



Mapping Regional Characteristics of National Resilience Through Data Mining Approaches

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Article Info:

Abstract

Keywords:

Artificial Intelligence;
Dimensions/Gatras of National Resilience;
K-means;
Similarity of Characteristics;
National Resilience;
Regional Clusters

Purpose: This study aims to assess Indonesia's national resilience in the VUCA (Volatility, Uncertainty, Complexity, Ambiguity) era by evaluating the characteristics of regional resilience and their interrelationships. The research focuses on the use of computational methods, including artificial intelligence, to classify regions based on national security conditions and identify effective measures to enhance national resilience.

Study Design/Methodology/Approach: The study utilizes public policy simulations and a national resilience index developed by Lemhannas. This system assesses national resilience through regional evaluations, considering both natural and social determinants. Computational methods such as K-means clustering and the Davies-Bouldin index were applied to classify regional resilience. The interactions between variables were analyzed, emphasizing the importance of regional characteristics in policy formulation.

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Findings: The research identified seven regional clusters through the K-means clustering method and the Davies-Bouldin index test, which effectively enhance national resilience. These clusters provide detailed insights into regional similarities, which are critical for designing targeted policies aimed at improving national resilience. The findings highlight the role of computational methods in processing extensive data and guiding policy decisions to strengthen regional and national resilience.

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Originality/Value: This study presents an innovative approach to assessing and enhancing national resilience in Indonesia by employing artificial intelligence and computational methods. By identifying and analyzing regional clusters and characteristics, the research offers valuable insights for policymakers to develop strategic, data-driven policies for strengthening national resilience. The integration of both natural and social determinants into the resilience assessment contributes to a more comprehensive understanding of the resilience dynamics at both regional and national levels.

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INTRODUCTION

The digital era, often characterized by volatility, uncertainty, complexity, and ambiguity (VUCA), presents a new level of complexity for global dynamics. In this context, countries must enhance their capacity to confront an increasing variety of threats, challenges, obstacles, and disturbances. For Indonesia, national resilience is a crucial strategy for navigating these complexities. National resilience can be understood as the capacity of a nation to return to a stable condition when exposed to disruption or pressure, ensuring both the survival of the nation and its ability to achieve national goals (Daihani, 2024).

Resilience, as defined by the Oxford English Dictionary, refers to "the ability to recover quickly from difficulties (toughness)" and "the ability of a substance or object to spring back into shape (elasticity)." Other dictionary definitions further elaborate resilience as "the ability to recover quickly from illness, change, or misfortune (buoyancy)" and "the property of a material that enables it to resume its original shape or position after being bent, stretched, or compressed (elasticity)." This adaptability and robustness are equally important for organizations, where resilience is described as "the ability of an organization to anticipate, prepare for, respond to, and adapt to incremental change and sudden disruptions in order to survive and prosper."

In Indonesia, the concept of resilience is deeply embedded in its national security framework. Prof. Muladi, a former Governor of Lemhannas (2005–2011), articulated that national resilience can be approached through two lenses: engineering and social perspectives (Lemhannas RI, 2018). The engineering perspective views resilience as a system's ability to return to its original form after being subjected to stress or disturbance, whereas the social perspective emphasizes the nation's capacity to adapt, interact with its environment, and withstand pressures that may come from external or internal forces.

Lemhannas provides a more holistic definition of national resilience, describing it as "a dynamic condition encompassing all aspects of integrated national life, characterized by tenacity and the ability to strengthen national power in overcoming challenges, threats, obstacles, and disturbances from both external and internal sources." This condition ensures the continuity of Indonesia's identity, integrity, and survival, while also supporting the achievement of its long-term national objectives.

The nature of national challenges has evolved significantly over time, especially with global developments. During the Cold War, national resilience was largely determined by geopolitical tensions, where conflicts between countries were shaped by geographic factors and territorial disputes. Today, with the rise of Industry 4.0 and Society 5.0, challenges are no longer confined to traditional geopolitical struggles but have expanded to include geo-cybernetic issues such as cybercrime, cybersecurity, and cyber warfare, often fueled by advancements in artificial intelligence. These shifts necessitate a rethinking of national resilience strategies to address not only physical threats but also the growing spectrum of digital and cyber risks.

