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Natural Disaster Mapping on Java Island Using Biplot Analysis

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ABSTRACT

Indonesia is located in the ring of fire region. This condition causes Indonesia to have the potential to experience various disasters, such as volcano eruptions. In addition, rapid population growth has led to rampant land conversions that cause floods, landslides, tornadoes, droughts, and forest fires. The research aims to map natural disasters in Indonesia, especially Java Island to find out the provinces and their natural disasters tendency using Biplot analysis. Based on the results, Central Java, East Java, and West Java have a tendency to have floods and landslides. East Java tends to undergo earthquakes and Central Java has the potential to experience volcano eruptions. Through the natural disasters mapping, the government, especially the BMKG, will be able to find various solutions to overcome the natural disasters that have great potential to occur in provinces in Indonesia, especially Java Island as the manifestation toward SDGs Target 2030.

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A. INTRODUCTION

Indonesia is a country that consists of thousands of islands and is located in the path of earthquakes and volcanoes. This condition causes Indonesia to be prone to various natural disasters. Natural disasters are unavoidable in Indonesia considering Indonesia's position at the confluence of four major world plates namely the Eurasian Plate, the Australian Plate, the Pacific Plate, and the Philippine Plate which greatly affect the intensity of geological disasters in Indonesia (Investments Indonesia, 2021). Due to its geographic location and regional characteristics, Indonesia is prone to natural disasters (Ilham et al., 2023). The confluence of the world's plates which continue to move actively has implications for the emergence of a chain of volcanoes that cross from Sumatra, Java, Nusa Tenggara, Sulawesi, to the Moluccas. As a result of this tectonic and volcanic activity, natural disasters such as earthquakes, tsunamis, lava eruptions, and volcanic gases have become frequent occurrences in Indonesia (Kusumastuti et al., 2014). Natural disasters that often hit Indonesia include tsunamis, landslides, earthquakes, volcano eruptions, floods, and droughts. Natural disasters are natural events that will have a major impact on human survival, especially in Indonesia's economic centre areas, such as the Java Island.

Java Island is often referred to the most populous island in Indonesia that has a population of 160 million people. Java Island is also Indonesia's largest economic centre (Savitri, 2022). This refers to the fact that natural disasters such as earthquakes can cause quite large losses, where the losses incurred are not only material but also non-material. Natural disasters which often happen on the Java Island are floods, landslides, tornadoes, droughts, earthquakes, abrasions, forest fires, and volcano eruptions. The magnitude of the intensity of natural disasters, especially floods and landslides, cannot be separated from human activities.

Natural disasters have significant impacts on human society and the environment. Various researchers are studying different

aspects of natural disasters. However, most existing reviews focus on partial aspects or topics of natural disaster studies (Shen et al., 2018). Efforts to deal with natural disasters that have been carried out so far are still in crisis, meaning temporary actions during and after a disaster occurs including evacuating victims, distributing aid, and rehabilitation (Hapsari and Farabi, 2019). Meanwhile, preventive actions carried out prior to the occurrence of a disaster are still very rarely to be carried out. Supposedly, this action is very important to be done to avoid casualties and material losses in the event of a disaster. In order to carry out comprehensive natural disaster management measures, basic information regarding disasters is needed such as the type of disaster, the location and distribution of the disaster, as well as the causative factors of the disaster (Handayani et al., 2019).

Biplot analysis is a statistical method that provides a graphical representation of data, allowing for the simultaneous display of observations and variables. The research gap is its predictive capabilities using biplot analysis are limited. The study might not be able to provide robust predictions about future natural disaster occurrences or their potential impacts without integrating more advanced predictive modelling techniques. While this technique has been widely used in various fields, its application in the context of natural disaster mapping, particularly in Java Island, represents a novelty approach. This study leverages biplot analysis to visually interpret and analyze the complex relationships between different types of natural disasters and their geographical distribution. Java Island, a region prone to a variety of natural disasters such as earthquakes, volcanic eruptions, floods, and landslides, provides a unique case study. Previous research may have focused on individual types of disasters or broader geographical areas, but this study's specific focus on East Java allows for a more detailed and localized understanding of natural disaster patterns. The study likely integrates multiple data sources, including historical records of natural disasters, geographical information, and possibly socio-economic factors. By combining these diverse datasets, the research can provide a more comprehensive and nuanced map of natural disaster risks and occurrences in Java Island.

