A Predictive Map of Larvae Presence Risk Based on Modeling Algorithm in Urban Settings of Endemic Area

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Abstract. *Dengue* is an infectious disease that is still a concern and requires severe treatment. One of the prevention efforts is health promotion activities regarding *Dengue* prevention in risk areas. Preparing a health promotion strategy will be effective and efficient if it is based on target area study data, which can be done by identifying risks and creating area mapping based on larval presence data. Jorong District has the highest incidence rate in Tanah Laut Regency, divided into 11 villages. This research used map methods and design. The research population was 10,003 households, and the sample size was 100 households, which was taken using simple random sampling. The larvae risk data were analyzed univariately and presented as a risk percentage. The research results showed that Jorong Village had the highest risk (62.66%) and Alur Village had the lowest risk (41.28%). There are five villages with a high category, namely Sabuhur Village (50.65%), Jorong (62.66%), Asam Jaya (59.93%), Asri Mulya (56.72%), and Batalang (55.03%). About 84% of high-risk villages had larvae, and 80% of low-risk villages had no larvae. It was concluded that risk mapping was proven to have 82% accuracy (good) in predicting the presence of larvae.

1 Introduction

Dengue fever has become a disease that has extraordinary occurrences in several regions of Indonesia. One of them is in South Kalimantan Province. The Case Fatality Rate (CFR) of *Dengue* Fever incidents in South Kalimantan Province increased from 2022 to 2023, namely 0.6% [1] to 1.3% [2]. Based on data from the Health Profiles of South Kalimantan Province in 2023, it is known that the highest incidence of *Dengue* Fever occurred in

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Tanah Laut Regency, namely 474 cases, which increased from 2022, namely 263 cases [1, 2]. Jorong District has the highest incidence of *Dengue* Fever in Tanah Laut Regency [3]. The distribution of *Dengue* Fever incidents is influenced by the density of larvae, which can be measured by knowing the presence of larvae [4].

Studies related to the assessment of the risk of the presence of larvae have been conducted by several previous researchers, such as that undertaken by Fansiri et al. [5] in Thailand, where the risk assessment by entomology showed that the high number of larvae in a household environment would increase the risk of *Dengue* fever transmission in that environment. In addition, research conducted by Djiappi-Tchamen et al. [6] in Cameroon found that the density of *Dengue* vector larvae indicated a high level of transmission, so immediate action was needed to control the mosquito population in that place. Research on the indication of the presence of mosquito larvae as a predictor of the occurrence of a *Dengue* fever epidemic has also been conducted by Udayanga et al. [7], where the assessment of the House Index (HI) or the number of houses containing larvae in an area can be used as an indicator of early detection of a *Dengue* fever epidemic.

To identify the risk of larvae in this study, a web-based larva risk prediction application that had previously been carried out as a multivariate regression algorithm modelling based on water reservoir characteristics was used to design the application [8]. Previously, studies that developed risk models based on water reservoir characteristics as primary data in predicting the presence of larvae were scarce. Previous studies primarily used data on *Dengue* fever incidents, such as those conducted by Lu et al. [9], which assessed risk based on climate or weather conditions associated with the presence of larvae. Similar research was also conducted by Perwitasari et al. [10].

Data on the identification of the risk of larvae can be visualized in the form of mapping to facilitate the determination of the target focus area of the *Dengue* Fever prevention program. The preparation of a health promotion strategy will be very effective and efficient if it is based on data on the risk of the presence of larvae in the area. Research on mapping the risk of *Dengue* fever has been conducted by Kaunang et al. [11], also using GIS. Another similar study was conducted by Syamsir et al. [12], which found a significant relationship between spatial-based *Dengue* fever cases. In addition, research was conducted by Ainnurriza et al. [13], which used GIS-based mapping to monitor *Dengue* fever occurrence in Sragen Regency. These studies describe the mapping of the risk of *Dengue* Fever, but mapping the risk of the presence of larvae has never been done.

Geographic Information System (GIS) is a technology used to map and analyze spatial data. The average level of GIS accuracy in predicting disease events varies depending on the type of disease, the data used, and the analysis method. In general, studies show that the accuracy of GIS in predicting diseases such as malaria, dengue fever, or other environmentally based diseases can reach 70% to 90% [14, 15]. The advantages of using GIS, in addition to accurate spatial monitoring, is also able to analyze risks in an integrated manner so that it can be more efficient in decision-making and help health authorities in allocating resources to areas that need them more [16].