Technological advancements have fundamentally altered how nations operate and think. What was once an analog way of life has now become digital, influencing everything from communication to national security (Lemhannas RI, 2018). These changes prompt several critical questions: How will these advancements impact human life and governance? What new challenges to national resilience will arise in the future?

And most importantly, how can nations like Indonesia strengthen their resilience in this fast-changing world?.

Recognizing these complexities, Indonesia has prioritized the strengthening of national resilience as a strategic imperative for maintaining state stability. According to Lemhannas' National Resilience Index, Indonesia scored 2.77 in 2023, indicating a relatively strong position in the face of emerging threats (Lemhannas RI, 2022). While this score reflects the nation's ability to manage these threats, it also reveals internal weaknesses that require immediate attention to prevent them from undermining national stability. A closer examination of the data shows variations in resilience across regions, with some areas demonstrating stronger resilience than others (see Table 1).'

The variations in resilience across regions indicate the need for a tailored approach to strengthening national resilience. A key factor in ensuring effective national resilience lies in understanding the strengths and weaknesses of each region. This article will analyze the regional disparities and explore the underlying factors that contribute to resilience in different provinces.

The development of Indonesia's National Resilience Index over the past seven years (2017–2023) demonstrates an overall upward trend. Starting at 2.63 in December 2017, the index rose steadily, peaking at 2.82 in December 2019. However, a significant decline to 2.72 was observed in December 2020, likely due to the COVID-19 pandemic, which highlighted vulnerabilities during global crises. Despite this setback, the index rebounded to 2.81 in December 2021, followed by a slight decline to 2.75 in December 2022. By December 2023, the index reached its highest point at 2.89, reflecting an overall improvement in Indonesia's national resilience despite fluctuations during challenging periods. This consistent upward trend indicates that while the country faced challenges, especially during the pandemic, it has made substantial efforts to stabilize and strengthen its resilience. The post-pandemic recovery, indicated by the increased resilience in 2021 and the sharp rise in 2023, suggests that Indonesia has effectively managed to address its internal weaknesses, laying a stronger foundation for the future. (Lemhannas RI, 2017, 2018, 2019, 2020, 2021, 2022, 2023).

Table 1. National Resilience Per Region

No.	Region	Index
1	NASIONAL	2,89
2	ACEH	2,93
3	SUMATERA UTARA	2,86
4	SUMATERA BARAT	3,04
5	RIAU	3,08
6	JAMBI	2,96
7	SUMATERA SELATAN	3,02
8	BENGKULU	2,99
9	LAMPUNG	3,01
10	KEPULAUAN BANGKA BELITUNG	3,02
11	KEPULAUAN RIAU	2,99
12	DKI JAKARTA	2,92
13	JAWA BARAT	2,87
14	JAWA TENGAH	3,03
15	BANTEN	2,99
16	JAWA TIMUR	2,99
17	D. I YOGYAKARTA	3,15
18	BALI	3,09

19	NUSA TENGGARA BARAT	2,99
20	NUSA TENGGARA TIMUR	2,91
21	KALIMANTAN BARAT	2,91
22	KALIMANTAN TENGAH	3,07
23	KALIMANTAN SELATAN	2,96
24	KALIMANTAN UTARA	2,52
25	KALIMANTAN TIMUR	3,02
26	SULAWESI UTARA	3,02
27	SULAWESI TENGAH	3,01
28	SULAWESI SELATAN	2,95
29	SULAWESI TENGGARA	2,94
30	GORONTALO	3,03
31	SULAWESI BARAT	2,96
32	MALUKU	2,92
33	MALUKU UTARA	2,91
34	PAPUA BARAT	2,8
35	PAPUA	2,84

Source: Labkurtannas [2-8]

Building upon the data from the Kurtannas Lab, this study aims to analyze the regional disparities in national resilience and explore the commonalities and differences in resilience characteristics across Indonesia's provinces. Previous measurements have not yet identified the key differentiating factors or clusters that contribute to these regional variations. This gap in understanding makes it challenging for the government to systematically and efficiently formulate effective strategies to enhance national resilience nationwide. Consequently, this article will focus on two key aspects: (1) grouping regions based on National Resilience Dimensions across all Gatras, and (2) mapping the strengths and weaknesses of each region in relation to its Gatras. By analyzing these regional groupings and identifying resilience patterns, this study seeks to provide insights that will enable the government to develop more targeted and effective strategies to strengthen national resilience and ensure long-term stability.

