

## IMPLEMENTATION OF AGGLOMERATIVE CLUSTERING METHOD ON MAPPING CRIME-PRONE AREAS OF WEBGIS-BASED LHOKSEUMAWE CITY CASE STUDY OF LHOKSEUMAWE PROSECUTOR'S OFFICE

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### Abstract

The application of the Agglomerative Hierarchical Clustering method was carried out for mapping the Lhokseumawe City area, with a focus on sub-districts grouped by village and their crime rates. The types of crimes analyzed include drugs, oharda (violations of public order and security), and kamtibmas (public order and security). The data used came from the Prosecutor's Office and was taken through the Department of Law, covering various crimes that are very detrimental to society. By utilizing Geographic Information System (GIS) technology, this system can provide clear visual information about the location of criminal incidents and the types of crimes that occur in each village. This clustering process allows for the grouping of villages that tend to have high crime rates, thus helping to identify areas that require more attention in law enforcement. The application of this clustering is not new, because previously many researchers and scientists have applied similar methods, but with different case studies. In this context, clustering helps provide more detailed insights into the distribution of crime at the village level, allowing for more focused and targeted prevention efforts.

**Keywords:** GIS, AHC, cluster, prosecutor's office, crime

### Introduction

Public safety and security are important aspects of daily life in every city. In big cities, including Lhokseumawe, crime rates can vary significantly in different areas. An in-depth understanding of the distribution and patterns of crime in an area can help in crime prevention and countermeasure efforts. Therefore, it is important to have a system that is able to map and analyze criminal data efficiently[1]. Therefore, it is important to have a system that is able to map and analyze criminal data efficiently. Crime is one of the major problems that is always faced and difficult to avoid in various countries, both developed and developing countries. Indonesia is one of the developing countries with a moderate crime rate compared to South America, Iraq and Columbia which occupy the top 3 positions of countries with high crime rates in the world. Although Indonesia's crime rate is in a moderate position in the world, it cannot be denied that crime is one of the major problems facing Indonesia [2].

Lhokseumawe City, as one of the centers of economic and social activity in Aceh Province, faces serious challenges related to crime[3]. The increase in crime rates in various areas of the city requires special attention from various parties, especially in prevention and mitigation efforts. One approach that can be used to analyze and map crime-prone areas is the agglomerative clustering method. This method allows data grouping based on similar characteristics, so that areas with high crime-prone levels can be identified.

Mapping crime-prone areas is not only important for law enforcement purposes, but also for more effective urban planning and public policy development. By utilizing WebGIS (Web Geographic Information System) technology, crime data analysis can be presented interactively and easily accessed by various parties, including law enforcement agencies, local governments, and the public. WebGIS provides visualization capabilities that make it easier for stakeholders to understand the distribution and patterns of crime spatially[4]. The Lhokseumawe District Attorney's Office as a law

enforcement agency has a vital role in collecting and analyzing crime data. By applying the agglomerative clustering method, the processed criminal case data can provide a clearer picture of crime-prone areas in this city. The results of this analysis are expected to be the basis for efforts to prevent and handle crime, as well as increase public awareness of the importance of security in their environment.

Through this research, it is expected to provide significant contributions in the development of geographic-based information systems that can be implemented by the Lhokseumawe District Attorney's Office[5]. In addition, this study also aims to provide recommendations for more targeted decision-making in handling criminal problems in the city of Lhokseumawe. Thus, this study is not only relevant to the academic field, but also to real practice in improving public security and order.

WebGIS, on the other hand, provides an interactive and accessible platform for geographic data visualization. By integrating the Agglomerative Hierarchical Clustering (AHC) method into the WebGIS system, the analysis results can be presented in the form of informative maps, allowing users to see the spatial distribution of crimes. This approach not only improves the understanding of crime patterns but also accelerates the data-driven decision-making process[6].

Therefore, this study aims to apply the Agglomerative clustering method in mapping criminal areas in the city of Lhokseumawe using the WebGIS platform. Thus, it is expected to obtain a more accurate and dynamic mapping of the distribution of crime, as well as provide a stronger basis for data-based crime prevention and control strategies[7]. This study is also expected to contribute to the development of information technology and geographic information systems in the context of public security in Indonesian cities and also as an application of an appeal for crime-prone areas in the city of Lhokseumawe so that the crime rate in the city of Lhokseumawe decreases.

