white areas with the lowest cases.

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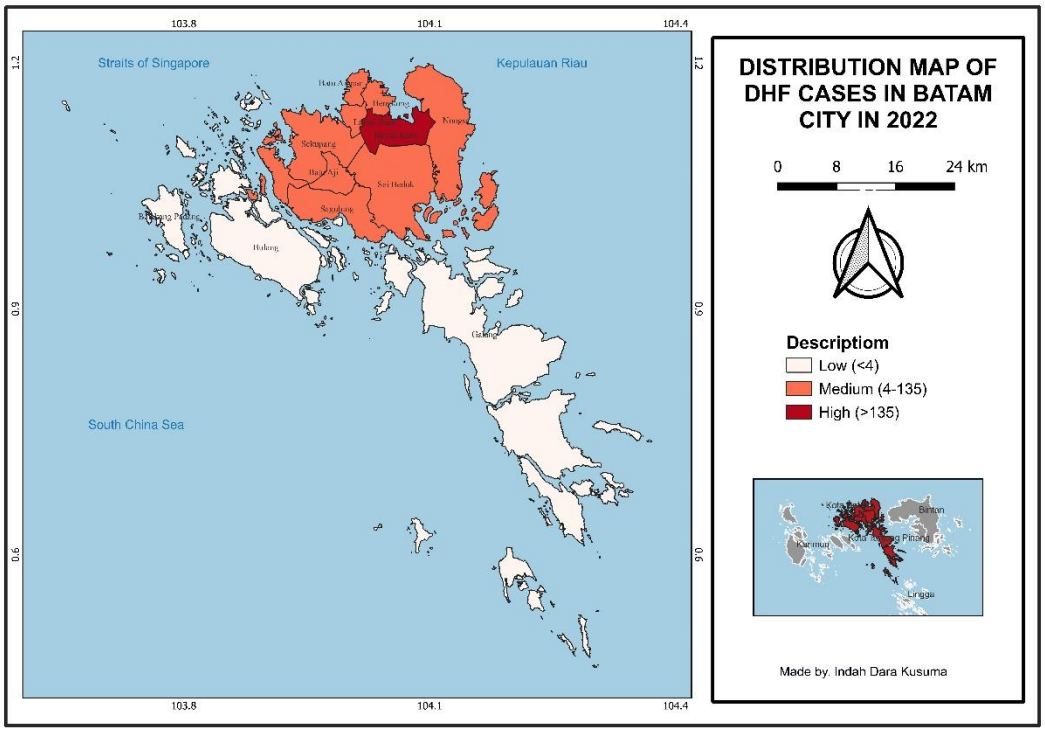

Figure 1 Distribution Map of DHF Cases in Batam City in 2022

Population density

The result of population density analysis using Geographic Information System (GIS) shows that there is a striking variation of density among areas in Batam City. The resulting population density map shows that Bengkong and Lubuk Baja sub-districts show very high density (>5612/Km2), while Batam Kota, Batu Aji, Batu Ampar, Sagulung and Sekupang sub-districts show medium density (952-5612/Km2) and five more sub-districts with density below 952/Km2 as shown in Figure 2.