Literature Review

The use of the clustering method in research is not an entirely novel phenomenon. The 2024 issue of Elsevier contains around 9,000 articles only dedicated to clustering, discussing both the implementation and development of the algorithm. Clustering is primarily used as an analysis technique to group unlabelled data and extract meaningful information. However, research on national resilience, particularly focusing on the classification of provincial characteristics based on dimensions of national resilience, is still very rare—if it exists at all. Therefore, this literature review will delve into the basic concepts of national resilience and briefly touch on clustering concepts and methods.

Basic Concepts of National Resilience

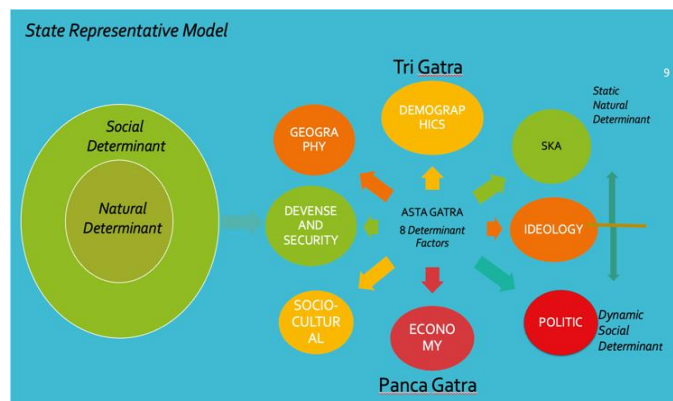
Referring to the definition of National Resilience above, to measure national resilience, it is necessary to determine the dimensions, variables, and parameters of national resilience. For this reason, it is necessary to develop a logic model that is able to represent all the resilience and tenacity of all aspects of national life. Based on the concept of the development of an organism, a system basically consists of two subsystems, namely the physical subsystem and the management system. In the context of a country, the physical subsystem reflects its natural determinants, while the management subsystem

represents its social subsystem. In the National Resilience concept developed by Lemhannas, the subsystem is further broken down into sub-subsystems and given the term *Gatras*. The physical or natural determinant subsystem consists of three *Gatras* (*Tri Gatra*), namely the Geography *Gatra*, which reflects the physical area; the Natural Wealth Resources *Gatra*, or SKA, which is the various natural resources owned at the boundaries of its geographical area; and the last one is the Demography *Gatra*. which represents all citizens with all their characteristics.

Meanwhile, the other subsystem, namely the Management subsystem, describes various activities in running this country, which are also called social determinants. In a country, these social determinants are relatively dynamic and can be represented through five (5) subsystems or forces, namely ideology, political forces, economic forces, socio-cultural forces, and defense and security (Defense and Security) forces. These five *gatras* are called *Panca Gatra*.

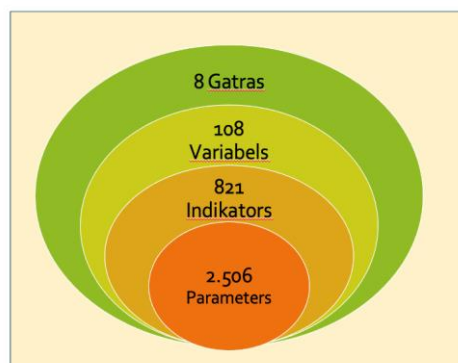
Based on the description of the logic model of State representation, the concept of *Asta Gatra* (static *Tri Gatra* and dynamic *Panca Gatra*) was born, which became an important element in the development of the concept of National Resilience. Based on these eight (8) *gatras*, national resilience is measured through the preparation of a resilience index for each *gatra*, which is aggregated into a National Resilience Index. See figure 1.