To provide information related to the location and distribution of natural disasters and integrate actions for anticipating climate change into national policies, strategies, and planning in order to prevent disasters in accordance with SDGs 13, the most appropriate method is the biplot analysis to map natural disasters, especially in Java. The data used in the research shows the number of natural disasters in each province on the Java Island. This data is used for planning and evaluating natural disasters so that they can be minimized. Therefore, it is necessary to map natural disasters that occur in provinces on Java Island. This study aims to apply the biplot analysis method in classifying provinces on the Java Island that have similar characteristics of natural disasters as well as analysing the correlation between natural disasters in each province on the Java Island so that policies constructed by the government in overcoming natural disasters become more precise.

B. RESEARCH METHOD

The data used in this study is secondary data regarding the number of natural disasters that have occurred in provinces on Java Island from 2020 to 2021. The data is taken from the website of the National Disaster Mitigation Agency (BNPB), namely https://dibi.bnpb.go.id/. The data used is data on natural disasters that occurred in Banten, Special Region of Yogyakarta, Capital City of Jakarta, West Java, East Java, and Central Java. The variables used in this study are types of natural disasters including floods, landslides, tornadoes, droughts, earthquakes, abrasions, forest fires, and volcano eruptions. Table 1 explains the definitions and symbols of natural disasters that are used as variables in the study.

Table 1. Natural Disasters as Research Variables

Natural Disaster	Symbol	Definition
Flood		A disaster in which a region or estate is submersed due to an enhancement in water volume.
Landslide		Type of soil or rock mass movement, fall or out of the hillside due to disruption of the equilibration of the soil or stone.

Natural Disaster	Symbol	Definition
Tornado		Robust winds that come unexpectedly with a centre, move in a ring like a spiral with a velocity of 40-50 km/hour until reach the earth's superficies and will vanish in a short time.
Drought		Drought is a disaster of water supply shortage in an area for a prolonged period. Availability of water which is under the need for existence needs, agriculture, economic activities, and the neighbourhood.
Earthquake		Vibrations that happen on the superficies of the earth caused by crash between the earth's plates, active faults, volcanic activity or rock debris.
Abrasion		The action of eroding the littoral by the destructive power of sea waves and ocean flows. Abrasion is also known as beach attrition. Damage to the coastline due to abrasion is triggered by the disruption of the natural balance of the littoral area.
Forest Fire		A situation in which forest and ground are stricken by fire, resulting in harm to forest and ground causing economic loss. Forest fires happened cause smoke disasters frequently that can interfere with the activities and health of the surrounding community.
Volcano Eruption		Volcano eruptions are disasters that happen due to magma deposits in the entrails of the earth which are shoved out by big pressure gas. The danger of volcano eruptions can be in the form of hot clouds, ejected material (incandescent), heavy ash rain, lava, poison gas, tsunamis and lava floods.

1. Biplot Analysis

Biplot is a two-dimensional representation of the $\mathbf{Y}$ matrix data showing each point from n observation vectors (rows from $\mathbf{Y}$) as well as variables (columns of $\mathbf{Y}$). There are four pieces of information regarding the appearance of the biplot, including the following.

1. Characteristic
   Proximity between observed objects is objects that have same characteristics with other objects. If two points are depicted with adjacent positions, then the two objects are said to have the same characteristics.
2. Variable diversity
   Variables that have substantial variability values are drawn with long vectors while variables that have small variability values are depicted with short vectors.

3. Correlation

The correlation between variables shows how a variable affects or is influenced by other variables. Variables will be described as directed lines. Two variables that have a positive correlation value $(+)$ are depicted as two lines with the same direction or establishing a narrow angle $(< 90^0)$. Two variables that have a negative correlation value are depicted as two lines in reverse directions or shaping a wide angle $(> 90^0)$. Two uncorrelated variables are depicted as lines with angles approaching 90^0.