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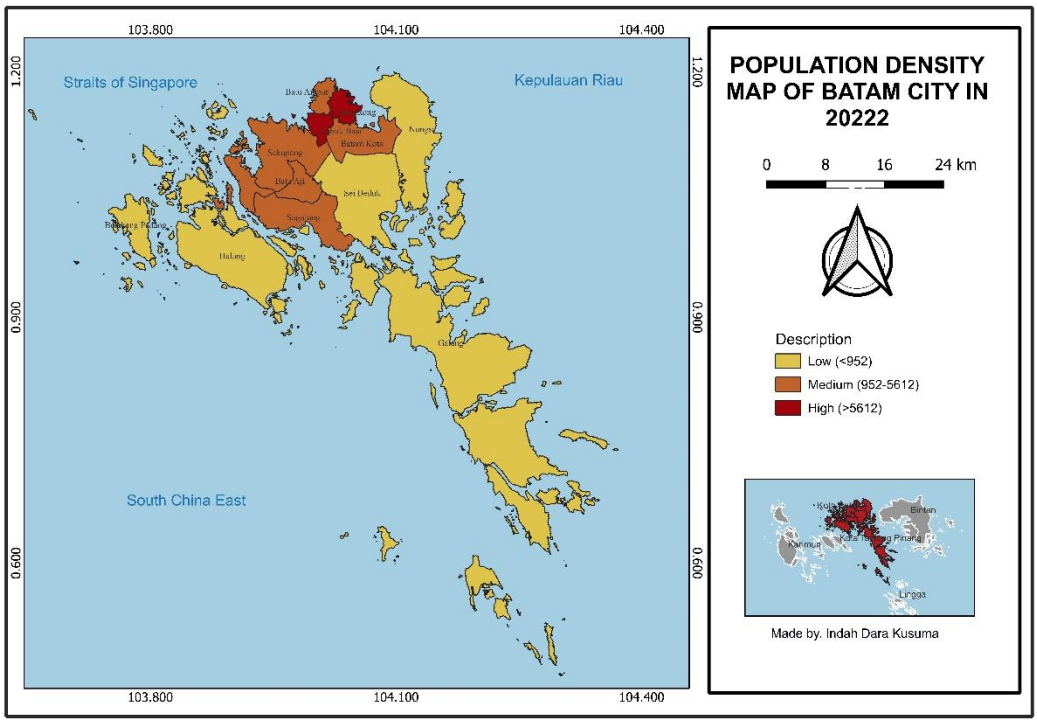

Figure 2 Population Density Map of Batam City in 2022

From the population density mapping, the bright red color indicates a higher population density compared to the orange and yellow colors.

Elevation of the area

The land surface in Batam City is a flat area with hilly variations. Based on the mapping results using the natural breaks jeans classification method, it can be seen that the height of the area is around 5 to 20 meters above sea level. Where Lubuk Baja and Batam Kota sub-districts marked with solid green color have high category altitude (>15mdpl), followed by four sub-districts in medium category (6-15mdpl) namely Batu Ampar, Batu Aji, Belakang Padang and Nongsa sub-districts and other sub-districts in low category as shown in the mapping. In the low category as seen in the following Figure 3 mapping.

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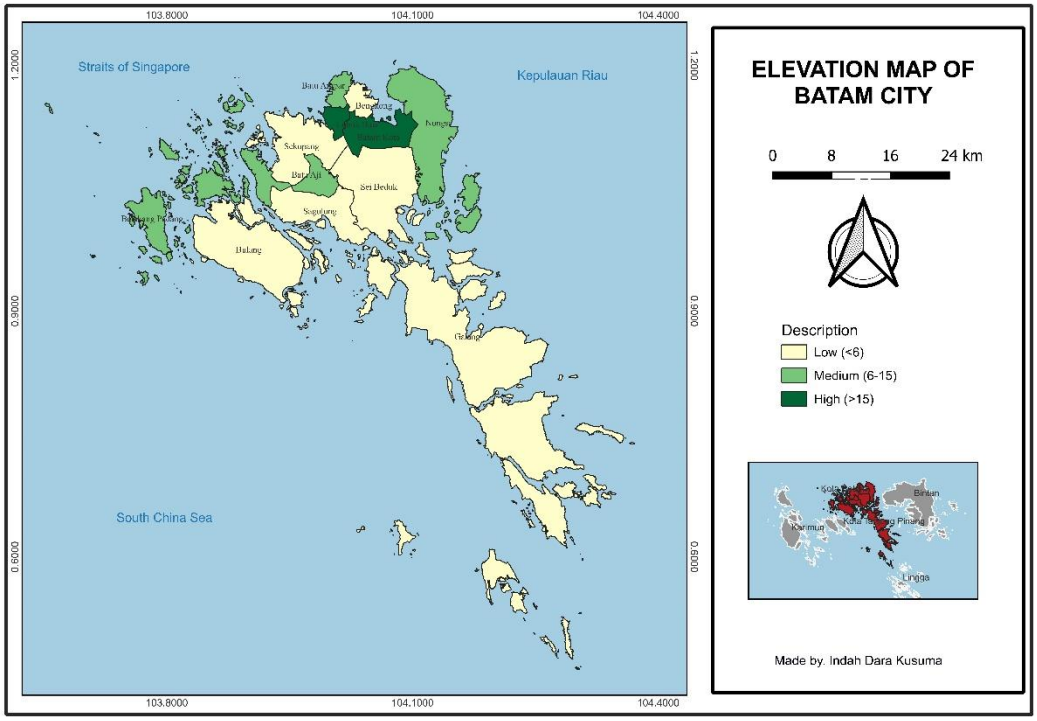

