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Analysis of the Spatial Error Model with Queen Contiguity Matrix Weights on Dengue Fever

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ABSTRACT

Dengue Fever is one of the deadly diseases caused by a rapidly spreading virus transmitted through the Aedes aegypti mosquito. This study focuses on the NTB region, which has different geographical characteristics and infrastructure challenges. The variables used in this study are: dengue fever incidence, population, hospitals, community health centers, poor residents, and floods. The aim of this study is to model the factors that influence the occurrence of dengue fever in NTB. The method used is the Spatial Error Model (SEM), which serves to analyze spatial data to observe spatial correlation in the error variables. The research results indicate that the Moran Index and the Lagrange Multiplier test confirm the existence of spatial dependence in the error aspects. Significant variables at the 5% level affecting dengue fever cases are population size, the number of hospitals, and the number of community health centers. These findings provide an important scientific contribution as they represent one of the early studies that specifically identify and model the spatial dependence patterns of dengue fever cases in West Nusa Tenggara using a spatial econometric approach, thereby enriching the literature on spatial epidemiology at the regional level. The findings indicate that population growth and disparities in healthcare facilities increase the risk of dengue fever. This implies that more equitable spatial planning of healthcare services, strengthening of primary care, population density control, and increased community participation in sanitation and regular mosquito breeding site eradication are necessary as part of an to reduce dengue fever cases in NTB.

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A. INTRODUCTION

Dengue Fever is one of the deadly diseases caused by a virus that spreads very quickly through the Aedes aegypti mosquito found in various parts of the world (Zhao & Liang, 2024). The presence of this disease has an impact on the social, economic, and demographic development of the community (Pakaya et al., 2023). Dengue Fever incidents do not only occur in developing countries, but also in developed countries, although the incidence rate is not higher compared to developing nations (Kutsuna et al., 2015). One of the developing countries with a relatively high incidence of dengue fever is Indonesia (Fauzi et al., 2022). Indonesia is a country made up of a cluster of islands that automatically has a very long and extensive coastline One of the regions often highlighted for its coastal area is West Nusa Tenggara (NTB) (Soraya et al., 2024).

The incidence of Dengue Fever over the past 6 years has been quite significant (Elisabeth et al., 2025; Koesmaryono et al., 2024). The districts/cities with the highest incidence of Dengue

Fever in succession are East Lombok, Central Lombok, and West Lombok. Meanwhile, the district with the lowest incidence of Dengue Fever is West Sumbawa. Dengue Fever occurrences in the province of West Nusa Tenggara (NTB) continue to occur every year in every district/city, although there was a decrease in 2020. However, this remains a concern because the incidence of Dengue Fever greatly impacts health and can potentially result in many fatalities (Salim et al., 2025). NTB is one of the areas at risk for high levels of Dengue Fever when viewed from its geographic location.

The occurrence of Dengue Fever in West Nusa Tenggara (NTB) cannot be separated from the status of the region, which is nationally categorized as 3T (Outermost, Underdeveloped, Isolated) (Yani, 2024). This means that despite economic activities taking place very well and being supported by various sectors (Soraya et al., 2021), NTB still remains a province with a high poverty rate in Indonesia (Primadianti & Sugiyanto, 2020). In addition, the increasing population is not supported by the availability of health facilities. The last factor is the misuse of land and the shift of people's livelihoods to rely solely on one source, as well as environmental degradation that causes flooding in various areas (Asyary, 2025). If the dengue fever cases continue and the factors that potentially influence them are not addressed or minimized, it will have fatal consequences for the survival of the community.

Research related to dengue fever events has been conducted extensively, among others by Kleden et al. (2023) About the factors that influence the occurrence of dengue fever in Sikka-Kupang, it was found that the size of the house, the color of the house walls, the habit of emptying water storage places, the habit of using mosquito repellent, and participation in cleaning mosquito nests affect a person suffering from dengue fever. Based on the odds ratio, it is known that a person with a house area of < 36m2 is at greater risk of contracting dengue fever compared to someone with a house area of > 36m2. Other research was conducted by Khaidir et al. (2024) related to analyzing the efforts in controlling dengue fever conducted in Mataram City and obtaining results that managerial aspects are a significant obstacle in handling dengue fever, particularly concerning program inputs such as limited budget allocation, the absence of technical guidelines and minimum standards for activity implementation, and the unavailability of regulations or regional laws that support it. Furthermore, research related to dengue fever incidents was also conducted by Manggo (2024) about describing the epidemiology of the spread of dengue fever based on age and gender, time and place, and the results show that gender factors influence the incidence of dengue fever.