Main component $z = \mathbf{a'y}$, where are the eigenvectors of $\mathbf{S}$, the sample covariance matrix, and y are the observed vectors. There are p eigenvectors $\boldsymbol{a_1, a_2, \ldots, a_p}$ so that there are $z_1, z_2, \ldots, z_p$ principal components for each observation $\boldsymbol{y_i}$ for $i = 1, 2, \ldots, n$. By using the central model, the observation vectors can be transformed into $z_{ij} = \boldsymbol{a'_j(y_i - \bar{y}) = (y_i - \bar{y})a_j}$ for $i = 1, 2, \ldots, n$ dan $j = 1, 2, \ldots, p$. Each $p \times 1$ observation vector is transformed into $p \times 1$ principal component vector where $\boldsymbol{z'_i = (y_i - \bar{y})'(a_1, a_2, \ldots, a_p) = (y_i - \bar{y})'A}$. Matrix A is a matrix of size $p \times p$ whose columns are eigenvectors of S that have been normalized. Principal components can also be written in Equation (1) dan Equation (2).

$$\boldsymbol{Z = Y_c A} \tag{1}$$

$$\boldsymbol{Z = \left(z'_1, z'_2, \ldots, z'_n\right)}, \qquad \boldsymbol{Y_=} \begin{pmatrix} \boldsymbol{(y_1 - \bar{y})'} \\ \boldsymbol{(y_2 - \bar{y})'} \\ \boldsymbol{\vdots (y_n - \bar{y})'} \end{pmatrix} \tag{2}$$

An exact two-dimensional representation of $\boldsymbol{Y_c}$ is obtained with the first two columns taken from and the first two columns from $\boldsymbol{A}$. If the resulting matrix is denoted by $\boldsymbol{Z_2}$ and $\boldsymbol{A_2}$, the Equation (3) will be obtained.

$$\boldsymbol{Y_c \cong Z_2 A'_2} \tag{3}$$

The adequacy of Equation (3) can be evaluated by examining the first two eigenvalues of matrix S namely λ_1 and λ_2 shown in Equation (4).

$$\frac{\lambda_1 + \lambda_2}{\sum_{i=1}^{p} \lambda_i} \tag{4}$$

Equation (4) shows that $\boldsymbol{Y_c}$ provides a good visual representation of the plot. Matrix $\boldsymbol{Y_c = ZA'}$ can be constructed with a single value decomposition shown by the Equation (5):

$$\boldsymbol{Y_C = UAV'} \tag{5}$$

where $\boldsymbol{\Lambda} = diag(\lambda_1, \lambda_2, \ldots, \lambda_p)$ is a diagonal matrix with square root elements of non-zero eigenvalues $\lambda_1^2, \lambda_2^2, \ldots, \lambda_p^2$ of $\boldsymbol{Y'_c Y_c}$ and $\boldsymbol{Y_c Y'_c}$, the column of $\boldsymbol{U}$ is the corresponding eigenvector of $\boldsymbol{Y_c Y'_c}$, and the column of $\boldsymbol{V}$ is the corresponding eigenvector of $\boldsymbol{Y'_c Y_c}$. The product $\boldsymbol{U\Lambda}$ in the equation is equal to Z, the principal component matrix scores in the Equation (1). This equation can be proven by multiplying by V, which is orthogonal because the matrix contains eigenvectors that have been normalized from the symmetric matrix shown by Equation (6).

$$\boldsymbol{Y_C V = U\Lambda V'V = U\Lambda} \tag{6}$$

Here is a two-dimensional representation of the matrix $\boldsymbol{Y_c}$ based on main component and the same representation as the equation on a single value decomposition shown by Equation (7).

$$\boldsymbol{Y_c \cong Z_2 A'_2} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \\ \vdots & \vdots \\ Z_{n1} & Z_{n2} \end{pmatrix} \begin{pmatrix} a_{11} & a_{21} & \ldots & a_{p1} \\ a_{12} & a_{22} & \ldots & a_{p2} \end{pmatrix} \tag{7}$$

Thus, each observation is represented as a linear combination and the coordinates become elements of vector (z_{i1}, z_{i2}) and the axes become elements of vector (a_{j1}, a_{j2}). Therefore, it is necessary to plot the dot (z_{i1}, z_{i2}), $i = 1, 2, \ldots, n$, and dot (a_{j1}, a_{j2}), $j = 1, 2, \ldots, p$. To see the difference and show the relationship of the points to the axes, the dots (a_{j1}, a_{j2}) are connected to the origin by straight lines forming arrows.