Gambar 3 Elevation Map of Batam City

Health Intervention Strategy Priority Areas Based on Level of Vulnerability

The vulnerability analysis was conducted using a GIS application calculation system that categorizes the level of vulnerability based on the distribution of cases, population density and elevation of the area into three levels, namely low, medium and high using the natural break jenks method illustrated in the following map.

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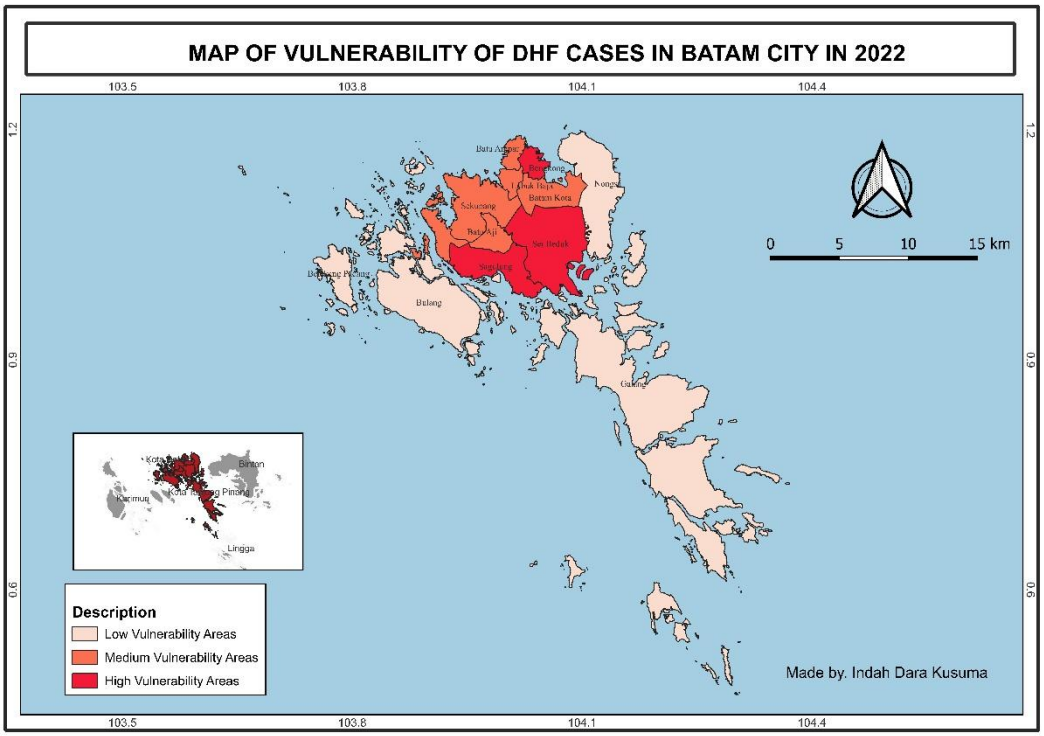

Figure 4 Map of Vulnerability of DHF Cases in Batam City in 2022

Sub-districts that are the main priority areas for health intervention strategies have the highest vulnerability score with an index value of more than six, followed by medium and low vulnerability with an index of six and less than six. The priority order of areas with high and medium vulnerability can be seen in Table 2.

