

## Correspondence Analysis of Natural Disaster Distribution Patterns on Java Island in 2023

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### ABSTRACT

Indonesia is geographically located at the convergence of major tectonic plates and within a tropical climate zone, making it highly vulnerable to various natural disasters. Java Island, as the most densely populated region in Indonesia, experiences a significant number of disaster events each year. This study aims to analyze the distribution patterns of natural disasters across provinces on Java Island in 2023 using Correspondence Analysis. Secondary data were obtained from the Indonesian National Disaster Management Agency (BNPB) and organized into a contingency table consisting of provinces and types of natural disasters, including floods, landslides, extreme weather, droughts, and forest and land fires. The analysis involved descriptive statistics, independence testing using Pearson's Chi-square, and correspondence analysis for dimensional reduction and visualization. The results indicate a significant association between disaster types and provincial characteristics. Floods were predominantly associated with DKI Jakarta, Banten, East Java, and Central Java, while droughts were closely related to West Java. Extreme weather events were mainly observed in the Special Region of Yogyakarta. These findings provide valuable insights for regional disaster mitigation planning and policy formulation tailored to provincial disaster characteristics.

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## 1. INTRODUCTION

Indonesia is located at the intersection of three major tectonic plates, namely the Eurasian, Indo-Australian, and Pacific plates. This geological condition places Indonesia within the Pacific Ring of Fire, resulting in a high risk of geological disasters such as earthquakes and volcanic eruptions [1]. In addition, Indonesia's tropical climate contributes to seasonal hydrometeorological disasters. During the rainy season, wet hydrometeorological disasters such as floods, extreme weather, and coastal abrasion frequently occur, while droughts and forest and land fires are common during the dry season [2].

According to the Indonesian Disaster Information Data Center, a total of 5,400 natural disaster events were recorded across Indonesia in 2023, representing a significant increase compared to 3,544 events in the previous year [2]. Among all regions, provinces on Java Island consistently experienced the highest number of disaster occurrences. Given Java Island's dense population and strategic economic role, understanding disaster distribution patterns in this region is crucial.

Natural disasters are events caused by natural, non-natural, or human-induced factors that threaten and disrupt human life, resulting in environmental damage, property loss, and casualties [3]. Effective disaster mitigation and preparedness strategies require a clear understanding of disaster characteristics across regions. One statistical approach suitable for this purpose is Correspondence Analysis, which allows simultaneous examination of relationships between categorical variables in a contingency table.

Correspondence analysis is a multivariate analysis that examines the relationships between two or more variables with various categories in rows and columns simultaneously from a contingency table [4]. Correspondence analysis is used to reduce dimensions and visually describe a data matrix from a contingency table. Correspondence analysis can explore data from contingency tables and involve more than two categories of variables [5]. Correspondence analysis is often used to determine similar categories in a variable and allows these similar categories to be combined into one category [4].

Various statistical and analytical methods have been employed to identify spatial patterns and relationships among variables. Commonly used methods include cluster analysis, principal component analysis (PCA) [6], regression analysis [7,8,9], and spatial autocorrelation [10] techniques such as Moran's I and Getis-Ord statistics. Cluster analysis is effective for grouping regions with similar disaster characteristics but does not explicitly reveal relationships between categorical variables [11]. PCA is useful for dimensional reduction of continuous variables; however, its application is limited when dealing with categorical data such as disaster types and administrative regions [4]. Regression-based approaches focus on causal relationships but often require strong assumptions regarding variable distribution and independence [1]. Spatial statistical methods emphasize geographic dependence but may overlook the categorical interaction structure between disaster types and regions. Compared to these approaches, Correspondence Analysis is particularly advantageous for analyzing contingency tables, as it simultaneously visualizes associations between categories of multiple variables in a low-dimensional space, making it well suited for disaster distribution studies based on categorical data [12].

Previous studies have applied correspondence analysis to disaster-related data, such as the analysis of climatological disasters on Java Island conducted by [13]. However, that study focused solely on climatological disasters, excluding other disaster types. Therefore, this study extends previous research by analyzing both geological and climatological disasters across provinces on Java Island in 2023. The objective is to identify distribution patterns and relationships between disaster types and provinces to support more effective disaster mitigation policies.

## 2. METHOD

### 2.1. Data Source

This study uses secondary data obtained from the official website of the Indonesian National Disaster Management Agency (BNPB), specifically from the Indonesian Disaster Information Database (DIBI). The dataset contains records of natural disaster events that occurred on Java Island throughout 2023.

### 2.2. Variables

The research variables and data scales used in this study are as follows.

