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Spatial Mapping of Endemic Diseases in Lamongan Regency Using Natural Breaks Clustering

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ABSTRACT— Endemic diseases represent critical public health challenges that require vigilant and continuous monitoring to prevent their spread. A key impediment, however, is the lack of interactive spatial data visualization, which often hinders health agencies' efforts to effectively analyze disease distribution. To address this gap, this study presents the development of a spatial mapping system for endemic diseases in Lamongan Regency, leveraging the Jenks Natural Breaks clustering method. The system utilizes regional data, including sub-district demographics, population figures, and official endemic disease reports obtained from the Lamongan Regency health profile website. Developed using the Laravel 10 framework and a MySQL database, the system integrates Metabase as the primary data visualization engine. The core of the system lies in its geovisualization technique, which is applied to intuitively display disease distribution through interactive, sub-district-based maps. This design allows users to trace the spatial and temporal trends of endemic diseases with greater clarity. Evaluation results confirm that the system displays information accurately and interactively, thereby significantly assisting health agencies in monitoring and planning regional health policies more effectively.

KEYWORDS — **Spatial Mapping, Endemic Disease, Natural Breaks Clustering, Metabase, Lamongan Regency**

I. INTRODUCTION

Endemic diseases are diseases that are perpetually present in a certain area or population group. These diseases are generally related to specific geographical, climatic, and environmental conditions. In Indonesia, various endemic diseases are spread across different regions, with Lamongan Regency being one such area [1], [2]. Lamongan Regency, located in East Java, faces several persistent endemic diseases that require serious attention, including Dengue Haemorrhagic Fever (DHF), malaria, hepatitis B, leprosy, tuberculosis, filariasis, and measles [3], [4]. This concern stems from the high incidence and negative impact caused by these diseases.

A clear illustration of this urgency is provided by data from the Lamongan Regency health profile: the number of dengue cases in 2022 was 416 cases with 1 death. Compared to 2021, which saw 259 cases without fatality, dengue cases in 2022 increased by approximately 60%—a truly dramatic rise [5], [6]. This drastic and concerning increase indicates an urgent problem in controlling and preventing the spread of DHF in Lamongan Regency.

The spread of endemic diseases can become one of the urgencies for a country, or even the world, if not handled quickly and appropriately [7], [8], [9], [10], [11], [12], [13], [14], [15], [16]. Despite this critical necessity, efforts to map and control endemic diseases in Lamongan Regency have faced various obstacles. Data on endemic diseases are often scattered across various institutions and lack integration, making it exceptionally difficult to get a complete and accurate picture of disease distribution. In addition, traditional mapping methods using tables are highly inefficient in providing clear visualizations that are easily understood by policy makers and the general public. This results in a lack of understanding of disease spread patterns and delays in response to outbreaks.

Spatial mapping of endemic diseases is therefore essential in understanding disease distribution patterns, identifying risk factors, and formulating effective control strategies. Lamongan Regency, as one of the areas with significant endemic disease cases, urgently requires a mapping system that is able to present information accurately and interactively. For this reason, this research proposes the development of a web-based endemic disease mapping system using Metabase as a spatial data visualization tool based on sub-districts. By leveraging the mapping features available in Metabase and the Jenks Natural Breaks clustering method—which is automatically applied—disease distribution data can be visualized in the form of interactive maps based on administrative areas, thereby providing key support to the Lamongan District Health Office in monitoring and decision-making [8].

Spatial mapping of endemic diseases in Lamongan Regency is expected to improve understanding of disease distribution, support evidence-based decision-making, and accelerate response to outbreaks. In addition, easily accessible data visualization can also increase public awareness of the importance of prevention and health measures. This information will be the fundamental basis for better decision-making in disease prevention and control efforts, as well as support the planning of more effective and targeted intervention strategies.

The primary goal of this research is two-fold: First, to map the spatial and temporal distribution of endemic diseases in Lamongan Regency based on sub-districts, using available data from the Lamongan Regency profile website. This mapping will employ Metabase digital technology and Jenks Natural Breaks clustering for categorization of high and low infection ratios. Second, this study aims to identify high-risk areas against specific endemic diseases based on spatial data obtained, while providing spatial and temporal information that is useful for local governments, health organizations and the community in prevention and control efforts. Ultimately, this research also seeks to increase the use of digital mapping technology in the field of public health in Lamongan Regency.