Based on the description above, this study aims to identify risks and map the risk areas of *Dengue* Fever based on risk prediction data obtained in Jorong District, Tanah Laut Regency. So far, local health authorities in Jorong District have carried out the Health Center and the local Health Office in predicting and managing the risk of dengue fever incidents, including collecting epidemiological data periodically, such as the number of dengue fever cases. In addition, mosquito density surveys were conducted using the ovitrap (mosquito egg trap) and larvitrap (mosquito larva trap) methods. Based on the survey results, areas with high mosquito populations will be given special attention and interventions such as fogging or larvasidation will be carried out. Other health authorities use weather data, such as rainfall, temperature, and humidity, to predict spikes in mosquito populations [17, 18, 19]. This study novelty is in the field of public health science related to infectious diseases, especially *Dengue* Fever, by prioritizing the risk prediction of the presence of larvae applied to the final product in the form of a map of the risk areas of *Dengue* Fever. This area map can later be used as a reference in designing a health promotion program to prevent *Dengue* Fever.

2 Materials and methods

2.1 Study design

This study was a quantitative observational study combined with a risk map design. The research activities were focused on identifying risk data on the presence of larvae per sub-district using a web-based larva risk prediction application to be further visualized into a map with a Geographic Information System (GIS) approach.

2.2 Study Subject

The number of households in Jorong District (**Fig. 1**) is 10,003. Determination of the number of samples using the Slovin Formula obtained from 100 households spread across 11 sub-districts/villages in Jorong District. Samples were selected for each sub-district/village using a simple random sampling technique. The number of samples in each village is presented in Table 1 based on the calculation results using the following formula:

$$\frac{Urban\ population}{District\ population}\ x\ study\ total\ sample = urban\ sample \quad (1)$$

Table 1. The number of research samples

No	Villages	Population	Sample
1	Sabuhur	1100	11
2	Swarangan	746	7
3	Alur	613	6
4	Jorong	1112	12
5	Karang Rejo	722	7
6	Muara Asam-Asam	735	7
7	Asam Jaya	562	6
8	Asri Mulya	421	4
9	Asam-Asam	1975	20
10	Batalang	303	3
11	Simpang Empat Sungai Baru	1714	17

No	Villages	Population	Sample
Total		10.003	100

2.3 Variables and data collection

The study's variable is the characteristics of water reservoirs that theoretically affect the presence of larvae, namely the type of water source, colour, location, and availability of cover. Data were collected by observation in each household. The research tools were observation sheets, flashlights, and the GIS software ArcMap 10.8. The research materials were files of Indonesian topographic maps on a scale of 1:25,000 for Jorong District based on villages.

2.4 Data analysis and interpretation

The larvae risk data were analyzed univariately and presented as a risk percentage. The risk percentage data were then grouped into two risk categories, namely low and high in each village, which were determined based on the formula from Sugiyono [20]:

$$Range = \frac{(highest\ \%) - (lowest\ \%)}{Number\ of\ categories} \quad (2)$$

The data of each category is then entered into the GIS application. Data processing in the GIS application produces a visualization product in the form of a map of the Jorong District area, which shows the risk of the presence of larvae in the form of yellow (low risk) and red (high risk).

2.5 Ethical clearance

The research ethical clearance number 357.1/KEP-UNISM/V/2024 was obtained from the Research Ethics Commission of Sari Mulia University.

3 Results and discussion

Data obtained in Jorong District shows that most water sources do not come from PDAM (75%). Judging from the color category of water reservoirs, most are light in color (82%). Based on location and frequency of cleaning, most are outside the house (60%) and are cleaned at least once in 7 days (55%) (**Fig. 1**).

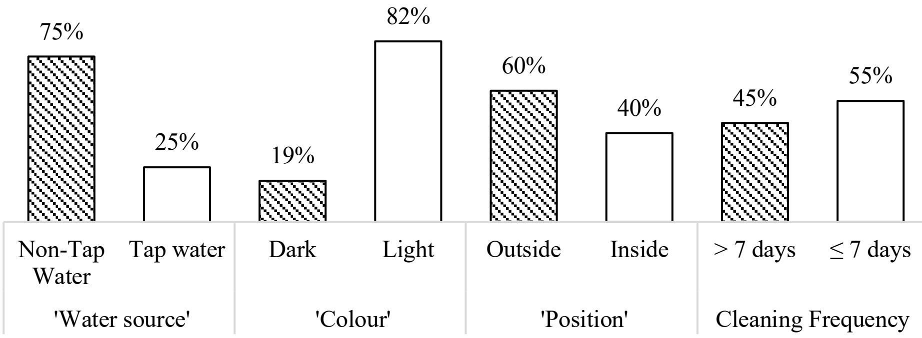

Fig 1. Frequency Distribution of Water Reservoirs Based on Risk Factors for the Presence of Larvae in Jorong District