Figure 1. Logic Model of Country Representation (Daihani, 2019)



To be able to measure the resilience of each *gatra*, it is further broken down into aspects, variables, indicators and parameters of each *gatra* according to the definition and understanding of *gatra* in the conception of national resilience. See figure 2.

Figure 2. Structures, Variables, Indicators, and Parameters of *Gatras*



Clustering Concept

Clustering algorithms, a category of unsupervised learning techniques, are used to partition objects in a dataset into groups based on shared characteristics. Clustering is the process of grouping data into clusters so that data within the same cluster has maximum similarity, while data between clusters has minimum similarity (INDONESIA, 2019). Thus, clustering partitions a set of data objects into subsets called clusters, where objects in the same cluster share similar characteristics (Sidi et al., 2021). Today, with the availability of various applications such as RapidMiner, clustering can be easily performed using specific algorithms, such as the k-means clustering method.

Clustering algorithms, a category of unsupervised learning techniques, are used to partition objects in a dataset into groups based on shared characteristics (Nasional et al., n.d.). Tan (2006) defines clustering as the process of grouping data into clusters so that data within the same cluster has maximum similarity, while data between clusters has minimum similarity (INDONESIA, 2019). In essence, clustering partitions a set of data objects into subsets called clusters, where objects within a cluster share similar characteristics (Sidi et al., 2021). Today, with the availability of applications like RapidMiner, clustering can be easily performed using specific algorithms, such as the k-means clustering method.

METHODS

The research methodology applied in this study follows the CRISP-DM (Cross-Industry Standard Process for Data Mining) approach, which was simplified into four main steps: defining the field of study, preparing the data structure, determining the appropriate method, and interpreting the results.

The first step, Defining the Field of Study, involved establishing the scope of the research, which aimed to analyze the similarities in characteristics among regions in Indonesia based on their national resilience index. The data source used for this analysis was obtained from Lemhannas' national resilience index measurements.

In the second step, Preparing the Data Structure, the raw data from Lemhannas was processed and reformatted using various features available in Excel. This step included data cleaning to ensure the accuracy of the attributes to be analyzed, focusing primarily on the provinces and their respective levels of national defense over multiple years, as discussed in the introduction.

The third step, Determining the Method, involved the selection of a clustering model to group the provinces based on their national resilience index. The k-means clustering algorithm was employed, and the effectiveness of the clusters was assessed using the Davies-Bouldin index, which helped to optimize the grouping process.

The final step, Interpretation of Results, focused on analyzing and interpreting the output of the clustering model. This involved mapping the similarities and differences among provinces and drawing conclusions in alignment with the study's objectives. The data was further visualized to provide clear insights into the clustering results. The tools used for data processing and analysis, including the clustering process, were carried out using RapidMiner, as shown in the accompanying diagrams. these steps can be seen in Figure 3 & 4.