The expected benefit of this research is to help local governments and health organizations to gain a deeper understanding of the spatial and temporal patterns of endemic diseases in Lamongan Regency. By mapping data accurately, this research can facilitate more informed and proactive decision making in resource allocation and intervention priorities for the prevention and control of endemic diseases. Furthermore, it is hoped that this research can increase the effectiveness of prevention and control efforts by identifying high-risk areas, as well as encouraging the use of digital mapping technology in the field of public health in Lamongan Regency. This research is also useful for promoting public awareness about areas at high risk of endemic diseases and encouraging better preventive measures. Finally, the findings are expected to support further research on the factors that influence the spread of endemic diseases and the development of more effective control strategies in the future.

This section discusses the theoretical basis and knowledge relevant to the development of a spatial temporal mapping system for endemic diseases in Lamongan Regency. Specifically, the discussion focuses on the basic principles of disease mapping systems, the current limitations in monitoring the spread of diseases geographically and in time, the role of data visualization technology in managing public health information, and the importance of integrating population data and case distribution for more accurate estimation and analysis of disease spread patterns..

A. Temporal Spatial Mapping

Spatial data provides a description of the spatial aspects of a phenomenon that can help provide precise location clues so that health interventions are implemented effectively and efficiently. Conversely, temporal data is related to certain times. Thus, temporal spatial mapping can be interpreted as the process of collecting, processing, and analyzing geographic data based on a certain time to produce a map or visual representation of a region or area. Temporal spatial mapping is commonly used to understand and analyze geographic phenomena, such as land use patterns, population distribution, environmental changes, and others [17].

B. OpenMap

In general, OpenMap is a concept referring to an open-source platform used to develop web-based interactive map applications. In the spatial mapping of endemic diseases in Lamongan Regency, the specific openmap system that will be used is Metabase. Metabase is a powerful platform for managing and visualizing data [18]. Metabase has many graphic modes and spatial region heatmap features. With only the open-source version of Metabase, it is enough to create an excellent spatial visualization dashboard. Metabase uses GeoJSON file format, which is used in this system as a supporting element of spatial data in the Metabase platform. GeoJSON data contains detailed information to characterize regions. This includes boundary information up to the sub-district and village level. Metabase requires region boundary information with each region label to create a region heatmap visualization.

C. GeoJSON

GeoJSON is a geographic data structure encoding format for representing simple geographic data along with its non-spatial attributes using human-readable text. The GeoJSON format is often used to exchange data over the internet and is a standard supported by many GIS (Geographic Information System) and mapping applications. GeoJSON uses the WGS 84 coordinate system to represent geographic points through latitude and longitude [19].

II. METHOD

Natural breaks, formally known as Jenks Natural Breaks Optimization, is a statistical method for classifying data into categories based on the inherent characteristics of their distribution. This method works by maximizing the variance between classes while minimizing the variation within each class, thereby grouping similar values and setting clear boundaries on values with large differences [20]. Applied here, this method classifies the impact ratio of endemic diseases into low, medium, and high levels. Since Metabase automatically integrates this technique for regional map visualization, with detailed data for 27 sub-districts and 12 urban villages and 462 villages in Lamongan Regency, this section will detail the core concept of the Jenks method, its algorithm, and its implementation in the Metabase platform for spatial visualization of endemic diseases in Lamongan Regency.

A. Basic Concept of Natural Breaks

Natural Breaks is a crucial statistical classification method that identifies natural data groupings to divide spatial data into homogeneous classes. The primary objective is to minimize intra-group variance and maximize inter-group variance. In mapping analysis, particularly geospatial studies like this one, the Jenks Natural Breaks method plays a pivotal role in revealing patterns and characteristics of disease incidence associated with specific spatial entities, thus facilitating informed decision-making.

B. Natural Breaks Algorithm (Jenks)

The Natural Breaks algorithm operates through an iterative process designed to find the optimal clustering. The basic steps of the Jenks Natural Breaks algorithm are:

1. *Initialization*: The data is sorted from lowest to highest value. The number of classes (k) is determined in advance.
2. *Initial division*: The data is divided into k classes with equal intervals.
3. *Calculation*: For each possible division, the algorithm calculates:
   - Sum of Squared Deviations of class values (SDCM): Measures within-class homogeneity:

$$SDCM = \sum_{i=1}^{k} \sum_{j=1}^{ni} (\text{xij} - \mu\text{i})^2 \quad (1)$$

Where:

- k is the number of classes
- n_i is the number of observations in class i
- xij is the j^{th} value in class i
- μi is the average of class i, which is calculated as:

$$\mu\text{i} = \frac{1}{ni} \sum_{j=1}^{ni} \text{xij} \quad (2)$$

- Sum of Squared Deviations of array mean values (SDAM): Measures the total variation in the data:

$$SDAM = \sum_{i=1}^{k} \sum_{j=1}^{ni} (\text{xij} - \mu)^2 \quad (3)$$

Where:

- μ is the overall average of the dataset, which is calculated as:

$$\mu = \frac{1}{N} \sum_{i=1}^{k} \sum_{j=1}^{ni} \text{xij} \quad (4)$$

(4)

- N is the total number of observations

$$N = \sum_{i=1}^{k} ni \quad (5)$$

4. Optimization: The algorithm iteratively shifts class boundaries to minimize (SDCM) and maximize the Goodness of Variance Fit (GVF). GVF determines how effectively the classification minimizes within-class variation and is defined as:

$$GVF = \frac{(\text{SDAM} - \text{SDCM})}{\text{SDAM}} \quad (6)$$

GVF values range from 0 to 1, where higher values indicate better classification. GVF = 1 means the within-class variation is zero (perfect classification), while GVF = 0 means there is no improvement in variation compared to the unclassified data.

5. *Convergence*: The process repeats until the GVF cannot be improved anymore, indicating the optimal division has been found.

C. Implementation of Natural Breaks in Metabase

Metabase automatically implements the Natural Breaks method in its map visualization feature. Here's how Natural Breaks works in the Metabase platform:

- *Automatic and Dynamic Classification:* Metabase automatically applies Natural Breaks and dynamically determines the optimal number of classes (up to 5) based on the input data distribution. This ensures meaningful visualization, even for skewed endemic disease prevalence data.
- *Hotspot Identification and Pattern Representation:* Unlike arbitrary methods, Natural Breaks is highly effective for identifying disease "hotspots"—areas with significantly higher case rates—by visualizing the natural patterns inherent in the data. This is crucial as endemic disease data often exhibits skewed distributions.
- *Intuitive Policy Interpretation:* The resulting classifications are mapped onto a color gradient, where intensity represents disease burden. This allows health policy makers to intuitively interpret the maps and facilitates more effective and targeted health intervention planning and resource allocation.
- *Real-time Recalculation:* As the underlying data in the MySQL database changes, Metabase automatically recalculates the Natural Breaks

classification in real-time, ensuring the map always reflects the latest patterns.

D. System Design and Data Flow

This research developed a web-based spatial-temporal mapping system using the Laravel 10 framework, MySQL database, and Metabase for visualization. The system architecture, illustrated in Figure 1, comprises three main stages:

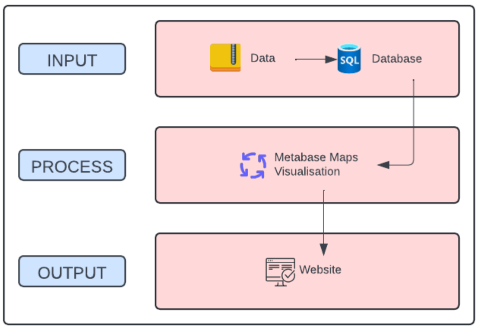

FIGURE 1. System Architecture Design

- Input (Data Collection): Endemic disease data (cases of DHF, malaria, hepatitis B, leprosy, tuberculosis, filariasis, and measles) and demographic data (total population) are obtained from the Lamongan Regency health profile website in table format. These non-spatial data are input into the MySQL database via the website interface..
- Process (Analysis and Classification): The MySQL database is connected to Metabase in real-time. Data preprocessing first normalizes disease cases with population size to generate prevalence rates. Metabase then automatically executes special queries and applies the Jenks Natural Breaks algorithm on the prevalence results to determine optimal class boundaries.
- Output (Visualization and Interaction): Metabase renders the classification results onto a GeoJSON map of Lamongan Regency. The resulting interactive map visualization is accessible via the website, allowing users to display distribution patterns based on year, sub-district, and disease type, thus supporting effective decision-making for disease control and prevention in Lamongan Regency.

III. IMPLEMENTATION AND RESULT

The spatial mapping system of endemic diseases in Lamongan Regency was successfully developed using Laravel 10 framework and Metabase as a data visualization tool. This section discusses the implementation process, the results obtained, and the evaluation of the system's performance.