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Table 1. Research Variables

Variable	Name	Category	Scale
X	Provinces on Java Island	DKI Jakarta, West Java, Central Java, East Java, Banten, and the Special Region of Yogyakarta.	Nominal
Y	Types of Natural Disasters	floods, landslides, extreme weather, droughts, and forest and land fires.	Nominal

The variables analyzed consist of:

- Provinces on Java Island: DKI Jakarta, West Java, Central Java, East Java, Banten, and the Special Region of Yogyakarta.
- Types of Natural Disasters: floods, landslides, extreme weather, droughts, and forest and land fires.

All variables are categorical and summarized in a contingency table representing the frequency of disaster occurrences.

**2.3. Data Analysis Procedure**

The analytical steps conducted in this study include:

1. Compiling disaster frequency data by disaster type and province.
2. Describing disaster characteristics using contingency tables.
3. Testing the independence between disaster types and provinces using Pearson’s Chi-square test.
4. Applying Correspondence Analysis, including row and column profile analysis, dimensional reduction, Euclidean distance interpretation, and biplot visualization.
5. Interpreting the results to identify disaster distribution patterns.

**3. RESULTS AND DISCUSSION**

**3.1. Data Characteristics**

The characteristics of natural disasters in provinces on the island of Java in 2023 can be presented in the following contingency table.

Table 2. Characteristics of Natural Disasters

Province	Natural Disaster					Total
	Floods	Landslides	Extreme Weather	Droughts	Forest and Land Fires	
DKI Jakarta	7	7	3	0	0	17
Jawa Barat	107	185	135	251	152	830
Jawa Tengah	95	125	43	159	204	626
DI Yogyakarta	6	24	57	0	88	175
Jawa Timur	41	5	32	29	27	134
Banten	28	1	6	17	10	62
Total	284	347	276	456	481	1844

Based on the table above, it is known that provinces on the island of Java tend to experience natural disasters in the form of forest and land fires, with Central Java being the province that experiences these disasters most frequently. Meanwhile, the province that frequently experiences natural disasters is West Java, with drought being the most common natural disaster. Furthermore, it is known that the Province of DKI Jakarta has a tendency to experience natural disasters such as floods and landslides. The Province of West Java has a tendency to experience natural disasters such as drought. The provinces of Central Java and DI Yogyakarta have a tendency to experience forest and land fires. The provinces of East Java and Banten have a tendency to experience floods.

**3.2. Independence Test**

The Independence Test was used to determine the relationship between the types of natural disasters and provinces in Java in 2023 using Pearson's Chi-Square as follows.

Hypothesis:

$H_0$ : There is no relationship between the types of natural disasters and provinces in Java.

$H_1$ : There is a relationship between the types of natural disasters and provinces in Java.

The independence test was conducted at a significance level of 0.05, with the rejection region for  $H_0$  being  $X^2 > X^2_{(a;df)}$  or  $p - value < a$ . The test statistics obtained were  $X^2 = 330.134$ , which is greater than  $X^2_{(0.05;20)} = 31.410$ . This value is also supported by a  $p - value < 0.001$ , which is smaller than the significance level. Therefore, from the independence test conducted, it can be concluded that  $H_0$  is rejected, meaning that there is a relationship between the types of natural disasters and the provinces on the island of Java in 2023.

### 3.3. Row Profile Analysis

The results of the row profile analysis are shown in the following table.

Table 3. Row Profile Analysis

Province	Natural Disaster					Active Margin
	Floods	Landslides	Extreme Weather	Droughts	Forest and Land Fires	
DKI Jakarta	0.412	0.412	0.176	0.000	0.000	1
Jawa Barat	0.129	0.223	0.163	0.302	0.183	1
Jawa Tengah	0.152	0.200	0.069	0.254	0.326	1
DI	0.034	0.137	0.326	0.000	0.503	1
Yogyakarta	0.034	0.137	0.326	0.000	0.503	1
Jawa Timur	0.306	0.037	0.239	0.216	0.201	1
Banten	0.452	0.016	0.097	0.274	0.161	1
Mass	0.154	0.188	0.150	0.247	0.261	1

Based on the table above, it can be seen that the province of DKI Jakarta has a tendency to experience natural disasters such as flooding and landslides. The province of West Java has a tendency to experience natural disasters such as drought. The provinces of Central Java and Yogyakarta have a tendency to experience natural disasters such as forest and land fires. The provinces of East Java and Banten have a tendency to experience natural disasters such as floods. The most frequent natural disaster in all provinces on the island of Java is forest and land fires.