Figure 3. Steps in implementing the study

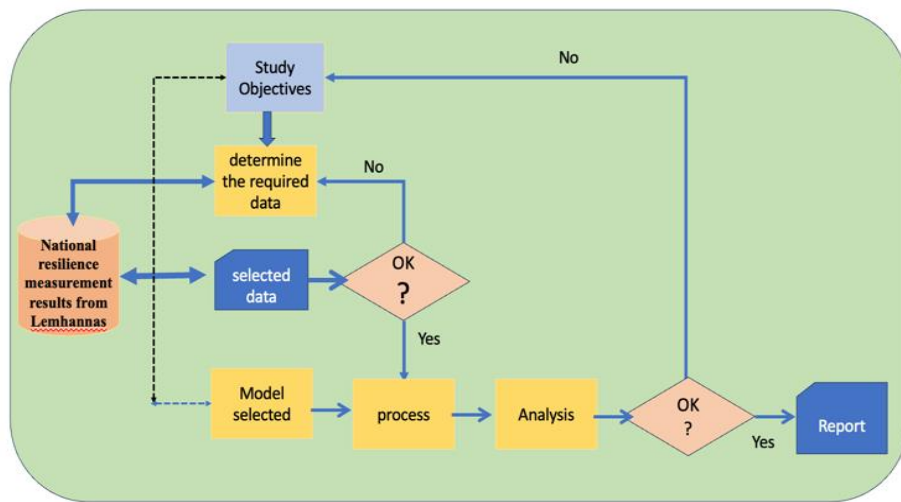
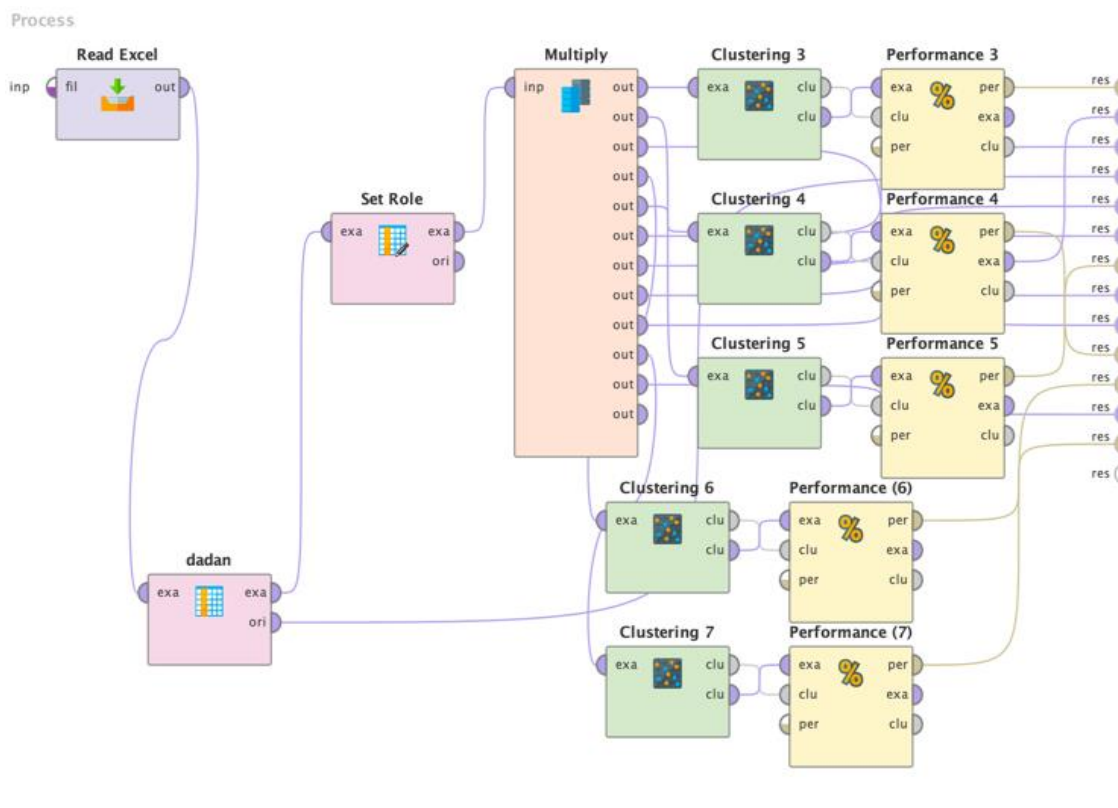


Figure 4. Clustering process



RESULT AND DISCUSSION

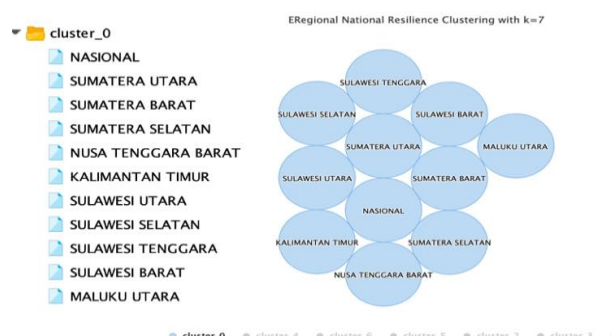
From the clustering results based on k-mean 7, various results were obtained, some of which can be seen in general in the figures 5.