## **Literature Review**

The Prosecutor's Office according to Law No. 16 of 2004 concerning the Prosecutor's Office of the Republic of Indonesia in Article 2 provides the understanding that the Prosecutor's Office is a government institution that exercises state power in the field of prosecution and other authorities based on law [8]. This power is exercised independently and cannot be separated. The Prosecutor's Office's power is exercised by the Attorney General's Office, the High Prosecutor's Office, the District Prosecutor's Office and in resolving a criminal case must pay attention to religious norms, humanity, decency and morality (Article 3 of Law Number 16 of 2004).

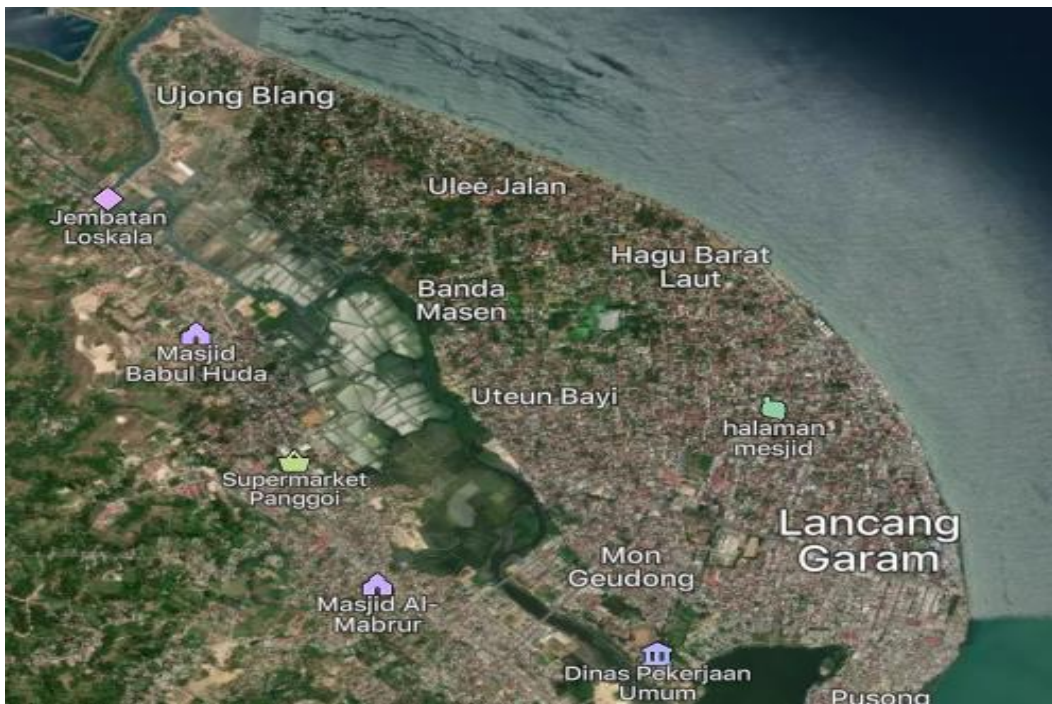
The role of the Prosecutor's Office as the only prosecution institution was officially first functioned by the Government Law during the Japanese occupation No. 1/1942, which was later replaced by Osamu Seirei No/1942, No/1944 and No/1944. The existence of the prosecutor's office is at all levels of the court, namely from the supreme court, high court and district court. Once Indonesia became independent, such functions were maintained in the Republic of Indonesia. This was emphasized in Article II of the Transitional Provisions of the 1945 Constitution, which was clarified by Government Regulation (PP) Number 2 of 1945. Its contents mandate that before the Republic of Indonesia forms its own state bodies and regulations in accordance with the provisions of the Constitution, all existing bodies and regulations are still directly applicable.