### 3.4. Column Profile Analysis

The results of the column profile analysis are shown in the following table.

Table 4. Column Profile Analysis

Province	Natural Disaster					Mass
	Floods	Landslides	Extreme Weather	Droughts	Forest and Land Fires	
DKI Jakarta	0.025	0.020	0.011	0.000	0.000	0.009
Jawa Barat	0.377	0.533	0.489	0.550	0.316	0.450
Jawa Tengah	0.335	0.360	0.156	0.349	0.424	0.339
DI	0.021	0.069	0.207	0.000	0.183	0.095
Yogyakarta	0.021	0.069	0.207	0.000	0.183	0.095
Jawa Timur	0.144	0.041	0.116	0.064	0.056	0.073
Banten	0.099	0.003	0.022	0.037	0.021	0.034
Active Margin	1	1	1	1	1	1

Based on the table above, it can be seen that natural disasters such as floods, landslides, extreme weather, and drought tend to occur in West Java province, while natural disasters such as forest and land fires tend to occur in Central Java province. The province most frequently affected by natural disasters is West Java province.

### 3.5. Dimension Reduction

The results of the dimension reduction analysis are shown in the following table.

Table 5. Dimension Reduction Analysis

Dimension	Inertia	Proportion of Inertia	
		Accounted For	Cumulative
1	0.101	0.613	0.613
2	0.043	0.258	0.871
3	0.021	0.125	0.996
4	0.001	0.004	1
Total	0.165	1	1

Based on the table above, it can be seen that dimension 1 has a mean value of 0.101 and a proportion of 0.613, which means that dimension 1 can explain 61.3% of the data diversity. Meanwhile, dimension 2 has a mean value of 0.043 and a proportion of 0.258, which means that dimension 2 can explain 25.8% of the data diversity. Dimension 3 has a mean value of 0.021 and a proportion of 0.125, which means that dimension 3 is able to explain 12.5% of the data diversity. Dimension 4 has a mean value of 0.001 and a proportion of 0.004, which means that dimension 4 is able to explain 4% of the data diversity. These four dimensions are able to explain 100% of the data diversity.

### 3.5. Euclidean distance

The distribution pattern of natural disasters on Java Island in 2023 is as follows.

Table 6. Euclidean Distance of Natural Disaster Distribution Patterns

Province	Natural Disaster				
	Floods	Landslides	Extreme Weather	Droughts	Forest and Land Fires
DKI Jakarta	0.155	0.352	0.866	0.767	1.068
Jawa Barat	1.164	0.837	1.309	0.597	2.128
Jawa Tengah	0.876	1.006	1.863	1.219	0.903
DI Yogyakarta	0.972	1.298	0.867	1.711	0.869
Jawa Timur	0.355	0.540	0.650	0.928	1.109
Banten	0.111	0.315	0.926	0.735	1.059

Based on the table above, it is known that in 2023, floods are likely to occur in the provinces of DKI Jakarta, Central Java, East Java, and Banten. Meanwhile, droughts are likely to occur in West Java Province. Meanwhile, extreme weather is likely to occur in DI Yogyakarta Province.

### 3.6. BIPLLOT

The distribution pattern of natural disasters in each province on the island of Java in 2023 is shown in the following figure.