A. System Implementation

The system was implemented using Laravel 10 as the web framework and MySQL as the database management system. The implementation process involved several key steps:

- *Database Design*: A relational database was designed to store data on year, subdistrict, population, disease type, and endemic disease cases in each year and subdistrict. The database structure includes tables for year, subdistrict, population by year and subdistrict, disease type, and disease cases categorized by year, subdistrict, and disease type.
- *GeoJSON Integration*: Sub-district boundary data for Lamongan Regency was obtained and converted into GeoJSON format. Each sub-district in the GeoJSON file was assigned a unique identifier that corresponds to the sub-district data in the database. This JSON/GeoJSON file was published and the link will be stored in the Metabase as a new region map.
- *Metabase Configuration:* Metabase was integrated with the Laravel application and configured to connect to the MySQL database. Custom queries were developed to be able to generate maps of population distribution, disease cases, and disease trends that would then be connected and displayed on the website. The selection of Metabase was strategic due to its suitability in a public health setting. Its intuitive, user-friendly interface facilitates broad adoption by non-technical health personnel, which is critical for system sustainability. Furthermore, as an open-source platform, Metabase offers a cost-effective solution and excels in producing the necessary geospatial visualizations required for effective epidemiological analysis and swift response planning.
- *Web Interface Development*: A user-friendly web interface was developed using Bootstrap, Tailwind CSS, and Laravel Blade templating engine. This interface allows users to filter data by year, subdistrict, and disease type.

B. System Features

This system will use Metabase as an open-source website mapping platform to visualize spatial-temporal data of endemic diseases. The system will provide various features, including:

1. *Disease information*: This website contains information about endemic diseases, including definition, symptoms, treatment, etc.
2. *List of years, sub-districts, and types of endemic diseases*: This website will display a list of years, sub-districts in Lamongan Regency along with the number of residents per year, and types of endemic diseases along with the number of infected and dead in each sub-district. This data will be presented in a table.

3. *Mapping the distribution of population*: This website will display a map of the population distribution in Lamongan Regency by year and sub-district.
4. *Mapping the distribution of endemic disease*: This website will display a map of the distribution of endemic diseases in Lamongan Regency along with the number of infections and deaths in each sub-district.
5. *Visualization of disease trends in each year*: This website will display the trend of endemic diseases in Lamongan Regency for each year.
6. *Data filtering*: This system allows data filtering based on year, sub-district, and type of endemic disease.
7. *Download data*: On this website, users can download disease case data based on year, sub-district, and disease type.

Using Metabase, these data will be visualized and analyzed effectively to identify high-risk areas for specific endemic diseases. The results of this spatial-temporal mapping will provide valuable information for local governments, health organizations, and communities in their efforts to prevent and control endemic diseases in Lamongan Regency.

C. Visualization Result

The system successfully visualizes the spatial distribution of endemic diseases in Lamongan Regency. Figure 4 shows the distribution of Dengue Hemorrhagic Fever cases in all sub-districts in 2022.

FIGURE 2. Mapping of Dengue Hemorrhagic Fever in 2022

Figure 3 presents a trend visualization and Figure 4 presents a comparison map visualization in 2021 and 2022 for tuberculosis cases, demonstrating the system's capability for temporal analysis.

FIGURE 3. Trend of Tuberculosis Cases

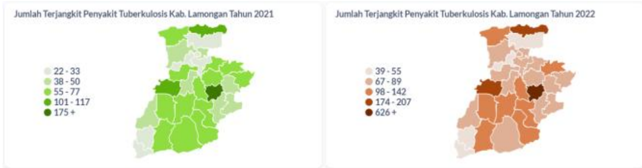

FIGURE 4. Comparison of Tuberculosis Cases in 2021 and 2022

The temporal comparison presented in Figure 4 demonstrates a significant escalation in Tuberculosis cases across Lamongan sub-districts from 2021 to 2022. Spatially, the majority of areas shifted from the lower-to-mid range of 22–77 cases (2021) to the higher category of 98–207 cases (2022), signaling a critical public health issue. This substantial increase suggests the interplay of several potential factors that require further scrutiny, including changes in diagnostic capacity and reporting consistency following the pandemic era, variations in local health service outreach and accessibility, and evolving socioeconomic or environmental determinants that facilitate disease transmission and clustering.