This development also includes fundamental changes to the organizational structure and procedures of the Prosecutor's Office based on Presidential Decree No. 55 of 1991 dated November 20, 1991. Initially, the Lhokseumawe District Attorney's Office and the Lhokseumawe District Court were under a Department, namely the Department of Justice, because the duties of the Prosecutor at that time were to investigate and prosecute cases, while the Judge sentenced or decided a case. Special Crimes Head of Special Crimes Section Has the following duties: Preparation of plans, implementation and control of investigation activities, For the smooth running of office activities, the role of a leader as a top manager is very much needed because a leader plays a role in assisting and fostering the implementation of his subordinates' duties. To facilitate the implementation of work tasks in the office, a leader is assisted by employees who work in various sections according to their respective fields. In carrying out these duties, an employee is responsible to his superiors. Conducting pre-prosecution, examination, additional, prosecution, implementation of judges and court decisions, supervision of the implementation of conditional release decisions and other legal actions in general criminal cases based on laws and regulations and policies by the Attorney General.

Overview of the Lhokseumawe District Attorney's Office A brief history The term Prosecutor's Office has actually existed for a long time in Indonesia. During the Hindu-Javanese kingdom in East Java, namely during the Majapahit Kingdom, the terms dhyaksa, adhyaksa, and dharmadhyaksa already referred to certain positions and positions in the kingdom. These terms come from ancient languages, namely from the same words in Sanskrit. A Dutch researcher, W. Stutterheim said that dhyaksa were state officials during the Majapahit Kingdom, precisely when Prabu Hayam Wuruk was in power (1350-1389 AD) [10]. dhyaksa are judges who are tasked with handling judicial matters in court hearings. These dhyaksa are led by an adhyaksa, namely the highest judge who leads and supervises the dhyaksa. This conclusion is supported by another researcher, namely H Juynboll, who said that adhyaksa are supervisors (opzichter) or highest judges (openrechter). Krom and Van Vollenhoven, also a Dutch researcher, even mentioned that the famous prime minister of Majapahit, Gajah Mada, was also an adhyaksa. During the Dutch occupation, the bodies that were relevant to the prosecutor and the Prosecutor's Office included the Openbaar Ministerie. This institution ordered its employees to act as Magistraat and Officier van Justitue in the District Court, the Court of Justice and the Supreme Court under the direct orders of the Resident / Assistant Resident. However, in practice, this function tended to be more of an extension of the Dutch.

Therefore, the new Attorney General's Law is considered stronger in determining the position and role of the Indonesian Attorney General's Office as a government state that exercises state power in the field of prosecution. Since 1962, the Lhokseumawe District Attorney's Office until now has been known by several previous leaders. The Lhokseumawe District Attorney's Office is now led by Mr. ROYANI, SH. Thus, the Lhokseumawe District Attorney's Office is expected to be able to prosecute the defendant's case as fairly as possible.

Crime is any kind of crime or act that is economically and psychologically detrimental that violates the laws in force in the country as well as social and religious norms. It can be said that criminal acts are acts that violate the law and are not liked by society or society opposes them [11].



**Figure 1.** The Lhokseumawe map is taken from satellite

Geographic Information System is a system that provides geographic information starting from information about places on the earth's surface, knowledge about information and various attributes on the earth's surface but with a known position and the location of an object on the earth's surface. The characteristics of GIS are as follows GIS has a data input subsystem that accommodates and can process spatial data from various sources [12]. This subsystem also contains a process of transforming different types of spatial data, for example from contour maps to elevation points. GIS has a data storage and retrieval subsystem that allows spatial data to be called, edited, and updated. GIS has a data manipulation and analysis subsystem that presents data roles, grouping and separation, parameter and constraint estimation, and modeling functions. GIS has a reporting subsystem that presents all or part of the database in the form of tables, graphics and maps.

## Materials & Methods

Agglomerative Hierarchical Clustering (AHC) is a hierarchical clustering method that starts from the lowest level (individual data points) and gradually combines the data into larger groups until all the data is combined into one cluster or until a certain stopping condition is reached. This method is a bottom-up approach in clustering, in contrast to divisive clustering which starts from one large cluster and then breaks it down [13].