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The Euclidean distance between two points (z_{i1}, z_{i2}) and (z_{k1}, z_{k2}) is approximately equal to the distance between the corresponding points (rows) $\boldsymbol{y_i'}$ and $\boldsymbol{y_k'}$ and in the Y data matrix. The cosine of the angle between arrows or lines drawn to each pair of axes points (a_{j1}, a_{j2}) and (a_{k1}, a_{k2}) indicates the correlation between two variables. Thus, a small angle between two vectors that is less than indicates that the two variables are positively or high correlated. Conversely, the angle between the two vectors that is greater than 90^0 indicates that the variable has a negative correlation.

2. Research Procedures

The following are the steps for biplot analysis in this research.

1. Conducting a search for data sources regarding the number of natural disasters that occurred in provinces in Java Island from 2020 to 2021.
2. Summarizing the data that has been found for further analysis.
3. Analyzing the data using descriptive statistics regarding the number of natural disasters in Java Island from 2020 until 2021.
4. Conducting biplot analysis.
5. Analyzing the results of biplot analysis for mapping natural disasters that occurred in Java.
6. Constructing an explanation of geographical location that causes natural disasters in Java Island.
7. Constructing conclusions and suggestions that are drawn from the research.

C. RESULT AND DISCUSSION

1. Data Tabulation

Natural disasters in Java are varied and frequent, owing to the region's geographical and climatic characteristics. Java is prone to several types of natural disasters, each with distinct causes, impacts, and challenges. Table 2 is a tabulation data on natural disaster in Java classified by provinces and eight types of natural disasters that occur from 2020 to 2021.

Table 2. Number of Natural Disasters on Java Island in 2020-2021

Province	Flood	Landslide	Tornado	Drought	Earthquake	Abrasion	Forest Fires	Volcano Eruption
Capital City of Jakarta	75	1	1	0	0	0	0	0
West Java	341	645	635	6	13	1	13	0
Central Java	334	502	368	8	1	7	19	8
Special Region of Yogyakarta	7	8	25	0	4	1	0	1
East Java	247	50	127	2	26	1	13	1
Banten	80	18	55	0	0	0	5	0

Based on the Table 2, it can be seen that provinces which are vulnerable to natural disasters are West Java, Central Java, and East Java. West Java and Central Java tend to experience flooding with a frequency of over 300 floods in the last two years. In addition, in West Java, landslides and tornadoes occur with a disaster frequency of 600. West Java is also a province on Java Island with the second highest frequency of earthquakes after East Java and the second largest frequency of forest fires after Central Java (BNPB, 2021)

Central Java is a province on Java Island with the second largest number of natural disasters after West Java. This is due to the frequency of floods which are at 300, landslides which have occurred more than 500 times, and tornadoes which have occurred more than 350 times in the last two years. In addition, Central Java is the province with the largest abrasion disaster on Java Island caused by the beaches in Central Java (BNPB, 2021).

East Java is the third province on Java Island with the highest frequency of disaster occurrences after West Java and Central Java. The frequency of floods is at 200, landslides have occurred 50 times, and tornadoes have occurred more than 100 times in the last two years. In addition, East Java is a province on Java Island with the highest frequency of earthquakes, which is 26 times (BNPB, 2021).