The occurrence of dengue fever has also been analyzed by various methods including random forest classifier and svmsmote, with the aim of classifying to assist medical personnel in distinguishing dengue fever occurrences from other diseases (Bria et al., 2025). Research others with machine learning methods to predict the occurrence of dengue fever in Malaysia (Majeed et al., 2023). Further research on the incidence of dengue fever was conducted by Lun et al. (2022) using spatial autocorrelation analysis methods using ArcGIS 10.5 and temporal-spatial analysis with SaTScan 9.5. Spatial methods were also used in research related to the incidence of dengue fever conducted by (Lun et al., 2022; Sarker et al., 2024; Zhao & Liang, 2024). Another function of the spatial method is for clustering, as done by (Fauzi et al., 2022). Spatial methods have also been used by Taryono et al. (2018) to analyze the occurrence of dengue fever in the Central Java region.

This research is relevant to previous studies. However, there are differences in method, context such as the region and variables used. If the reference research is conducted in Central Java, this study focuses on the NTB region, which has different geographical characteristics and infrastructure challenges. This adjustment is made to ensure that the model fits the characteristics of the region, as it is emphasized that the spatial structure of the location must be considered in the development of spatial models (Mukolwe et al., 2025). This research aims to describe the spread pattern of dengue fever and to identify the spatial relationships between regions. A spatial approach can reveal hidden dimensions in the dynamics of infectious diseases in a certain area (Taryono et al., 2018). The method used in this study is the spatial error model (SEM), which functions to analyze spatial data in order to see the spatial correlation in the error variables (Kleden et al., 2025). Its main purpose is to consider the impact of nearby locations on the dependent variable, with the assumption that the error at one location may be influenced by the error at other nearby locations.

This study fills this gap by trying to prossvide a spatial element in the analysis of dengue fever cases and the factors influencing them. This is the novelty of this research, which is the addition of a spatial element in the analysis. Thus, the objective of the research is to identify the factors that significantly influence the spread of dengue fever incidents in NTB. The results of this research are expected to serve as a consideration for the NTB government in designing more targeted policies for dengue fever control. In addition, this research is hoped to encourage the community to be more active in maintaining environmental cleanliness, managing sanitation, and routinely eradicating mosquito breeding sites. With the synergy between the government and the community based on this empirical data, it is hoped that the number of dengue fever cases can be significantly reduced.

B. METHODS

This type of research is quantitative research. The data used is cross-sectional data from the Satu Data NTB website and the Central Bureau of Statistics of West Nusa Tenggara Province (BPS-NTB) in 2023. The data that is the object of the research is the data on the incidence of dengue fever in districts/cities in the NTB province as the response variable. Then the variables acting as predictors are the population per district/city, the number of general hospitals, the number of community health centers, the number of poor residents, and the number of houses affected by flooding. Several stages of the research can be explained through the following steps (Costa et al., 2021; Soraya et al., 2021): (1) Describing the data of dengue fever cases in NTB Province in the year 2023 has been obtained, (2) Describing each predictor variable as an illustration of the dengue fever case in West Nusa Tenggara and the factors that are expected to influence it, (3) Identifying the pattern of relationships between the response variable and the predictor variable through Scatter Plot, (4) Establishing a spatial weighting matrix for each area using Queen Contiguity weights, (5) Testing spatial aspects (spatial dependence and spatial heterogeneity), (6) Testing the appropriate spatial model using the Lagrange Multiplier, (7) Evaluating the model that has been formed, and (8) Interpreting the model that has been obtained. This stage of the research can be illustrated in the research flowchart Figure 1.

