The 2nd International Conference on Multidisciplinary Engineering (2nd ICOMDEN 2024)

The 2nd International Conference on Multidisciplinary Engineering: 00074 (2024) https://doi.org/10.29103/icomden.v2.xxxx
Volume 2, 2024
eISSN: xxxx-xxxx
Research Original Article

Identification Of Environmental Security In Relation To The Crime Case Rate In Simeulue Regency Using Density Based Spatial Clustering Method With Noise (DBSCAN)

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Abstract: Criminal offenses are acts that violate criminal law and are punishable by the state, either through imprisonment, fines, or other sanctions. These offenses cause significant distress and harm to the general public, individuals, and the state. In Simeulue Regency, the number of criminal cases has been increasing annually, driven by social, economic, environmental, cultural, legal, technological, and psychological factors. This study aims to analyze the relationship between environmental security and the level of criminal cases in Simeulue Regency using the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm. The data used includes criminal cases from 2019 to 2023 across 10 districts, along with environmental information such as population density, public facilities, and socioeconomic indicators. The research methodology involves data collection and cleaning, Euclidean distance calculation, parameter selection for DBSCAN, and the application of validation formulas to determine the vulnerability to criminal offenses in Simeulue Regency. The analysis results, using an epsilon parameter of 5 and MinPts of 3, yielded clusters 0, -1, and 1. Cluster 0 includes Salang and Teluk Dalam districts; cluster -1 includes Alafan, Simeulue Tengah, Simeulue Timur, Simeulue Barat, Teupah Barat, and Teupah Selatan districts; and cluster 1 includes Simeulue Cut and Teupah Tengah districts. The validation formula indicates that the highly vulnerable area is in Simeulue Timur district, while the at-risk areas are Teupah Tengah, Teluk Dalam, and Teupah Barat districts. The areas classified as not at risk are Alafan, Salang, Simeulue Tengah, Simeulue Cut, Simeulue Barat, and Teupah Selatan districts. This study provides insights into areas that require increased attention in efforts to address and prevent criminal offenses.
Keywords: environmental security, criminal offenses, DBSCAN, clustering, Simeulue Regency

I. Introduction

Environmental security is one of the key indicators in assessing the well-being of a region. Communities that feel safe from the threat of criminal offenses tend to have a better quality of life and a high level of trust in the government and law enforcement agencies. However, high crime rates can undermine social stability, generate public distrust, and lead to economic and psychological losses

Simeulue Regency, which is one of the island regions in Aceh Province, is not exempt from issues related to criminal offenses. Although this area is relatively remote, reports of criminal cases such as theft, assault, and violence have increased in recent years. The dispersed geographical condition, limited infrastructure, and disparities in welfare levels among regions in Simeulue contribute to the social dynamics and criminality in the area. Therefore, identifying crime-prone areas is crucial to prevent the occurrence of more serious offenses in the future.

One method that can be used to identify patterns and trends in criminal cases is the Density- Based

Spatial Clustering of Applications with Noise (DBSCAN). Clustering using the DBSCAN method groups observations based on density, where areas with high data density form clusters, while areas with low density are detected as noise data (Yanto, Homaidi, & Lutfi, 2024). This method

has the advantage of clustering spatial data based on density and can identify outliers or data considered noise. By using DBSCAN, it is possible to map regions with high crime rates in Simeulue Regency. This is expected to assist authorities in formulating preventive policies and enhancing environmental security.

This study aims to analyze the spatial distribution of criminal cases in Simeulue Regency using DBSCAN and to identify crime-prone areas. Thus, the results of this research are expected to provide a clearer picture of the security conditions in Simeulue, as well as more effective policy recommendations for maintaining public safety and order.

II. Literature Review

2.1. Environmental Security

Environmental security refers to the condition in which communities feel protected from physical and psychological threats in their surroundings. Environmental security is fostered by various factors, such as strong social ties, economic stability, and high employment opportunities. A well-maintained and secure environment tends to reduce crime rates, as offenders perceive a
strong presence of social control**.** (Siahan, Chairani, & Pradana, 2024)

2.2. Criminal Offenses

Criminal offenses are acts prohibited by legal regulations, with such prohibitions accompanied by threats (sanctions) of specific penalties for anyone who violates them. To impose penalties on offenders, it is necessary to establish which acts fall into the category of criminal offenses, in accordance with the principle of legality: No act may be punished except by virtue of a penal law that was in effect prior to the commission of the act (Candra, 2013).