Unlike the other three provinces on Java Island, Capital City of Jakarta, Special Region of Yogyakarta, and Banten have an insignificant frequency of natural disasters. Banten is a province with more than 50 floods and tornadoes, 18 landslides, five forest fires, and has never experienced drought, earthquakes, abrasion, and volcano eruptions. Capital City of Jakarta is a province with a frequency of 75 floods, landslides and tornadoes once each, and has never experienced drought, earthquakes, abrasion, forest fires, and volcano eruptions in the last two years. Special Region of Yogyakarta is a province on Java Island with

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the least frequency of natural disasters. In this province, there have only been seven floods, eight landslides, 25 tornadoes, four earthquakes, an abrasion and a volcano eruption, and have never experienced drought and forest fires (BNPB, 2021).

2. Biplot Variance

Table 3 illustrates the variance explained by the biplot analysis conducted in this research. It provides a detailed breakdown of the proportion of variance attributable to different natural disasters. This information helps in understanding how much of the total variability in the data is captured by the biplot model. By examining these values, researchers can assess the effectiveness of the biplot analysis in representing the underlying data structure.

Table 3. Explanation of Biplot Analysis of Variance

Components	Total	Initial Eigenvalues	
		% of Variances	cumulative %
1	5,465	68,309	68,309
2	1613	20.164	88,473
3	0.813	10.16	98,632
4	0.088	1,097	99,730
5	0.022	0.27	100
6	5.235×10^{-16}	6.543×10^{-15}	100
7	-5.093×10^{-17}	-6.36610^{-16}	100
8	1.413×10^{-16}	-1.766×10^{-15}	100

Based on Table 3, the variance that can be explained by all types of natural disasters is 100%. However, by conducting a biplot analysis and reducing all types of natural disasters into a two-dimensional space, only 88.473% of the information that can be explained which is obtained from the sum of 68.309% and 20.164%. Therefore, it can be said that the biplot provides sufficient information regarding the relationship between the eight natural disasters.

3. Biplot Analysis

Figure 1 visualizes the results of biplot analysis where the eight types of natural disasters have a positive correlation because the angles are less than 90^0. Landslides and forest fires have the greatest positive correlation. Both disasters were most likely caused by humans. For example, if humans carry out illegal logging, forest fires will occur in the summer and landslides will occur during the rainy season. This is because there are no trees that can withstand the rain that hits the ground. Drought and forest fires also have a high positive correlation. This shows that if there is a drought, then the probability of a forest fire will be even greater. The drought, which is likely caused by a long dry season, triggers tree friction and dry leaves. This friction can cause sparks and can cause forest fires.

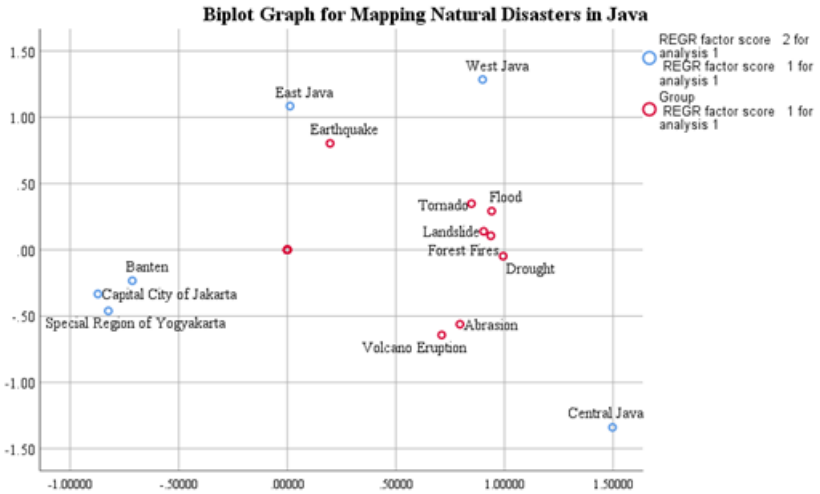

Figure 1. Biplot Graph

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Based on Figure 1, it can be seen that drought, forest fires, landslides, floods and tornadoes have a high positive correlation because they have a small angle and high correlation. These disasters can be caused by human or nature. Based on the human factor perspective, if there are irresponsible groups who carry out illegal logging, then drought can occur because there are no trees that can withstand the hot sun in the dry season. In addition, the drought can cause forest fires due to the friction of dry leaves in the dry season.