Jorong District consists of 11 villages, namely Sabuhur, Swarangan, Alur, Jorong, Karang Rejo, Muara Asam-Asam, Asam Jaya, Asri Mulya, Asam-Asam, Batalang, and Simpang Empat Sungai Baru. The frequency distribution of water reservoirs based on water source risk factors in each village is presented in **Fig. 2.**

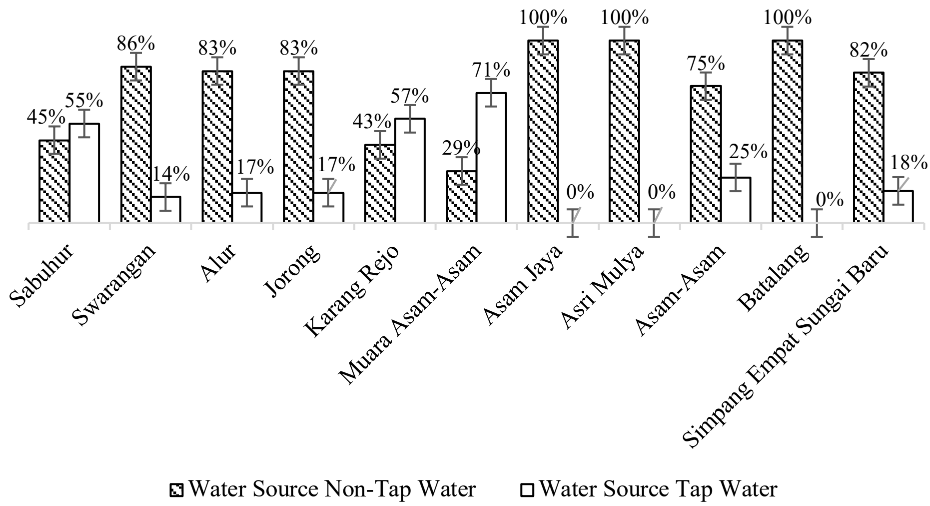

Fig 2. Frequency Distribution of Water Reservoirs Based on Water Sources in Each Village in Jorong District

Figure 2 shows three villages that do not use 100% water from tap water: Asam Jaya Village, Asri Mulya Village, and Batalang Village. Of the 11 villages, three mostly use water sources from tap water: Sabuhur Village (55%), Karang Rejo Village (57%), and Muara Asam-Asam Village (71%). **Fig. 3** presents the frequency distribution of water reservoirs based on color risk factors in each village in Jorong Village.

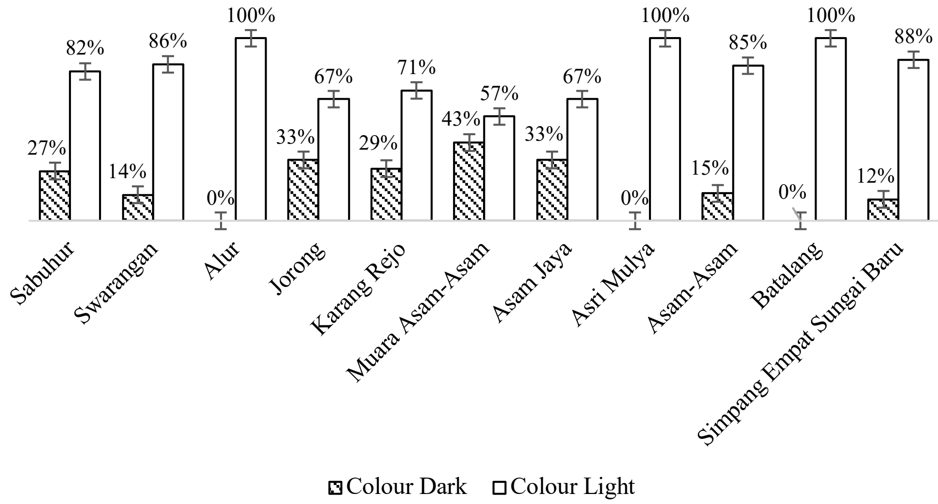

Fig 3. Frequency Distribution of Water Reservoirs Based on Color in Each Village in Jorong District

Based on **Fig. 3**, it is known that all villages in Jorong District mostly have light-colored water reservoirs. There are still dark-colored water reservoirs in 8 villages, with the highest percentage being in Muara Asam-Asam Village (43%), followed by Jorong Village (33%) and Asam Jaya Village (33%). The frequency distribution of water reservoirs based on location risk factors in each Jorong Village is presented in **Fig. 4**.