D. Performance Evaluation

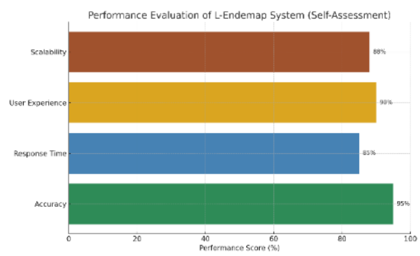

Figure 5. L - Endemap system performance evaluation chart

The performance of the L-Endemap system was evaluated through personal testing by the author. The evaluation focused on four key criteria: accuracy, response time, user experience, and scalability. Each criterion was assessed based on direct observation during realistic usage scenarios. The results of this evaluation are presented in Table X.

Table 1. L - Endemap System Performance Evaluation Table

No	Criteria	Basis for Observation	Score (%)
1	Accuracy	Visualization results are manually compared with the original data in the database. There is no difference.	95%
2	Response Time	Time Average time when opening a visualization < 5 seconds; complex queries 6-7 seconds.	85%
3	User Experience	Easy navigation, clean interface, interactive maps are easy to understand even by novice users.	90%

4	Scalability	The system was tested by adding disease and year data, performance remained stable without errors.	88%

These results confirm that the L-Endemap system performs reliably and efficiently in supporting spatial-temporal disease mapping. While we acknowledge the scientific value of incorporating advanced inferential methods such as Hotspot Analysis or Moran's I, the primary scope of this study was focused on validating the system's operational readiness and utility for rapid, descriptive monitoring and reporting by public health officials. The validation criteria were thus intentionally prioritized on metrics critical for practical deployment: Data Accuracy, Response Time, and User Experience. The high performance scores achieved in these aspects (95% Accuracy, 85% Response Time, and 90% UX) collectively indicate the system's stability and reliability as a foundational tool for immediate practical use. Future work will focus on integrating a dedicated module to facilitate the inferential statistical analysis requested, but this initial evaluation strongly supports its deployment for real-time epidemiological visualization.

IV. CONCLUSION

The spatial mapping system of endemic diseases in Lamongan Regency using Openmap technology successfully addresses the need for effective visualization of disease distribution patterns. By leveraging the Laravel framework and Metabase visualization capabilities, the system provides users with an interactive platform to monitor and analyze endemic disease trends across sub-districts and over time in Lamongan Regency.

The implementation results demonstrate that spatial visualization significantly enhances the interpretation of disease data compared to traditional tabular formats. The system has proven effective in identifying disease clusters, tracking temporal changes, and supporting evidence-based decision making for health interventions.

Future work will focus on enhancing the system's analytical capabilities through predictive modeling, real-time data integration, and expanded geographical coverage. These improvements will further strengthen the role of spatial mapping as an essential tool in endemic disease surveillance and control efforts in Lamongan Regency and potentially serve as a model for other regions facing similar challenges.

The system is able to display data on endemic diseases based on year, sub-district and type of disease in the form of a map of the Lamongan Regency area. Visualization is supported by the Natural Breaks classification method which automatically groups disease prevalence levels into different color categories.

Although the system developed has shown good results and can function according to the stated objectives, there are still several aspects that can be developed further to improve the quality and functionality of the system. This continued development is important to ensure that the system can continue to provide optimal benefits and can adapt to developing needs in the future. Based on the results of the evaluation and analysis that have been carried out, the following are several recommendations for future system development

Research Data Coverage: Research data can be developed more widely and widely, such as immunization coverage, distribution of health facilities, etc. Data Enrichment and Diversification: It is recommended to add disease and population data from previous years as well as more detailed reporting down to the village level to increase the accuracy of spatial analysis. Expansion of Visualization and Analysis Features: Added graphic or other visualization features to Metabase, which can provide deeper insight into disease distribution patterns. Implementation of an Early Warning System: The system can be developed with an early warning feature which provides automatic notification when there is a significant spike in cases in an area for a faster response. Application of Predictive Analysis: The system can be developed by adding predictive analysis features based on historical data, such as forecasting trends in the spread of disease using statistical or machine learning methods. This feature will help related parties in planning early preventive measures based on data.

The successful implementation of this system represents a significant step forward in leveraging digital technology for public health management in Indonesia, particularly at the regency level where resources for advanced health informatics may be limited. By making complex spatial data accessible and interpretable, the system empowers local health authorities to respond more effectively to endemic disease challenges and ultimately improve health outcomes for the population.

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