Illegal logging carried out by humans can cause deforestation. Deforested forests contribute to landslides because there are no trees or plants to hold the soil. In addition, deforested forests cause flooding because there are no trees to absorb and store water during the rainy season.

Based on the nature factor perspective, drought, forest fires, landslides, floods and tornadoes can occur due to several factors. The prolonged dry season causes drought and forest fires. In addition, the relatively long rainy season causes flooding and landslides because the soil is no longer able to absorb large amounts of water. In addition, tornadoes can occur due to the transition season.

Volcano eruption and abrasion have a high correlation due to the narrow angle between the vectors. An erupting volcano will emit hot clouds, thick lava, molten lava, and lava. Lahar is the material that is released when a volcano erupts in the form of stones, gravel, and sand. Volcanic material carried out by volcano eruptions can damage the soil, especially mountains near the coast or sea which may cause abrasion.

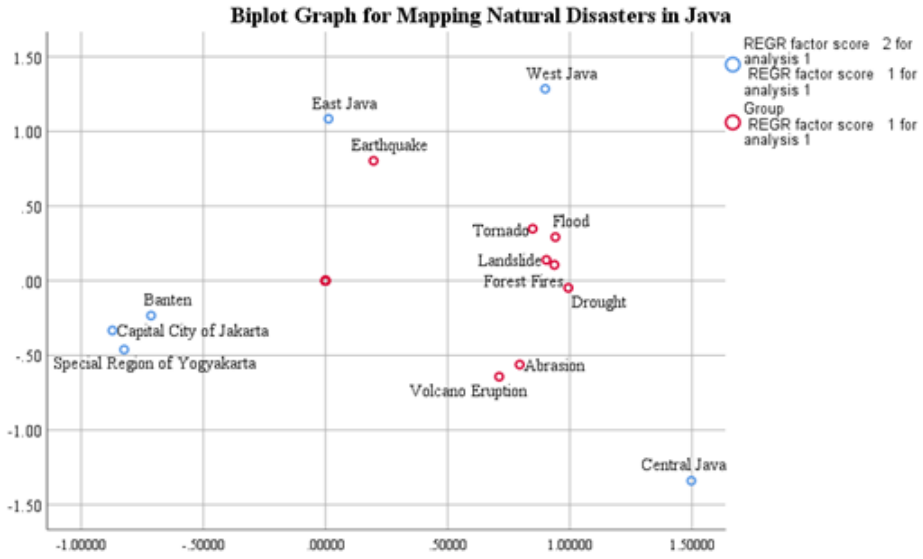

Figure 2. Biplot Graph

Based on Figure 2, it can be seen that floods, tornadoes, landslides, forest fires, volcano eruptions, and abrasion are at close angles so that they have a high correlation. In addition, natural earthquake disasters tend to occur in the East Java and West Java regions due to the location of the two provinces and the earthquake that are close on the coordinates of the biplot chart. Banten, Capital City of Jakarta, and Special Region of Yogyakarta do not have a tendency to these eight natural disasters because they are located in a different quadrant from the natural disasters that are the variables in this research.

Provinces on Java Island tend to frequently experience floods and landslides, both of which occur as a result of forest destruction and land conversion in the mountains and land subsidence on the coast. More and less trees will make it more difficult for water to seep into the ground so that it stagnates on the surface. In addition, the use of water catchment areas for settlements can cause the soil to lose traction so that areas with slopes without trees will easily slide when exposed to continuous rain.

4. Geographical Conditions in Java Island

Central Java has a tendency to encounter volcano eruptions because the province is located in the ring of fire area that forms five active volcanoes. This condition causes Central Java to have a high tendency to experience volcano eruptions (Nurhadi et al., 2015). Apart from volcano eruptions, Central Java also has a tendency to have floods, landslides, and tornadoes. According to

urban spatial planning and environmental observers, one of the causes of environmental damage that has an impact on natural disasters is population growth. The rapid population growth that occurred in Central Java caused the conversion of tree land into residential as a place for activities (Muir et al., 2020).