Figure 5. Visualization of 7 clusters



The clustering analysis resulted in seven distinct clusters, each representing different regions of Indonesia grouped based on their national resilience index. These clusters offer insights into the similarities and differences in regional resilience characteristics across the country and have significant implications for policy formulation in enhancing national resilience.

Figure 6. Visualization of Cluster 0



Cluster 0 includes 11 provinces (see figure 6), mainly from Sulawesi, with the exception of Gorontalo and Central Sulawesi, and also parts of northern Sumatra. These provinces exhibit similar resilience characteristics, particularly in defense and social stability. Sulawesi, with its robust agricultural and fisheries sectors, provides a stable economic foundation that supports regional resilience (Tomich et al., 2001). This highlights the importance of regional cooperation, as islands with shared economic interests tend to exhibit greater resilience to external threats. The presence of both Sulawesi and Sumatra provinces in this cluster suggests that geographical proximity is not the sole determinant of resilience. Instead, regional economic structures and social

cohesion play a more significant role. National policies aimed at strengthening regional resilience should consider these socio-economic factors.

Cluster 1 consists solely of North Kalimantan, which recorded the lowest national resilience score. The province's geographic isolation, underdeveloped infrastructure, and limited access to resources contribute to its low resilience. According to Yates (2012), newly formed regions, like North Kalimantan, often struggle to establish governance and infrastructure, resulting in lower resilience. Regions with limited connectivity face significant challenges in mobilizing resources and recovering from disruptions (Gunderson & Holling, 2002). North Kalimantan's position as an outlier underlines the need for targeted interventions, such as infrastructure development, capacity building in governance, and investments in education and health services. These strategies are crucial for improving resilience in such regions, as supported by resilience theory, which advocates tailored approaches for areas with weaker infrastructure (Walker et al., 2006).

Cluster 2 includes five provinces, encompassing most of Kalimantan and Central Java. The inclusion of Central Java, an economic hub, alongside less developed Kalimantan provinces is surprising. This anomaly can be attributed to environmental degradation in Central Java, which has become a significant issue (Dewi et al., 2017). Despite its economic and infrastructural strength, environmental sustainability challenges may explain why Central Java aligns with the Kalimantan provinces in this cluster. This grouping demonstrates that resilience is multi-dimensional, with economic factors alone insufficient to prevent environmental vulnerabilities. As noted by O'Brien et al. (2007), even regions with strong economies may face substantial environmental risks, necessitating policies that integrate environmental management into economic planning to build sustainable resilience.

Cluster 3 is notable for including only two provinces: DI Yogyakarta and Bali. These provinces demonstrate high levels of social cohesion and educational attainment, which are key contributors to resilience. Regions with high cultural capital, such as Yogyakarta and Bali, tend to exhibit greater social resilience (Jacobs, 2006). Bali's reliance on tourism, paired with strong governance, has allowed it to recover quickly from shocks like the Bali bombings in 2002 (Beirman, 2003). Similarly, Yogyakarta's long-standing reputation as a cultural and educational hub has fostered its adaptability to changing socio-economic conditions. These provinces serve as models of resilience, showing that social capital, cultural identity, and economic diversification are vital for building resilient communities. As Cutter et al. (2008) suggest, social resilience is critical for mobilizing resources and responding effectively to challenges. National strategies could focus on promoting cultural and educational development to replicate these resilience-building conditions in other regions.

Clusters 4 through 6 reflect varying levels of resilience based on specific attributes. Cluster 4, which includes West Java, Aceh, Papua, and West Papua, demonstrates how provinces with strong regional identities and political autonomy often struggle to integrate with national resilience frameworks. Research by Bertrand (2004) indicates that regions with strong autonomy movements, such as Aceh and Papua, face difficulties in aligning with national policies, which can hinder resilience. Cluster 5, comprising Jambi, Lampung, and East Java, exhibits economic resilience but moderate social cohesion, likely due to economic disparities within these provinces. Meanwhile, Cluster 6, which includes nine provinces (Riau, Bengkulu, Bangka Belitung, Kepulauan Riau, DKI Jakarta, Banten, Nusa Tenggara Timur, Gorontalo, Maluku) shows balanced resilience,

suggesting a comprehensive approach to development that integrates social, economic, and environmental strategies. The diversity in resilience across these clusters highlights the need for tailored policies that address the unique challenges of each region. For example, Cluster 4 could benefit from policies aimed at improving national integration, while regions in Cluster 5 should prioritize addressing social disparities to complement their economic resilience.