One of the important components in agglomerative hierarchical clustering is the linkage method, which determines how the distance between two clusters is calculated after merging. Here are some popular linkage methods: Single Linkage Measures the distance between two clusters as the distance between the two closest points in both clusters. This method tends to form long, slender clusters, because it always merges the closest points, which can cause a chaining effect. Complete Linkage Measures the distance between two clusters as the distance between the two furthest points in both clusters. This produces more compact and rounded clusters, but can ignore some weaker relationships between the data. Average Linkage Calculates the average distance between all pairs of points in both clusters. This method tries to balance the characteristics of single linkage and complete linkage, resulting in more stable clusters.

Data Mining is the process of exploring and analyzing large amounts of data to find patterns, trends, and hidden

information that is useful in decision making [14]. Data mining is often referred to as data mining, because just like mining precious metals from the earth, data mining extracts valuable information hidden in data. This process is very important in the field of data science and analytics because it helps transform raw data into meaningful knowledge.

Clustering in Python is the process of using the Python programming language and related libraries to group data based on the similarity or proximity of its characteristics. Clustering is one of the main techniques in unsupervised learning, where we try to find structures or patterns in data without any predefined labels or categories. In clustering, we try to divide a dataset into groups or clusters in such a way that data within the same cluster are more similar to each other than to data from different clusters [15]. Python has a robust ecosystem of libraries for clustering, including the scikit-learn, SciPy, and NumPy libraries, which allow users to easily apply various clustering algorithms to datasets.

## Results and Discussion

Stages of results and discussions to clarify the flow and steps of this research. The list of initial tables to be studied in this study uses the Agglomerative Hierarchical Clustering (AHC) method to analyze data, the data used is historical data on criminal perpetrators at the Lhokseumawe prosecutor's office, which was collected from 2020 to 2024. The following data table is presented and can be seen in the table below.

**Table 1.** Table of initial data collected

NO	Village Name	Latitude	Longitude	Narcotics	Oharda	Kamtibum
1	tempok tengah	5.190.414.849.833.370	9.713.715.256.114.680	10	1	3
2	simpang empat	5178276814361260,00	9714484231568300,00	4	0	6
3	lhokseumawe	51966671772171600,00	9713535261968410,00	0	1	0
4	pusong baru	5173473651068750,00	9714995484317460,00	4	0	1
5	.....	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	.....	.....
66	Padang sakti	5194926696771880,00	970740907520382,00	1	0	0
67	Paloh Punti	5177301090114570,00	9708996778024560,00	0	0	0
68	Ujong Pacu	5201977629049500,00	9703648850811540,00	1	0	0

It can be seen in the table above explaining the data table collected as many as 68 rows consisting of village names, coordinates of the village latitude and longitude, the types of crimes collected are Narcotics, Oharda and Kamtibum. This data is historical data taken in the Lhokseumawe area of North Aceh Regency, which has 4 sub-districts and a total of 68 villages, as for the crimes in the narcotics category such as crystal methamphetamine, drug use, marijuana which are prohibited in Indonesia. The category of Oharda is an abbreviation of People and Property, crimes committed by individuals and finally from Kamtibum is a violation of public order such as illegal trade, disturbing public peace and many others.

This data performs standard scaler for data processing for feature standardization, which is one of the features often used in data preprocessing. This technique is important and is always used in general because of the use of algorithms that are sensitive to scale or distance between features such as the application of the Support Vector Machine algorithm, Kmean and many others. This standard scaler has a library from scikit learn which functions to change data in such a way that each feature has an average range of 0 and a standard deviation of 1[16]. The data that uses the standard scaler can be seen in the image below.