Apart from Central Java, West Java is also prone to experiencing floods and landslides. These disasters can be caused by natural and human factors. The main problem that causes floods and landslides is land conversion. Land that should have been used as a place to grow crops and collect water was converted as a place for residents to carry out their activities. This condition has an impact on the lack of water reservoirs in West Java when the rainy season occurs which can cause flooding. In addition, morphologically, West Java is a slope area with loose soil and is sensitive to water. The morphology of the area causes West Java to be very vulnerable to ground movement so that it has a tendency to have landslides (Ismana et al., 2022). Same as Central Java and West Java, East Java has a tendency to experience flooding due to rapid population growth which triggers land conversion (Cahyono et al., 2021). In addition, East Java also has a tendency to experience earthquakes. The earthquake that occurred is most likely caused by the subduction activity of the Indo-Australian Plate with a downward movement mechanism or normal fault. The earthquake that occurs is usually a medium earthquake that can be felt in the surrounding area but does not cause damage or a tsunami.

Forests are valuable natural resources because they contain biodiversity as a source of germplasm, timber and non-timber forest products, water regulation, flood and erosion prevention as well as soil fertility, protection of biological nature for the benefit of science, culture, recreation, and tourism. If a forest fire occurs automatically many disasters will occur (Ngo et al., 2021). Disturbance to forest resources continues and the intensity is increasing. Forest destruction has increased carbon emissions by almost 20% which is very significant because carbon dioxide is one of the greenhouse gases which has implications for the trend of global warming.

Extreme weather conditions that cause drought, floods and tornadoes, as well as the distribution of disease-causing organisms are predicted to occur. The main cause of forest fires is the human factor which originates from the following activities or problems, such as the traditional shifting cultivation system of the local population, clearing of forests by holders for timber industry and oil palm plantations, and structural causes, namely the combination of poverty, development policies, and governance, giving rise to conflicts between customary law and positive law of the state (Rasyid, 2014). For example, if humans carry out illegal logging and do not apply a selective logging system, forest fires will occur in the summer and landslides will occur during the rainy season. This is because there are no trees that can withstand the rain that hits the ground (Septianingrum et al., 2018).

West Java has nine rivers consisting of the Cisadane, Citarum, Cimanuk, Cisanggarung, Citanduy, Cilonggan, Cibuni, Cimandiri, and Citarik. The Cimanuk River is the widest river with an area as large as 3221 $km^2/sq.km$ and has the largest extreme discharge 491 m^3/sec. The instantaneous extreme discharge (m^3/s) is the maximum or minimum instantaneous flood discharge or the annual maximum or minimum discharge that occurs momentarily BPS (2021). The large number of rivers in West Java with a large enough instantaneous extreme discharge and a very wide watershed area makes West Java vulnerable to flood disasters.

Central Java has eight rivers, including Bodri, Putih, Garang, Bengawan Solo, Progo, Tangsi, Bogowonto and Jali. Bengawan Solo Rivers the widest river with an area as large as namely 3568 km^2/sq and has the largest extreme discharge 740 m^3/sec BPS (2021). The large number of rivers in Central Java makes the province vulnerable to floods which are not much different from West Java.

Special Region of Yogyakarta only has two rivers, namely Opak and Serang, while Banten only has four rivers, namely Cidanau, Ciujung, Cibanten and Cidurian. In addition, Capital City of Jakarta only has a river, namely the Ciliwung River which is in South and Central Jakarta Regencies. That is the reason why the frequency of floods in Special Region of Yogyakarta, Capital City of Jakarta, and Banten does not seem significant when compared to other provinces on Java Island. Based on the Observation of Climate Elements at the Meteorological, Climatological, and Geophysical Agencies Station by Province in 2020, obtained minimum, maximum, and average temperature data in provinces on Java Island. Table 4 can be used to predict the probability of natural disasters based on climate change in each province.