2.3. Clustering

The definition of clustering, or cluster analysis, is the process of dividing (or partitioning) a set of data objects (or observations) into several subsets. Each subset is referred to as a cluster, such that the objects within a cluster are similar to one another, but not similar to objects in other clusters (Nanda, Nugraha, & Firdaus, 2019). The main objective of clustering is to ensure that data within a group has a high degree of similarity, while data between groups exhibits significant differences. One clustering algorithm is the Density-Based Spatial Clustering of Applications with Noise (DBSCAN), a density-based algorithm that clusters data based on local density. This algorithm is useful for detecting clusters with irregular shapes and for handling outlier data (Safitri, Wulandari, & Rahmawati, 2019).

2.4. DBSCAN

The Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is an algorithm that belongs to the category of density-based clustering, which involves the process of forming clusters based on the proximity or density of distances between objects in a dataset. DBSCAN has advantages in clustering processes, as it groups data based on density, making it effective for handling large datasets. In DBSCAN, data density is characterized by three types of statuses: core, border, and noise (Kristianto, 2022). This algorithm works by identifying areas with high density as clusters, while isolated points or those in low-density areas are considered noise or outliers (Zilrahmi, Amalita, & Mukhti, 2024).

There are two main parameters in DBSCAN:

- **Epsilon (ε)**: The maximum distance between two points for them to be considered part of the same cluster.
- **MinPts**: The minimum number of points required to form a cluster.

The primary advantage of DBSCAN is its ability to find clusters of arbitrary shapes and handle noise without needing to specify the number of clusters in advance, unlike the K-Means algorithm.

2.5. Geographic Information System (SIG)

In general, a Geographic Information System (GIS) is a component that consists of hardware, software, human resources, and data that work together effectively to input, store, retrieve, update, manage, manipulate, integrate, analyze, and display data in a geographic information context. GIS processes the quantitative location of important features, along with the properties and attributes associated with those features, to analyze spatial relationships and interactions. This process involves hardware, software, data, people, and organizations within an integrated system (Ilmawan & Mawarni, 2024).

III. Materials & Methods

3.1. Type of Research

This study is a descriptive research with a quantitative approach aimed at analyzing the relationship between environmental security and the level of criminal cases using the DBSCAN algorithm.

3.2. Materials

The materials used in this study include secondary data consisting of criminal cases obtained directly from the Simeulue Police Department. The data includes the location and time of incidents from 2019 to 2020, as well as data on neighborhood security posts (siskamling) in Simeulue Regency

Table 1. Data on Criminal Cases in Simeulue Regency from 2019 to 2023

Subdistrict	2019	2020	2021	2022	2023
Alafan	11	5	7	9	10
Salang	9	8	8	6	5
Simeulue Barat	10	9	8	15	16
Simeulue Cut	3	3	5	4	9
Simeulue Tengah	6	7	10	7	9
Simeulue Timur	15	19	21	20	25
Teluk Dalam	10	8	7	5	9
Teupah Barat	11	12	20	17	23
Teupah Selatan	8	10	9	10	14
Teupah Tengah	3	4	5	6	7