Table 2. Distribution of *Gatra* Resilience Scores per Cluster

Attribute	cluster_0	cluster_1	cluster_2	cluster_3	cluster_4	cluster_5	cluster_6
GEOGRAFI	3.026	2.750	3.494	3	3.380	3.360	3.103
DEMOGRAFI	3.207	2.930	3.198	3.480	2.910	3.537	3.136
SKA	2.629	2.050	2.652	2.215	2.653	2.527	2.279
IDEOLOGI	2.815	2.140	2.982	3.060	2.553	2.713	2.841
POLITIK	3.097	2.010	2.946	3.265	2.867	3.147	3.112
EKONOMI	3.052	3.110	3.112	3.065	2.985	3.013	3.099
SOSBUD	2.695	2.360	2.672	3.305	2.565	2.710	2.952
HANKAM	3.198	2.890	3.092	3.350	3.170	3.153	3.203

The analysis table 2, distribution of *Gatra* resilience scores across clusters reveals specific strengths and weaknesses. Cluster 3 (Yogyakarta and Bali) leads in socio-cultural and economic resilience, while Cluster 1 (North Kalimantan) shows vulnerabilities across most *Gatras*, except for economic resilience. As noted by Carpenter et al. (2001), focusing on the weakest aspects of resilience can yield significant improvements, making this a relevant approach for addressing the challenges faced by regions like North Kalimantan.

The clustering results provide a structured framework for developing targeted national resilience strategies. These findings align with Cutter et al. (2008), who emphasize the importance of differentiated policies based on regional resilience characteristics. Regions that share resilience attributes, even if geographically separated, can benefit from collaborative policy efforts. On the other hand, outlier regions like North Kalimantan require customized interventions to address their unique vulnerabilities. These findings underscore the need for more nuanced, region-specific approaches to resilience, as advocated by Walker et al. (2006).

CONCLUSION

Based on the results of the data processing and analysis, this study provides a comprehensive understanding of regional resilience across Indonesia by clustering the provinces according to their National Resilience Index. The findings reveal that the similarities in resilience characteristics among provinces are not necessarily determined by geographic proximity, but rather by shared socio-economic, political, and cultural factors. This highlights that resilience is influenced by complex interactions between internal regional dynamics and broader national factors, such as governance, infrastructure development, and socio-economic stability.

The clustering analysis revealed several key insights. Provinces with similar resilience levels often share common approaches to addressing threats and vulnerabilities,

regardless of their geographic locations. For instance, regions with strong social cohesion and economic diversity tend to have higher resilience, while regions that struggle with political instability or lack of infrastructure face more significant challenges. This study demonstrated that resilience is a multi-dimensional construct, and simple geographic proximity does not adequately explain the clustering patterns observed.

However, the analysis also underscores the need for further research to fully understand the various factors that contribute to national resilience at the provincial level. The study identified the importance of exploring variables beyond the traditional "gatra" pillars, such as economic diversity, governance quality, and social capital. By incorporating a wider range of variables and indicators, future studies could provide more detailed insights into how these factors interact to shape resilience outcomes in different regions. Additionally, future research could examine the dynamic changes in resilience over time, especially in response to external shocks such as natural disasters or economic downturns.

In conclusion, this study provides valuable insights into the regional variations in resilience across Indonesia and offers a framework for more targeted policy interventions. The findings suggest that enhancing national resilience requires policies that are tailored to the specific socio-economic and political contexts of each region. Policymakers should focus on strengthening governance, investing in infrastructure, and promoting social cohesion, particularly in regions with lower resilience scores. Ultimately, this study contributes to a deeper understanding of the factors influencing national resilience and provides a foundation for future research aimed at developing more effective strategies for building a stronger and more resilient Indonesia.

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