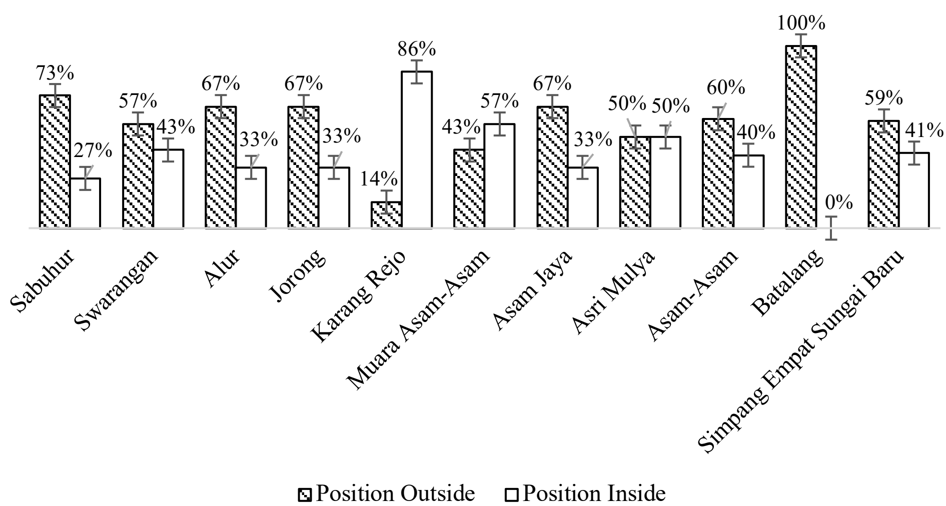

Fig 4. Frequency Distribution of Water Reservoirs Based on Location in Each Village in Jorong District

Fig. 4 shows seven villages with water reservoirs mainly located outside the house, with the highest number in Batalang Village (100%) and the lowest in Karang Rejo

Village (86%). **Fig. 5** presents the distribution of the frequency of water reservoirs based on the risk factor of the frequency of cleaning in each Jorong Village.

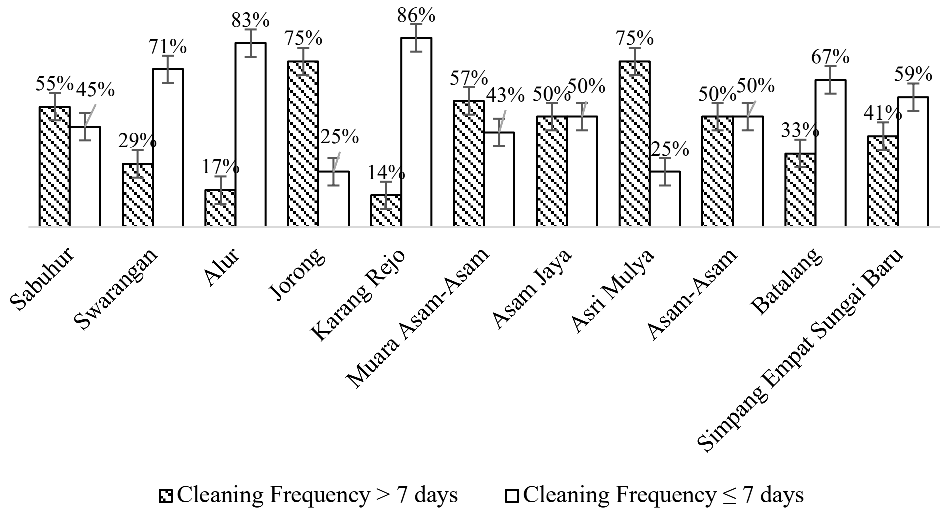

Fig 5. Distribution of Frequency of Water Reservoirs Based on Cleaning Frequency in Each Village in Jorong District

Based on **Fig. 5**, it is known that there are still four villages with a frequency of cleaning water reservoirs mostly more than seven days, namely Sabuhur Village (55%), Jorong Village (75%), Muara Asam-Asam Village (57%), and Asri Mulya Village (75%). Meanwhile, the village with a frequency of cleaning water reservoirs mostly less than once every seven days is the highest in Karang Rejo Village (86%).