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Table 2 Prioritization of Vulnerability Levels

Priority	District	Level of Insecurity
1	Bengkong	High
2	Sagulung	High
3	Sei Beduk	High
4	Batam Kota	Medium
5	Batu Ampar	Medium
6	Lubuk Baja	Medium
7	Batu Aji	Medium
8	Sekupang	Medium

Prioritization of intervention areas after mapping using geographic information system reached 37.5% coverage of areas with high vulnerability to the distribution of DHF cases in Batam City, namely Bengkong, Sagulung and Sei Beduk sub-districts. The remaining areas with medium vulnerability are Batam Kota, Batu Ampar, Lubuk Baja, Batu Aji and Sekupang.

DISCUSSION

Based on the results of the analysis of the level of vulnerability with variables of dengue cases, population density and elevation data, it is known that there are 3 sub-districts that are at a high level of vulnerability, namely Bengkong, Sagulung and Sei Beduk sub-districts. From the research conducted by Sajab to analyze the ecological factors affecting dengue incidence in Bali, it shows that there is a relationship between several factors that influence the spread of Dengue incidence in Bali, some of which are related to altitude and population density (15).

Population density increases the risk of spreading zoonotic diseases, both from known pathogens and new pathogens, which move from animals to humans and pose a health threat due to disturbed ecosystems (16). Although population density is associated

with an increase in dengue cases, environmental and climatic factors are more influential. High temperatures accelerate virus replication, humidity increases mosquito survival, and rainfall creates breeding grounds. El Niño further accelerates the mosquito life cycle, worsening the spread of the disease. In addition, limited health systems in endemic countries can lead to delays in diagnosis and treatment, increasing the risk of complications and death (17).

Based on population density in Batam City, it can be seen that high dengue cases are not in the densest areas but occur in areas with medium density but on the other hand, dengue cases are also low in areas with low population density. This is in line with a study conducted in Medan City which showed that population density was spread not only in densely populated areas but also in less densely populated areas with 2 out of 21 sub-districts known to have high density with high cases (18). This is also in line with research conducted in the Gambirsari Health Center Working Area with the highest DHF cases in Surakarta from 2015 to 2019 which found that population density occurred in areas with moderate population density (19).

From the map data, it can be seen that Batam city is in the range of 5 to 25 meters above sea level where Aedes aegypti as a vector of DHF disease lives at an altitude of 0-500 meters above sea level (masl) with high vitality (20). Based on the analysis related to the altitude of the area on the distribution of DHF cases in Batam City, it is known that altitude affects the distribution of DHF cases in Batam city with 33% moderate cases found more in areas with lower altitude. In another study conducted by Khakim, it was also found that sub-districts with moderate altitude showed higher case rates. This result indicates that the topography of the area, especially the altitude from sea level, has a relationship with the distribution of DHF cases because it can create environmental conditions that support

mosquito breeding. However, the altitude does not directly affect the incidence rate of DHF (21).

Through a geographic information system with knowledge of the location of expected outbreaks can help health workers in preparedness during dengue season. So that they can prepare resources and manpower to fight the situation. It can also conduct additional preventive measures such as awareness campaigns and destruction of vector breeding sites (22). Health workers can develop an intervention plan for the Mosquito Nest Eradication Movement (LSEM) by destroying mosquito breeding sites. PSN is carried out through 3M Plus: draining, closing water reservoirs, and recycling used goods that have the potential to become mosquito nests. This method is effective in eradicating Aedes aegypti mosquito nests and breaking their life cycle, thus preventing dengue transmission (23).

CONCLUSIONS AND RECOMMENDATIONS

Out of 12 sub-districts in Batam City, 11 sub-districts will be the distribution of DHF cases in 2022. Based on the results of mapping through geographic information system, it is known that the highest case distribution is in low density areas and based on altitude, low areas have moderate cases. The distribution of cases is generally influenced by area density and altitude although the influence is not direct. The mapping is expected to be a reference for health workers to develop health interventions ranging from preparing resources, manpower to additional prevention such as awareness campaigns and mosquito nest eradication movements according to the level of regional vulnerability.

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