0	1	2
3.7957	2.1676	2.1327
1.1753	-0.3737	4.835
-0.5716	2.1676	-0.5696
1.1753	-0.3737	0.3312
1.1753	-0.3737	-0.5696
-0.1349	-0.3737	-0.5696
-0.1349	-0.3737	-0.5696
0.3019	-0.3737	0.3312
-0.5716	-0.3737	-0.5696
-0.1349	-0.3737	1.2319

Figure 2. standard scaler data results

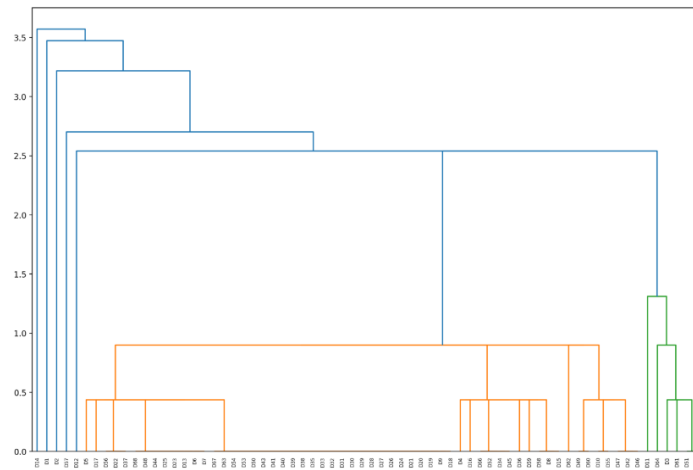
Judging from the screenshot of the program, the crimes with an index of 0 to 2 are narcotics, oharda and kantibun. For the next stage is the result of the standard process of the agglomerative hierarchy application scaler this stage has similar data because this stage is also the result of clustering this table displays several villages as samples that the program is running and each village has several variables Latitude, Longitude, narcotics, oharda, kantibun and the final result is a cluster column that shows which group the village is included in. You can see in the table below.

Desa	Latitude	Longitude	Narkotika	Oharda	Kantibun	Cluster
0 Tempok Tengah	5.1904	97.1372	10	1	3	2
1 Simpang Empat	5.1795	97.1432	4	0	6	0
2 Kota Lhokseumawe	5.2001	97.1318	0	1	0	0
3 Pusong Baru	5.1735	97.1504	4	0	1	0
4 Kampung Jawa Baru	5.1859	97.1441	4	0	0	0
5 Banda Masen	5.2010	97.1217	1	0	0	0
6 Hagu Barat Laut	5.2013	97.1356	1	0	0	0
7 Hagu Selatan	5.1903	97.1488	2	0	1	0
8 Hagu Teungoh	5.1946	97.1425	0	0	0	0
9 Kampung Jawa Lama	5.1857	97.1487	1	0	2	0
10 Keude Aceh	5.1754	97.1435	5	1	0	0
11 Kuta Blang	5.1840	97.1361	2	2	0	0
12 Lancang Garam	5.1820	97.1469	1	0	0	0
13 Mon Geudong	5.1780	97.1366	14	0	1	1
14 Pusong Lama	5.1706	97.1483	2	0	1	0
15 Ujong Blang	5.2079	97.1182	5	0	1	0
16 Ulee Jalan	5.2022	97.1310	3	0	0	0
17 Uteun Bayi	5.1891	97.1314	0	0	0	0
18 Alue Lim	5.1191	97.1184	0	0	0	0
19 Asan Kareung	5.0945	97.1609	0	0	0	0

Figure 3. Clustering Results Image Table

The figure above shows that by using Agglomerative Clustering, data from these villages can be grouped based on similar patterns in terms of geographic coordinates and variables related to narcotics cases, oharda, and kamtibum. This grouping can help in understanding which villages need more attention in terms of security and public order or narcotics cases.

The next step of this application is generally experts use the relationship diagram of the distance between villages in salt called the dendogram diagram, one of which presents the results of agglomerative showing the merging of clusters and the level of similarity between data. At the bottom of the dendogram, each data point object is represented as a single node, each branch that merges shows the merging of two clusters, the vertical axis shows the dissimilarity distance between the merged clusters. The results of the dendogram diagram can be seen below.