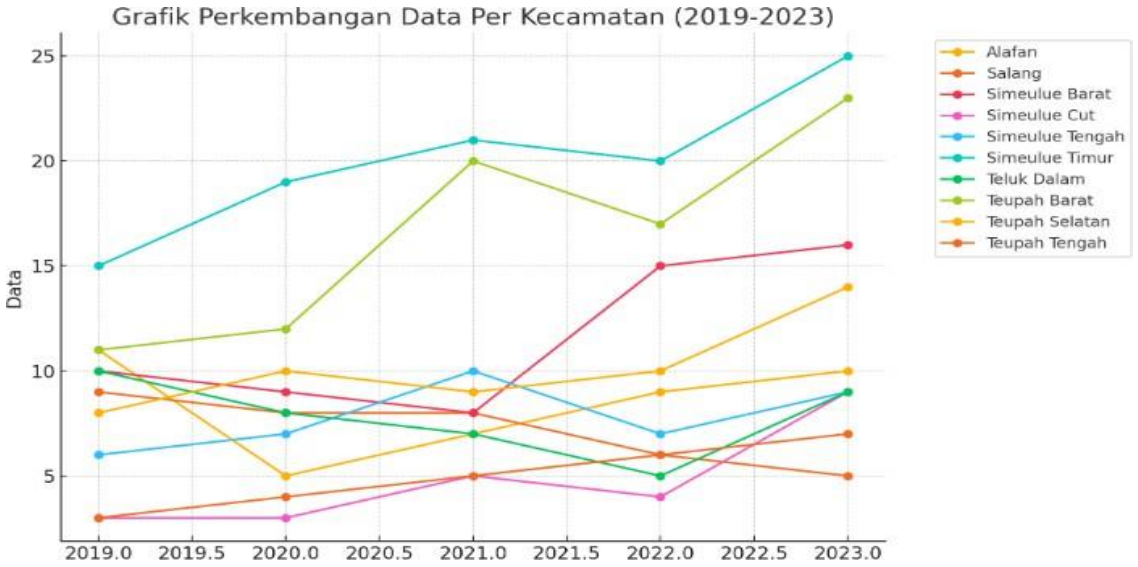

Figure 1. Visualization in Graph

From the graph above, it can be observed that each district shows different trends. Some

districts have experienced a decline in data over the five years, while others have shown significant increases. This helps to identify which districts are experiencing growth, decline, or stability in their data. By using this graph, decision-makers or relevant stakeholders can design more targeted policies or interventions in line with the emerging patterns in each region.

Table 2. Data on Security Posts in Simeulue Regency

Nama Pos Satkamling	Rt/Rw	Desa/Kelurahan	Polsek	Ket
Pos Kamling Air Dingin	02/03	Dusun Ita Megitia, Desa Air Dingin Kecamatan Simeulue Timur	Polsek Simeulue Timur	Aktif
Pos Kamling Desa Simpang Abail	01/02	Dusun Bunga Indah,Desa Air Dingin Kecamatan Simeulue Timur	Polsek Simeulue Timur	Aktif
Pos Kamling Desa Kahad	01/02	Dusun Amaselatu Desa Kahad Kecamatan Simeulue Timur	Polsek Simeulue Timur	Tidak Aktif
Poskamling Desa Kota Batu	01/02	Dusun Air Terjung, Desa Kota Batu Kecamatan Simeulue Timur	Polsek Simeulue Timur	Tidak Aktif
Pos Kamling Desa Nancawa	01/02	Dusun, Nancawa Desa Nancawa Kecamatan Simeulue Timur	Polsek Simeulue Timur	Tidak Aktif
Pos Kambling Desa Lanting	01/02	Dusun, Desa Lanting Kecamatan Simeulue Tim	Polsek Simeulue Timur	Tidak Aktif
Pos Kambling Desa Labuah	01/02	Dusun Kayu Arang Desa Labuah Kecamatan Simeulue Tim	Polsek Simeulue Timur	Aktif
Pos Kamling Desa Sefoyan	01/01	Dusun Batu Ampar,Desa Sefoyan Kecamatan Simeulue Timur	Polsek Simeulue Timur	Tidak Aktif
Pos Kamling Langi	01/01	Dusun Sejahtera,Desa Langi Kecamatan Alafan	Polsek Alafan	Tidak Aktif
Pos Kamling Lewak	01/01	Dusun Suka Bakti,Desa Lewak Kecamatan Alafan	Polsek Alafan	Tidak Aktif
Pos Kamling Lafakha	01/01	Dusun Muda Jaya,Desa Lafakha Kecamatan Alafan	Polsek Alafan	Tidak Aktif
Pos Kamling Lamerem	01/01	Dusun Binti,Desa Lamerem Kecamatan Alafan	Polsek Alafan	Tidak Aktif
Pos Kamling Lhok Pauh	01/01	Dusun Suka Indah,Desa Lhok Pauh Kecamatan Alafan	Polsek Alafan	Tidak Aktif
Pos Kamling Laayon	01/01	Desa Laayon Kecamatan Teupah Barat	Polsek Teupah Barat	Tidak Aktif
Pos Kamling Angkeo	01/01	Desa Angkeo Kecamatan Teupah Barat	Polsek Teupah Barat	Tidak Aktif
Pos Kamling Awe Kecil	01/01	Desa Awe Kecil Kecamatan Teupah Barat	Polsek Teupah Barat	Tidak Aktif
Pos Kamling Lantik	01/01	Desa Lantik Kecamatan Teupah Barat	Polsek Teupah Barat	Tidak Aktif
Pos Kamling Leubang	01/01	Desa Leubang Kecamatan Teupah Barat	Polsek Teupah Barat	Tidak Aktif
Pos Kamling Bunon	01/01	Desa Bunon Kecamatan Teupah Barat	Polsek Teupah Barat	Aktif
Pos Kamling Pulau Teupah	01/01	Desa Pulau Teupah Kecamatan Teupah Barat	Polsek Teupah Barat	Tidak Aktif
Pos Kamling Kuala Baru	01/01	Desa Kuala Baru Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif
Pos Kamling Bulu Hadek	01/01	Desa Bulu Hadek Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif
Pos Kamling Ujung Salang	01/01	Desa Ujung Salang Kecamatan Salang	Polsek Salang	Tidak Aktif
Pos Kamling Along	01/01	Desa Along Kecamatan Salang	Polsek Salang	Tidak Aktif
Pos Kamling Panton Lawe	01/01	Desa Panton Lawe Kecamatan Salang	Polsek Salang	Tidak Aktif
Pos Kamling Meunafa	01/01	Desa Meunafa Kecamatan Salang	Polsek Salang	Tidak Aktif
Pos Kamling Padang Unoi	01/01	Desa Padang Unoi Kecamatan Salang	Polsek Salang	Tiak Aktif
Pos Kamling Karya Bakti	01/01	Desa Karya Bakti Kecamatan Salang	Polsek Salang	Aktif
Pos Kamling Tamon Jaya	01/01	Desa Tamon Jaya Kecamatan Salang	Polsek Salang	Tidak Aktif