The risk value of larvae in Jorong District based on the risk factors of water sources, color, location, and frequency of cleaning has been analyzed according to each village. Based on the data obtained, the village with the highest risk value is Jorong Village (62.66%), and the village with the lowest risk value is Karang Rejo Village (40.72%). The risk value of larvae per village in Jorong District is presented in **Fig. 6.**

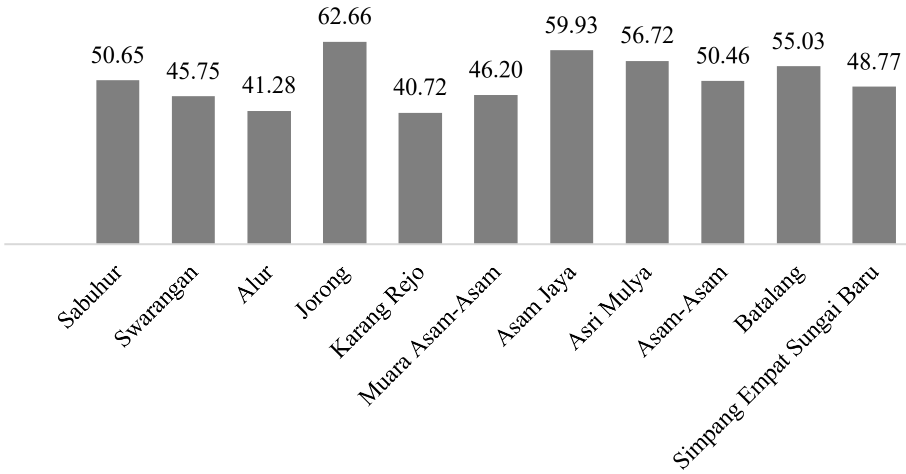

Fig 6. Risk of Larvae Presence Per Village in Jorong District (%)

Based on the calculation results by entering the highest risk values (86.18%) and the lowest (14.30%), an interval value of 35.94% was obtained. The highest and lowest risk percentage values were obtained from the calculation of the logarithmic regression equation model obtained in previous research [8], as follows:

$$Y = -1{,}791 + 0{,}829\ X_1 + 0{,}857\ X_2 + 0{,}812\ X_3 + 1{,}123\ X_4 \quad (3)$$

(X_1: water sources ; X_2: colour ; X_3: led existence ; X_4 : cleaning frequency)

Furthermore, the range value for the risk of the presence of larvae in the low category was determined to be 14.30% - 50.59%, and the high category was >50.59% - 86.18%. Based on these results, the risk category of larvae for each village can be determined, presented in **Table 2.**

Table 2. Risk Category of Larvae Presence Per Village in Jorong District

Villages	Larvae Present Risk	Category
Sabuhur	50,65	High
Swarangan	45,75	Low
Alur	41,28	Low
Jorong	62,66	High
Karang rejo	40,72	Low
Muara Asam-Asam	46,20	Low
Asam Jaya	59,93	High
Asri Mulya	56,72	High
Asam-Asam	50,46	Low
Batalang	55,03	High
Simpang Empat Sungai Baru	48,77	Low
Jorong Regency	**50,74**	**High**

Based on **Table 2**, it is known that, on average, Jorong District has a high risk of the presence of larvae with a risk value of 50.74%. There are five villages with a high category, namely Sabuhur Village (50.65%), Jorong (62.66%), Asam Jaya (59.93%), Asri

Mulya (56.72%), and Batalang (55.03%). The data is visualized into a map using the GIS application presented in **Fig. 7**.