**Figure 4.** Dendrogram Diagram Agglomerative Hirarki Cluster

The horizontal axis at the bottom contains the labels or data points that are clustered. Each label represents a single data point (e.g., a village or entity in the clustered dataset). The vertical axis shows the distance or dissimilarity between the clusters. The higher the merging line, the greater the dissimilarity or distance between the clusters. A horizontal line connecting the data points or clusters indicates the merging of two clusters. The lower the merging line, the more similar (closer) the data points are. When two larger clusters are merged, the merging line appears at a higher level on the vertical axis, indicating that the clusters are less similar than the clusters that formed earlier. Clusters and Colors Dendrograms use color to highlight different cluster groups. In this figure, there are three main colors that make up the clusters. Blue is the largest cluster that forms at the top level. Orange is the middle cluster that forms below the blue cluster. Green is the smaller cluster that forms on the right side of the dendrogram. This grouping occurs because the data within it is more similar to each other than to the data outside of that cluster. Whenever there is a merge (marked by a horizontal line), it indicates that two clusters or data points have been merged into a new cluster. Merging at a higher level indicates that the clusters are more distinct or have more differences. We can “cut” the dendrogram at a certain level (for example, around the vertical line at 2.0 on the vertical axis) to determine the desired number of clusters. Cutting the dendrogram at this point can produce three main clusters, as indicated by the three different colors. More effective clustering occurs when data points are merged at a lower level (shorter merge line). This indicates that the data points have more similarity. Conversely, merging at a higher level (for example, around 3.0 or higher) indicates that the merged clusters are more distinct from each other.

The last step is to display the clusterization results using a geographic information system where there are colors that distinguish each clusterization carried out on the Lhokseumawe map. The GIS is displayed as follows.

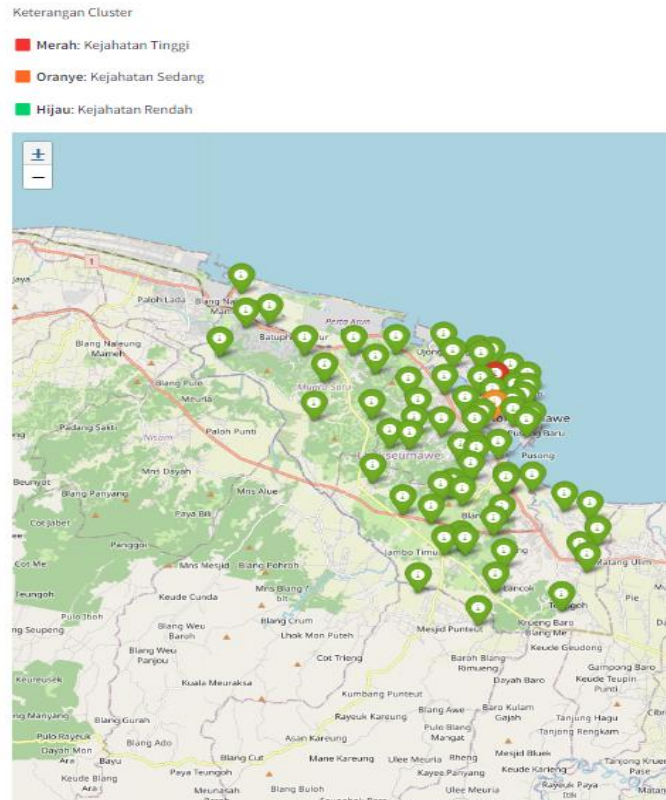


Figure 5. Results of GIS information system with Agglomerative Hierarchy

The map uses color to represent varying levels of crime in different locations within an area. Here is an explanation of the key elements in the image Red High Crime Indicates areas with high crime rates. Orange Medium Crime Indicates areas with ongoing crime rates. Green Low Crime Indicates areas with low crime rates. Map View The map shows the North Aceh district area representing the location of the village where crime data has been collected. Each marker is color-coded according to the level of crime in that particular area. Green markers dominate the map, indicating that most areas have low crime rates. There are a few orange markers indicating moderate crime rates. There is at least one red marker representing an area of high crime activity.



Figure 6. Result Cluster High Criminal

The Geographic Region appears to cover coastal areas, with a concentration of data points around what appears to be a central city or town. The names of villages and towns surrounding Lhokseumawe suggest that the area could be part of Aceh, Indonesia. Low crime zones Green The majority of areas on the map appear to have low crime rates, as suggested by the large number of green markers. Medium and high crime zones Orange Small concentrations of crime hotspots are clustered around certain areas, indicating that authorities may need to focus more on crime prevention or intervention in these areas. Potential Use Cases This map can be used by local governments, law enforcement, or city planners to allocate resources more effectively. It also serves as a visual aid to understand the geographic distribution of crime and help identify high-risk areas for targeted intervention. The map uses color to represent varying levels of crime at different locations within a region. Here is an explanation of the key elements in the image Red High Crime Indicates areas with high crime rates. Orange Medium Crime Indicates areas with moderate crime rates.