Pos Kamling Mutiara	01/01	Desa Mutiara Kecamatan Salang	Polsek Salang	Tidak Aktif

Pos Kamling Jaya Baru	01/01	Desa Jaya Baru Kecamatan Salang	Polsek Salang	Aktif
Pos Kamling Lalla Bahagia	01/01	Desa Lalla Bahagia Kecamatan Salang	Polsek Salang	Aktif
Pos Kamling Kenangan Jaya	01/01	Desa Kenangan Jaya Kecamatan Salang	Polsek Salang	Tidak Aktif
Pos Kamling Suak Manang	01/01	Desa Suak Manang Kecamatan Salang	Polsek Salang	Aktif
Pos Kamling Nasreuhe	01/01	Desa Nasreuhe Kecamatan Salang	Polsek Salang	Aktif
Pos Kamling Bunga	01/01	Desa Bunga Kecamatan Salang	Polsek Salang	Aktif
Pos Kamling Lugu Selbahak	01/01	Desa Lugu Sekbahak Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif
Pos Kamling Sambay	01/01	Desa Sambay Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif
Pos Kamling Luan Balu	01/01	Desa Luan Balu Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif
Pos Kamling Gunung Putih	01/01	Desa Gunung Putih Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif
Pos Kamling Kuala Bakti	01/01	Desa Kuala Bakti Kecamatan Teluk Dalam	Polsek Teluk Dalam	Aktif

In the data on security posts above, there are 41 security posts; however, not all of them are active. There are 16 active security posts and 25 inactive ones. This situation also impacts the increasing number of criminal cases each year.

2.3. Data Preprocessing

Before analysis, the data obtained undergo several processing steps, which include:

- **Data Cleaning**: Removing duplicate entries and incomplete data.
- **Data Normalization**: Adjusting the scale of numeric variables to ensure consistency, so that no feature dominates the analysis.
- **Feature Extraction**: Selecting relevant features for analysis, such as crime locations and environmental factors.