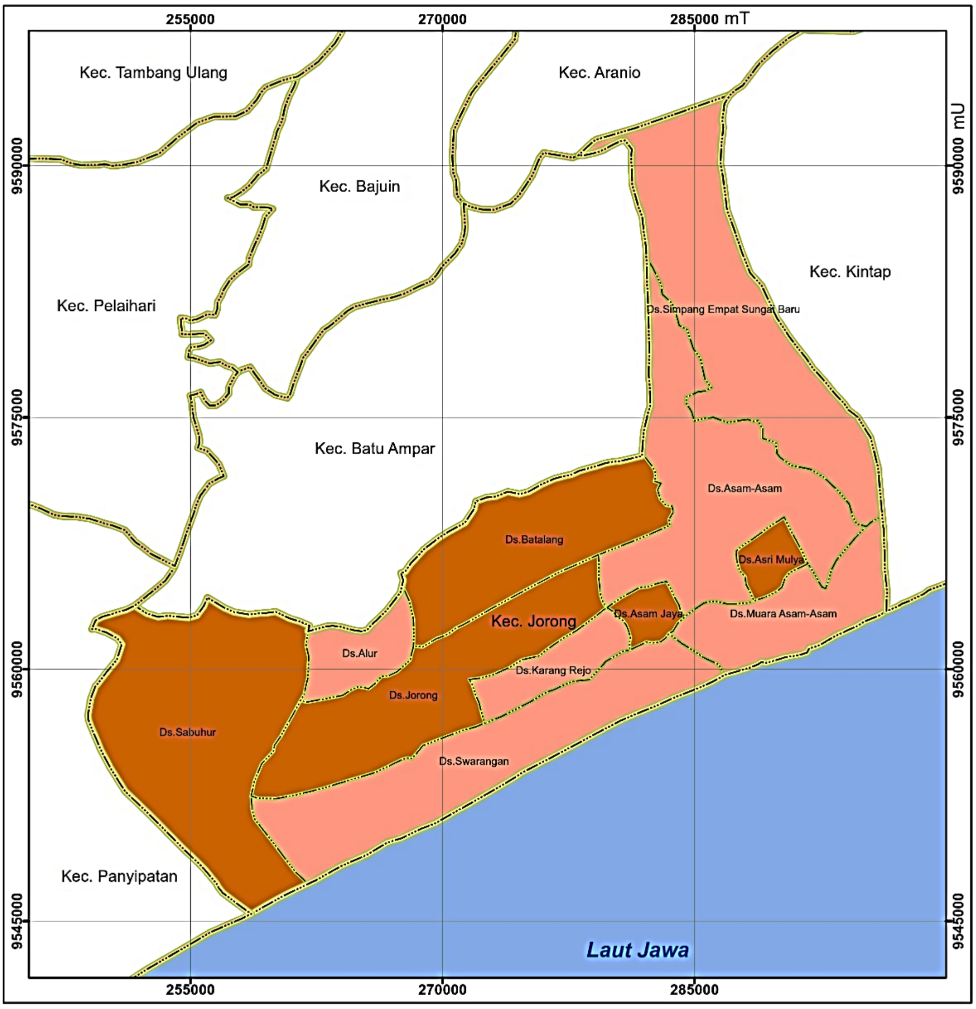

Fig 7. Map of Risk Areas for Larvae in Jorong District High risk area ; Low risk area)

Disease risk maps have been created in various studies. As conducted by Khoirunnisa [21], risk mapping was carried out for tuberculosis (TB), in addition to the research conducted by Purwoko et al. [22], which made mapping by utilizing geographic information systems (GIS) in analyzing tuberculosis transmission. These studies describe the mapping of the risk of a disease, but mapping the risk of the presence of larvae has never been carried out.

The mapping that has been done is then tested in the field, namely comparing the risk category with the presence of larvae in the water reservoir. The frequency distribution by cross-tabulation between the risk category and the presence of larvae in the water reservoir is presented in **Table 3.**

Table 3. Results of Mapping Product Tests with the Presence of Larvae

Risk Category	Larvae Presence				Total	%
	Found		Not Found			
	f	%	f	%		
High	42	84	8	16	50	100
Low	10	20	40	80	50	100
Total	52	52	48	48	100	100

Table 3 shows that most of the water reservoirs at high risk of finding larvae did have larvae when observed in the field (84%). Meanwhile, most water reservoirs with a low-risk category did not find larvae when observed in the field (80%). Based on this, it is concluded that the risk map of the presence of larvae has an accuracy of 82% ((84%+80%)/2) in predicting the presence of larvae in water reservoirs. Important factors that affect accuracy are the quality of environmental data, epidemiological parameters, and geographic relationships between variables [23]. GIS is used to visualize the distribution of larvae down to the house level, which helps more targeted interventions. Azizah's research [24] showed that GIS helps map points prone to the presence of larvae in residential areas through data collection on environmental conditions and community behavior. Based on these results, GIS has proven effective in predicting the presence of mosquito larvae with a spatial approach.

4 Conclusion

The identification of the presence of larvae in Jorong District found the highest risk in Jorong Village (62.66%) and the lowest risk in Karang Rejo Village (40.72%). Based on the risk category of larvae, there are five villages (45.5%) with a high category and six villages (54.5%) with a low category. The risk map of the presence of larvae has an accuracy of 82% in predicting the presence of larvae in water reservoirs or can represent the risk area of larvae quite well.

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