Figure 7. Result Medium criminals

Green Low Crime Indicates areas with low crime rates. Map View The map shows the area of North Aceh Regency representing the location of villages where crime data has been collected. Each marker is color-coded according to the level of crime in that particular area Green markers dominate the map, indicating that most areas have low crime rates. There are a few orange markers indicating moderate crime rates. There is at least one red marker representing an area of high crime activity. The Geographic Area appears to cover the coastal area, with a concentration of data points around what appears to be a central city or town.

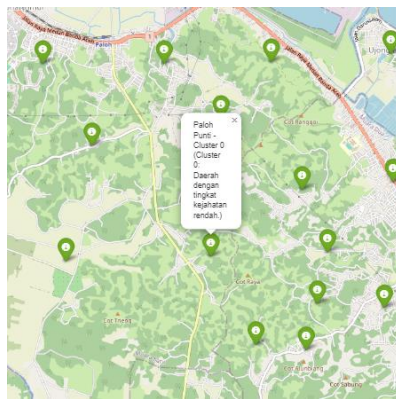


Figure 8. Result Clusters low

The names of the villages and towns surrounding Lhokseumawe suggest that the area could be part of Aceh, Indonesia. Green Low Crime Zone The majority of the area on the map appears to have low crime rates, as suggested by the large number of green markers. Medium and high crime zones Orange Small concentrations of moderate crime hotspots are clustered around certain areas, indicating that authorities may need to focus more on crime prevention or intervention in these areas. Potential Use Cases This map can be used by local governments, law enforcement, or city planners to allocate resources more effectively. It also serves as a visual aid to understand the geographic distribution of crime and help identify high-risk areas for targeted intervention.

### Equations

As we know that village data and criminal data are not directly processed just like that but there is a step by step processing process that is carried out using calculations and placing data mathematically to be sure of its value and determination. The formulas that will be written are as follows.

Standar Scaller

$$z = \frac{x - u}{\sigma} \tag{1}$$

Description

- x is the original value of each feature
- u is the average value of each feature
- σ is the standard deviation of the feature

application of Agglomerative Hierarchical Clustering with Euclidean metrics and single linkage.

Metric euclidian

$$d(x, y) = \sqrt{\sum_{i=1}^n (x_i - u_i)^2} \tag{2}$$



Description:

X and y are two data points in n-dimensional space

$x_i$  and  $y_i$  are the values of the i-th feature for each point x and y

$d(x,y)$  is the Euclidean distance between points x and y.

Euclidean distance calculates the straight distance between two points in Euclidean space. The smaller this distance, the more similar the two points are. In clustering, this distance is used to measure the similarity between two data points or two clusters.

after calculating the distance between data points with a metric such as euclidean, we need to decide how to combine the clusters. Single linkage merges two clusters based on the shortest distance between the points in the two clusters.

$$\mathcal{D}(A, B) = \min\{d(x_i, y_i) \mid x_i \in A, y_i \in B\} \quad (3)$$

Description

A and B is two cluster

$x_i$  is a data point in A cluster

$y_i$  is a data point in cluster B

$\mathcal{D}(A, B)$  a and b, and it is defined as the minimum distance between any pair of points from those two clusters.

## Conclusions

In the conclusion of this paper by using agglomerative hierarchical cluster that has been obtained the conclusion of the results given from each step where this study utilizes the map of North Aceh district with data generated at the beginning of the cluster there are marker icons that display data that is clustered icon with green color is an area that is not prone to crime and the orange icon is a crime area with a moderate level and while the red one is a high crime rate. This algorithm shows very good results but there is an application of the linkage method that is not implemented so it is lacking, because the data for each mapped village variable is zero and there is data that is similar to other data, with this there is a more capable algorithm for the future.

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