2.4. Application of Density-Based Spatial Clustering of Applications with Noise (DBSCAN)

- **Parameter Selection**: The DBSCAN parameters used in this study are an epsilon (eps) value of 5 and a minimum point (MinPts) of 3. The epsilon value is determined based on the analysis of distances between points, while MinPts is set according to literature recommendations and preliminary experiments.
- **Distance Calculation**: The distance is calculated using the Euclidean formula:

From the previous data, the Euclidean distance is calculated using the formula:

$$\sqrt{(p_x - p_y)^2 + q_x - q_y^2 \cdots\cdots\cdots\cdots} \text{ n}$$

Thus, the results of the Euclidean distance calculations are as follows :

Table 3. Results of the Euclidean Distance Calculations

Kecamatan	alafan	salang	simeulue barat	simeulue cut	simeulue tengah	simeulue timur	teluk dalam	teupah barat	teupah selatan	teupah tengah
Alafan	0	6.92	9.48	9.89	6.55	27.45	5.19	21.23	7.41	9.32
Salang	6.92	0	14.28	9.486	5.56	30.36	4.35	24.67	10.14	8.06
Simeulue Barat	9.48	14.28	0	16.24	11.70	20	12.28	14.38	5.91	15.65
Simeulue Cut	9.89	9.48	16.24	0	7.68	34.17	8.88	27.11	12.28	3
Simeulue Tengah	6.55	5.56	11.70	7.681	0	27.76	5.47	21.11	6.92	6.92

Simeulue Timur	27.45	30.36	20	34.17	27.76	0	28.68	8.88	22.24	33.83

Teluk Dalam	5.19	4.35	12.28	8.88	5.47	28.68	0	22.93	7.87	8.60
Teupah Barat	21.23	24.67	14.38	27.11	21.11	8.88	22.93	0	16.24	27.0
Teupah Selatan	7.41	10.14	5.916	12.28	6.92	22.24	7.87	16.24	0	11.91
Teupah Tengah	9.32	8.06	15.65	3	6.92	38.83	8.60	27.0	11.91	0

- **Algorithm Implementation**: The DBSCAN algorithm is implemented using the Python programming language with the scikit-learn library. The clustering process is conducted to identify areas with a high concentration of criminal activity.

2.5. Analysis of Results

After the implementation of the DBSCAN algorithm and data validation, the clustering results are analyzed to identify the spatial patterns of criminal activity. Visualization or mapping is carried out by applying Geographic Information System (GIS) technology to display areas with low, moderate, and high levels of criminal activity. Additionally, statistical analysis is used to evaluate the relationship between environmental factors and the rate of criminal offenses.

IV. Results and Discussion

4.1. Results

The clustering results using the DBSCAN method indicate the presence of several clusters in Simeulue Regency with significant densities of criminal cases. The Euclidean distance calculations have previously been established with parameters of epsilon 5 and minimum points 3, resulting in the following clusters:

Table 4. Cluster Results from Euclidean Distance

Cluster	Subdistrict
-1	Alafan
0	Salang
-1	Simeulue Barat
1	Simeulue Cut
-1	Simeulue Tengah
-1	Simeulue Timur
0	Teluk Dalam
-1	Teupah Barat
-1	Teupah Selatan
1	Teupah Tengah

After obtaining the clusters above, the next step is to perform the data validation calculations. The results are as follows:

Table 5. The Results of Calculations Using the Validation Formula

Subdistrict	Cluster	Total Criminal Offenses	Label
Alafan	-1	42	Tidak Rawan
Salang	0	36	Tidak Rawan
simeulue barat	-1	58	Tidak Rawan
simeulue cut	1	24	Tidak Rawan
simeulue tengah	-1	39	Tidak Rawan
simeulue timur	-1	100	Sangat Rawan

teluk dalam	0	39	Rawan
teupah barat	-1	83	Rawan
teupah selatan	-1	51	Tidak Rawan
teupah tengah	1	25	Rawan

Based on the analysis and calculations above, several clusters were identified, indicating areas with a high density of criminal cases. Specifically, 1 cluster was identified as a highly crime- prone area, 3 clusters were identified as crime-prone areas, and 6 other clusters were identified as areas not prone to criminal cases

Figure 1. Mapping Using Geographic Information Systems (GIS)

From the mapping or visualization above, it can be seen that the areas identified as crime- prone are Simeulue Timur subdistrict in red, Teluk Dalam, Teupah Barat, and Teupah Tengah subdistricts in yellow, while the rest are in blue.