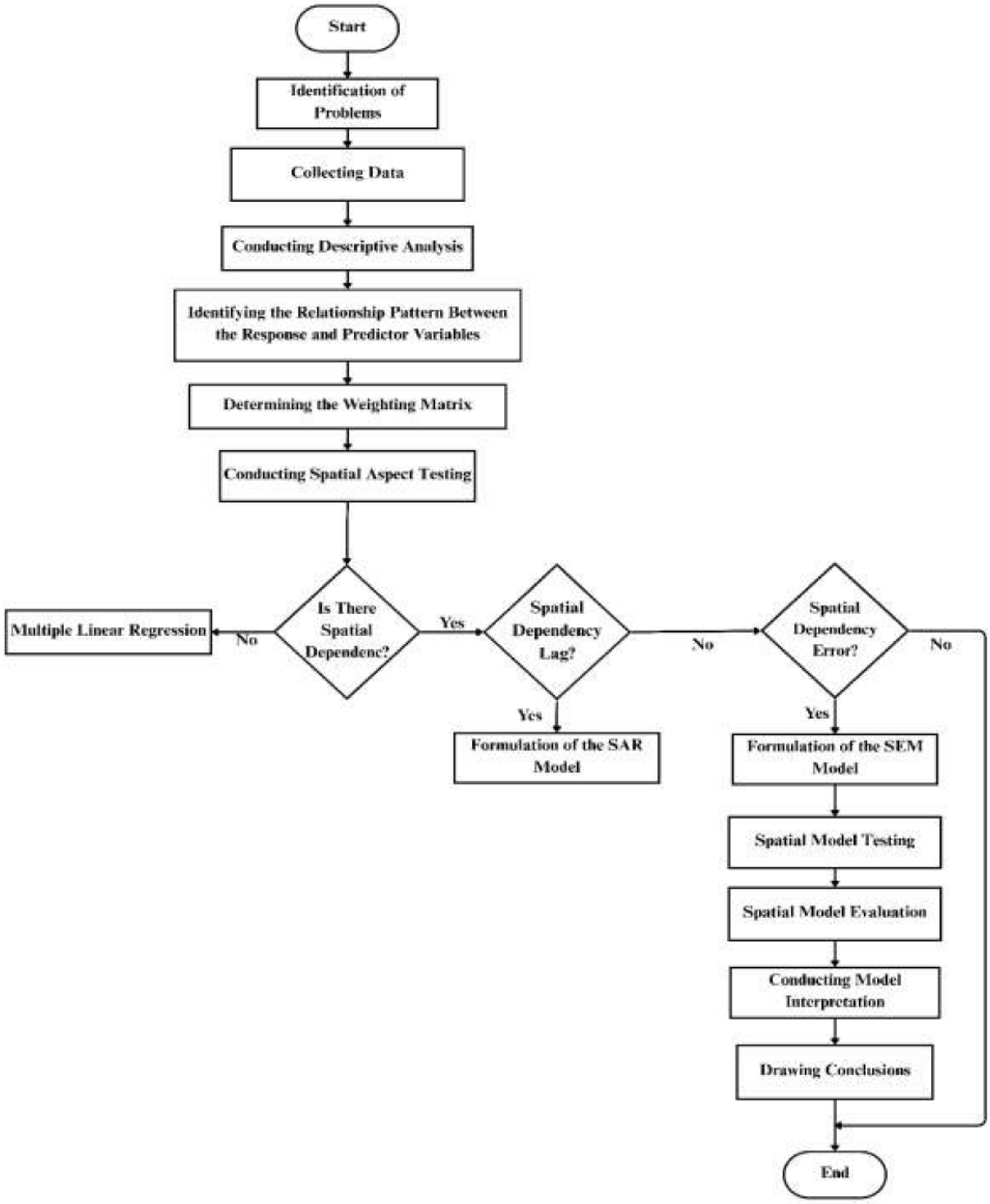

Figure 1. Research Flowchart

C. RESULT AND DISCUSSION

The occurrence of dengue fever is a disease that always draws attention in various regions, especially in the Province of West Nusa Tenggara (NTB). In this study, Figure 2 provides a description of the distribution of dengue fever occurrences in 2023 across 10 districts/cities in West Nusa Tenggara, as shown in Figure 2.