Table 4. PSO Feature Selection Results

Province	Minimum Temperature ^0C	Maximum Temperature ^0C	Average Temperature ^0C	Temperature Range ^0C
Capital City of Jakarta	24	35.6	28.8	11.6
Special Region of Yogyakarta	17.3	35.5	28	10.7
Banten	21.2	36.2	29.5	8.3
East Java	14.2	32	25.3	11.1

Province	Minimum Temperature ^0C	Maximum Temperature ^0C	Average Temperature ^0C	Temperature Range ^0C
Central Java	21	36	29.5	8.5
West Java	19.9	34.4	26.4	6.5

In addition, the Observation of Climate Elements at the Meteorological, Climatological, and Geophysical Agencies Station by Province in 2020 also noted that the largest number of precipitation on Java Island was West Java Province, which was 4,309.7 mm when compared to other provinces, such as the Capital City of Jakarta, which was 2831.5 mm, Central Java which was 2507.7 mm, Yogyakarta Special Region as much as 3057.8 mm, East Java as much as 2133.3 mm, and Banten which was 2697.8 mm. In addition, West Java is also the province with the largest number of rainy days on Java Island, which is 244 days. The large amount of rainfall and rainy days in West Java has caused the province to become a province with high vulnerability to floods when compared to other provinces.

The research findings reveal a strong correlation between volcanic eruptions and coastal abrasion, likely due to geographical and geological factors. Moderate correlations among certain disaster types suggest shared climatic or environmental conditions, while earthquakes display unique characteristics driven by tectonic activity. Practical implications include the need for region-specific mitigation strategies, such as abrasion-related measures in volcanic regions and integrated disaster management plans for areas prone to multiple correlated disasters. Earthquake-prone areas require specialized strategies due to their distinct nature. The biplot analysis provides valuable insights into the relationships among various natural disasters and their regional associations in Java, essential for effective disaster risk management and resilience planning. This research inline with Research conducted by (Musid et al., 2023) aims to identify and group villages in West Java based on the level of disaster risk they experience. This study uses data on natural disaster occurrences and the number of victims as the primary information. The research results show that there are areas in West Java with a relatively high level of disaster risk. The study also employs a clustering algorithm to group villages based on the level of disaster risk they experience, using the K-Means method. The findings of the study can help in raising awareness and disaster mitigation in West Java, as well as in developing more effective disaster mitigation strategies. In contrast, the research conducted in Java utilizes biplot analysis, a statistical technique that graphically represents data, enabling the simultaneous display of both observations and variables. This approach provides a comprehensive understanding of how different disaster types interact and correlate within specific regions. The biplot analysis generates graphs that visually depict these relationships, facilitating the identification of patterns and correlations. Although both studies aim to enhance disaster management, their methodologies and outcomes differ significantly. The research in West Java employing K-means clustering focuses on categorization and the practical application of results to disaster risk management, producing clear, actionable clusters for targeted interventions. Conversely, the research in Java using biplot analysis emphasizes visualization and a thorough examination of the relationships between disaster variables. This approach aids in understanding the broader context and underlying factors contributing to disaster risks, thereby informing long-term strategies and comprehensive disaster resilience planning.

D. CONCLUSION AND SUGGESTION

Indonesia is in the ring of fire area which causes Indonesia to have great potential to experience natural disasters. Based on the results, it can be concluded that the provinces that have a tendency to have floods, landslides and tornadoes are East Java, Central Java, and West Java. Floods and landslides that occurred in Java Island were mostly caused by population growth and land conversion. In addition, East Java is prone to earthquakes and Central Java has a tendency to experience volcano eruptions because there is subduction activity of the Indo-Australian plate in East Java and there are around five active volcanoes in Central Java.

Because of Indonesia's geographical condition which is prone to natural disasters, the Badan Meteorologi Klimatologi dan Geofisika (BMKG) should provide routine information and warnings if a disaster is likely to occur and the government should conduct socialization on disaster management to minimize losses and damage when facing an unpredictable disaster. In addition, it would be better if the community followed the Family Planning (KB) program properly so that the government could control population growth and land convertion into settlements in order to minimize the potential for natural disasters.

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