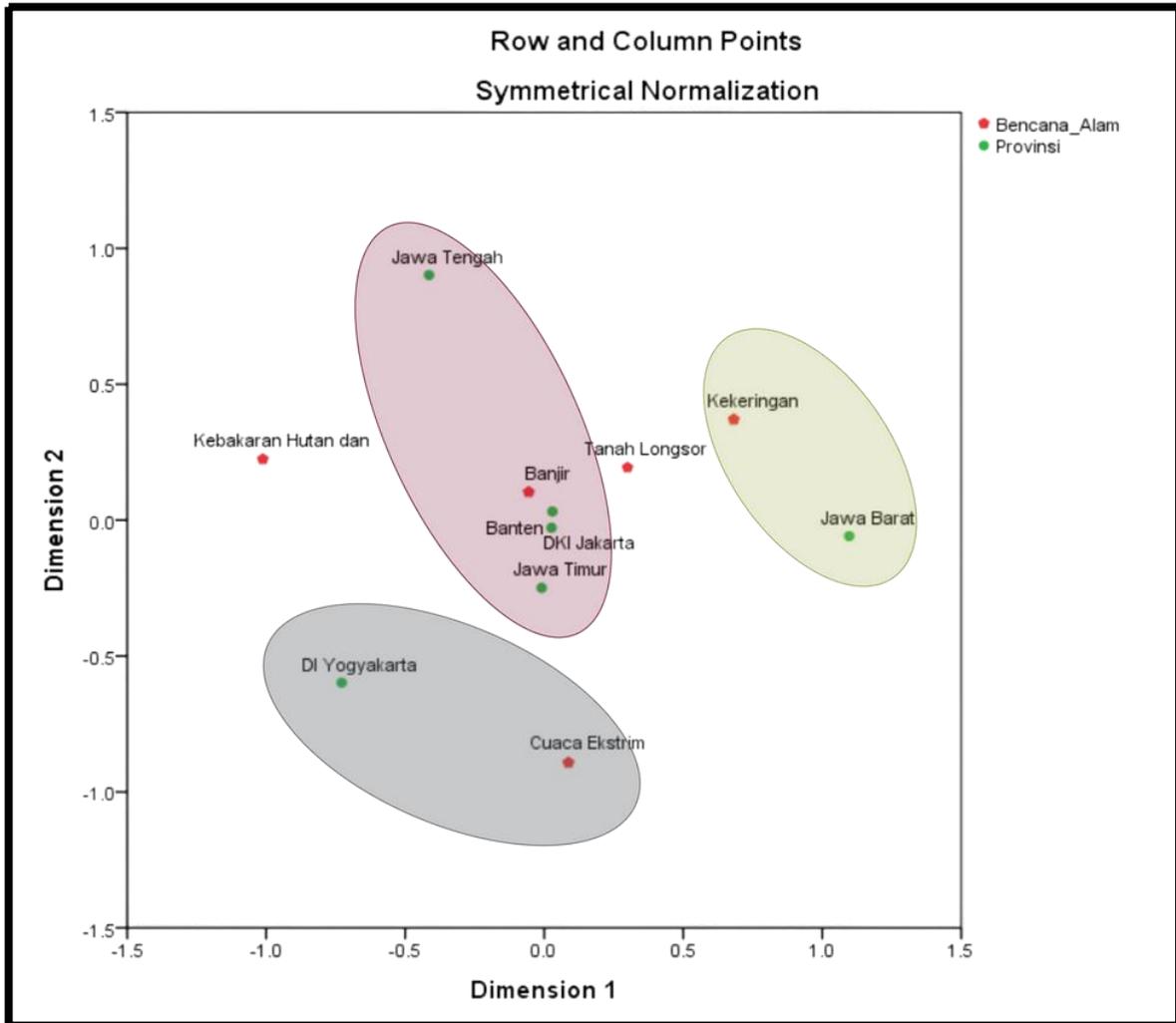


Figure 1. Graph of Natural Disaster Distribution Patterns

Based on the image above, it is known that in 2023, the Province of DI Yogyakarta is prone to natural disasters in the form of extreme weather. Then, in the provinces of Central Java, Banten, DKI Jakarta, and East Java, there is a tendency for flooding disasters to occur. Meanwhile, in the province of West Java in 2023, natural disasters in the form of drought are likely to occur.

#### 4. CONCLUSION

Based on the results of the analysis, the following conclusions were drawn.

1. The provinces most frequently affected by natural disasters are Central Java and the most common natural disasters are land and forest fires.
2. Dependency testing shows a relationship between the type of natural disaster and the provinces on the island of Java in 2023.
3. The correspondence analysis results show that in 2023, the Special Region of Yogyakarta tends to experience natural disasters in the form of extreme weather, while Central Java, Banten, DKI Jakarta, and East Java tend to experience floods. Meanwhile, West Java tends to experience natural disasters in the form of drought in 2023.

The suggestion for further research is that researchers can expand and use this research as a basis for more complex future research. The suggestion for readers is to use the information in this study as a reference to understand the natural disaster phenomena that often hit Java Island. The suggestion for government agencies or policy makers is to design and implement appropriate policies in dealing with disaster issues. This will help in improving preparedness and mitigating the impact of disasters on the community.

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**AUTHOR CONTRIBUTIONS STATEMENT**

This study was conducted collaboratively by the authors following the Contributor Roles Taxonomy (CRediT). All authors have read and approved the final manuscript.

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C : Conceptualization	I : Investigation	Vi : Visualization
M : Methodology	R : Resources	Su : Supervision
So : Software	D : Data Curation	P : Project administration
Va : Validation	O : Writing - Original Draft	Fu : Funding acquisition
Fo : Formal analysis	E : Writing - Review & Editing	

**CONFLICT OF INTEREST STATEMENT**

Authors state no conflict of interest.

**DATA AVAILABILITY**

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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