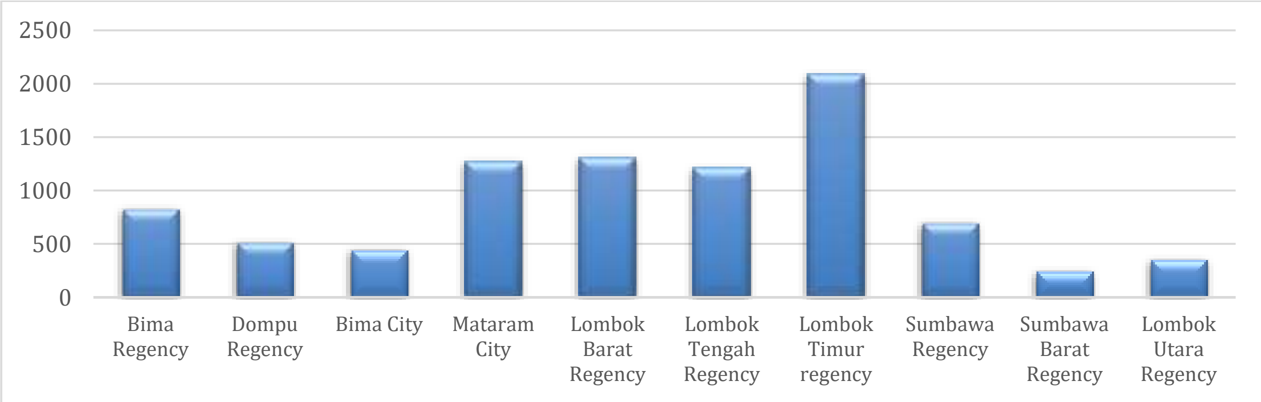

Figure 2. Data on Dengue Fever Incidence by District/City in NTB Province in 2023

Based on Figure 2, it states that in 2023, East Lombok Regency has the highest incidence of dengue fever, followed by West Lombok Regency, Mataram City, Central Lombok Regency, Bima Regency, Sumbawa Regency, Dompu Regency, Bima City, North Lombok Regency, and finally West Sumbawa Regency. Dengue fever incidents continue to occur every year, and this is an important issue to be analyzed and researched. It is noted that the incidence of dengue fever is influenced by factors such as population size, availability of hospitals, health centers, the number of impoverished people, and flooding incidents in various regions. The relationship between dengue fever incidents and the influencing factors is presented in Table 1.

Table 1. The Relationship between Dengue Fever Incidence and Its Factors

Variabel	Dangue Fever (Y)	Population (X1)	Hospital (X2)	Community Health Center (X3)	Poor Population (X4)
Population (x_1)	0,910				
Hospital (x_2)	0,680	0,447			
Community Health Center (x_3)	0,605	0,827	0,222		
Poor Population (x_4)	0,875	0,977	0,345	0,814	
Floods (x_5)	-0,530	-0,496	-0,355	-0,372	-0,497

Based on Table 1, it can be explained that the population size and the incidence of dengue fever have a very strong relationship of 91%. This is followed by the presence of impoverished residents with a relationship strength of 87%. Next, the relationship between the incidence of dengue fever and the number of hospitals and community health centers is 68% and 60.5% respectively, indicating that the strength of these relationships is moderate. Lastly, the incidence of flooding and the incidence of dengue fever have an opposing relationship with a value of -53%. From the description of Figure 2 and Table 1, a check will be conducted regarding the spatial dependence between regions possessed by the response variable and the predictor variable using Moran's I index, the results are shown in Figure 1.

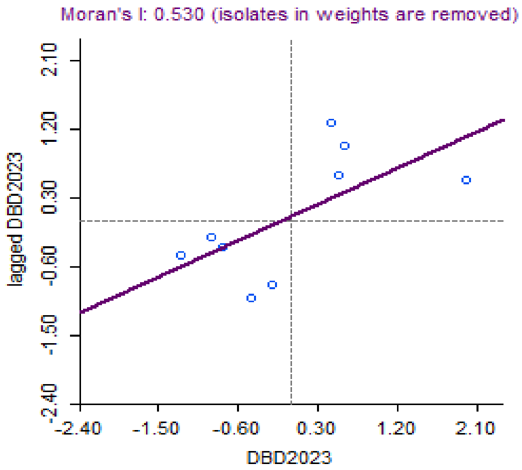

Figure 3. Moran's I

The obtained Moran's Index value is 0.530, which falls within the range of $0 < I \leq 1$, indicating that the dangue dever in NTB has positive spatial autocorrelation. This means that districts/cities that are close together have similar occurrences of dengue fever, or it indicates that dengue fever incidents tend to cluster. Testing spatial effects using Moran's I is the first step in conducting spatial regression analysis. Further spatial testing is conducted using the Lagrange Multiplier to identify the interrelations between regions related to the occurrence of dengue fever.