4.2. Discussion

The results of clustering using DBSCAN show an interesting pattern, where areas with higher population density and ease of access tend to have higher crime rates. This aligns with social theory, which states that urban or economic center areas typically exhibit higher crime rates due to various factors such as poverty, social inequality, and high economic activity.

- Simeulue Timur subdistrict, as the capital of Simeulue Regency and the center of administration and economy, has the highest number of cases. This is attributed to high population mobility, trade activities, and greater opportunities for crime compared to other regions. Additionally, the lack of security monitoring, such as CCTV or regular patrols, also contributes to the increase in criminal cases.
- The Teluk Dalam, Teupah Tengah, and Teupah Barat subdistricts exhibit a similar pattern. These areas are still close to the capital city and have a high population density and active socio-economic activities. The developing infrastructure and increasing community activities create greater opportunities for criminal activities, particularly theft and violence.
- Outlier areas such as Alafan, Salang, and Simeulue Cut subdistricts have low crime incidents. This is because these regions are far from the capital, have low population density, and minimal economic activities, resulting in a lower crime rate in these areas.

4.3. Policy Implications

Based on the findings of this study, the local government of Simeulue needs to prioritize enhancing security in clusters identified as prone and highly prone areas, particularly in the Simeulue Timur subdistrict. Actions that can be taken include increasing police patrols, installing

surveillance cameras, and conducting public safety campaigns to raise community awareness. Additionally, there needs to be an improvement in synergy between the community and law enforcement agencies to create a safer environment.

For areas identified as not prone to crime, such as Simeulue Cut and Salang subdistricts, even though the crime rates are low, it is still necessary to have infrastructure and public services in place to maintain long-term security stability. Furthermore, this condition presents an opportunity to study the factors that contribute to keeping crime rates low.

V. Conclusions

In This Study, The DBSCAN Algorithm Is Applied To Analyze The Spatial Distribution Of Criminal Cases In Simeulue Regency, Using An Epsilon (Eps) Parameter Of 5 And Min Points (Minpts) Of 3. By Calculating The Euclidean Distance, Clusters 0, -1, And 1 Were Obtained. Using The Validation Formula, The Area Identified As Highly Vulnerable Is The Simeulue Timur District, While The Areas At Risk Include Teupah Tengah, Teluk Dalam, And Teupah Barat. The Remaining Districts Are Considered To Be Less Prone To Criminal Cases

The Research Results Indicate That High-Density Clusters Related To Criminal Cases Are Concentrated In Urban Areas, Particularly In The City Center, Where Population Density And Accessibility Are Higher. Medium-Density Clusters Are Found In Suburban Areas, While Rural Or Remote Regions, Which Experience Fewer Criminal Incidents, Are Categorized As Noise Due To Their Low Crime Rates.

These Results Indicate That Population Density, Transportation Accessibility, And Socioeconomic Activities Significantly Influence Crime Patterns. Therefore, Security Policies Should Focus On Enhancing Surveillance In Areas With High-Density Clusters, Improving Security Infrastructure Along Major Transportation Routes, And Implementing Preventive Measures In Suburban Areas To Maintain Stability And Safety

Overall, The Dbscan Method Has Proven Effective In Mapping Crime Distribution And Providing Data-Driven Insights To Enhance Environmental Security In Simeulue Regency..

VI. Acknowledgments

The Author Would Like To Express Deep Gratitude To Mr. Munirul Ula, S.T., M.Eng., Ph.D., And Mr. Sujacka Retno, S.T., M.T., My First And Second Supervisors, For Their Invaluable Guidance, Insights, And Support. I Am Also Very Thankful To My Beloved Family For Their Unwavering Support, Prayers, And Encouragement Throughout My Studies. Additionally, I Would Like To Extend My Heartfelt Thanks To My Colleagues For Their Support And Contributions, Which Helped Ensure The Successful Completion Of This Research.

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