Test results of the lagrange multiplier, p-value of 0.0321 was obtained. When compared to the value of α (0.05), H_0 is rejected because $p{-}value < \alpha$. From the results of the spatial autocorrelation test, using a confidence level of 95%, the existing data supports the rejection of the null hypothesis, which indicates the presence of spatial error dependence. According to the results obtained from this Lagrange Multiplier test, it can be concluded that there is spatial dependence in the data on dengue fever occurrences in West Nusa Tenggara and its factors, thus the spatial regression model used to analyze the factors influencing dengue fever occurrences in West Nusa Tenggara is the Spatial Error Model (SEM). Based on the Lagrange Multiplier test on the occurrence data of dengue fever and its factors, a spatial error dependence was obtained, thus requiring the estimation of parameters for the Spatial Error Model (SEM) as show by Table 2.

Table 2. Estimasi Parameter Spatial Error Model

No	Variable	Coefficient	Standar Error	P-value
1	Constant	224.589	76.7697	0.00344
2	Population (x_1)	1.44116	0.524328	0.00599
3	Hospital (x_2)	56.2137	20.7255	0.00668
4	Community Health Center (x_3)	-14.3701	6.94678	0.03858
5	Poor Population (x_4)	-1.35354	3.28764	0.68055
6	Floods (x_5)	-0.00834148	0.0126025	0.50804
7	Lambda	-0.764223	0.150112	0.00000

The results of the Spatial Error Model regression in Table 2 show that there are three predictor variables that influence the number of dengue fever cases, namely variables (x_1), (x_2), (x_3), while two predictor variables that do not significantly affect the number of dengue fever cases are (x_4) and (x_5) because the p-value of the coefficients is greater than 0.05. Based on the data from Table 2, a spatial error model is presented for dengue fever case data as follows:

$$(\hat{\boldsymbol{Y}}_{\boldsymbol{i}}) = 224.589 - 0.764 \sum_{j=1,i\neq j}^{m} \boldsymbol{W}_{ij}\boldsymbol{y}_{\boldsymbol{j}} + 1.441x_1 + 56.213x_2 - 14.370x_3 - 1.353x_4 - 0.008x_5$$

Based on the presented spatial error model, it can be interpreted that assuming other factors are constant, a one percent change in x_1 results in a change of 1.441 in the number of dengue fever occurrences. Furthermore, a one percent change in $x_2$results in a change of 56.213 in the number of dengue fever occurrences. Then, a one percent change in x_3 results in a change of -14.370 in the number of dengue fever occurrences. Furthermore, a one percent change in x_4 results in a change of -1.353 in the number of dengue fever occurrences. Finally, a one percent change in x_5 results in a change of -0.008 in the number of dengue fever occurrences. Lastly, the spatial lambda value between districts/cities is correlated at 0.764, which means that the spatial interaction among the 10 districts/cities in West Nusa Tenggara Province has a spatial influence on the number of dengue fever cases by 76%, indicating a fairly high level of dependency between the regions.

The results of this study are in line with previous studies that highlight the importance of a spatial approach in analyzing the distribution of dengue fever case (Taryono et al., 2018). This is reflected in the presence of spatial autocorrelation detected through the Moran's Index and Lagrange Multiplier tests, as also reported in various studies in other regions of Indonesia (Husnaeni et al., 2024). The selection of the Spatial Error Model (SEM) as the best model based on a smaller AIC value compared to SAR indicates that spatial dependence occurs more strongly in the error component than directly in the response variable. In addition, the significant influence of population size and the availability of health facilities, such as hospitals and community health centers, is in line with previous studies that place demographic factors and access to health services as the main determinants of dengue fever incidence (Pakaya et al., 2023). Therefore, this study not only reinforces previous findings but also expands their application in the context of NTB.

D. CONCLUSION AND SUGGESTIONS

This study aims to form a model of the distribution of dengue fever cases in the districts/cities of NTB Province. The results of the Moran Index and Lagrange Multiplier tests indicate a spatial dependency relationship in the error aspect. The significant variables at the 5% level affecting dengue fever cases are: population size, number of hospitals, and number of health centers. The findings indicate that population growth and disparities in healthcare facilities increase the risk of dengue fever. This implies that more equitable spatial planning of healthcare services, strengthening of primary care, population density control, and increased community participation in sanitation and regular mosquito breeding site eradication are necessary as part of an to reduce dengue fever cases in NTB. This method has weaknesses in dealing with the presence of outliers and heterogeneity in the data. This needs to be taken into account considering the demographic and geographical conditions of the West Nusa Tenggara region. Therefore, the recommendation for future research is that the application of a Bayesian approach in spatial models should be considered.

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