Spatial Analysis of the Economic Resilience Index during COVID-19 in the Marginal Land of the Gunungsewu Karst Area, Gunungkidul, Indonesia

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DOI: https://doi.org/10.52939/ijg.v20i8.3457

Abstract
The global COVID-19 pandemic, which began in March 2020, has significantly impacted global health, causing symptoms ranging from mild flu to severe illness and death. This condition has also severely hampered economic activities, particularly in marginalized communities such as the Gunungsewu Karst Area in Gunungkidul, Indonesia. This study aimed to analyze the spatial distribution of economic resilience during COVID-19. The study employed a combined approach, incorporating both qualitative and quantitative methods. Qualitative data collection was conducted through expert interviews to determine the weight of economic resilience factors using the Analytic Hierarchy Process. Quantitative data was gathered through questionnaires. Data processing of the economic resilience index distribution was carried out using Geographic Information Systems. The results indicate that 81.36% of respondents in the marginal land of Gunungsewu earn less than the regional minimum wage, with a monthly income of less than 113.98 USD. The highest level of education for 34.69% of respondents is elementary school, and 95.92% are employed in the informal sector. The economic resilience index comprises six factors: socio-economic conditions, infrastructure, institutions, communities, natural resource utilization, and information and communication technology use. The spatial distribution of the economic resilience index varies among villages in the study area, with three distinct patterns: high-class resilience (50%), moderate-class resilience (37.5%), and low-class resilience (12.5%). This study highlights the predominance of high-class economic resilience in the research area, despite its marginal land status. Spatial analysis of the economic resilience index is crucial for informing targeted policies aimed at disaster risk reduction.

Keywords: Analytic Hierarchy Process, COVID-19, Economic Resilience, Gunungsewu, Spatial Analysis

1. Introduction

The coronavirus was first identified in December 2019, and by March 11, 2020, COVID-19 had been declared a global pandemic [1]. Caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), the pandemic is transmitted through droplets from infected individuals, leading to pneumonia, severe illness, and death [2]. COVID-19 was initially detected in Wuhan, China, in December 2019 and subsequently spread worldwide [3]. The pandemic has affected more than 227 countries and territories[4], making it the most severe health disaster of this century. The widespread lockdowns in 2020 had a direct negative impact on economic activity. Pre-crisis data indicates that over 50% of households in both advanced and emerging economies could not maintain their basic standard of living for more than three months in the event of income loss [5]. The impact of COVID-19 was also felt in Girisubo Village, Gunungkidul, Indonesia, with 342 cases reported between March 23, 2020, and March 23, 2021 [6]. This region, characterized by marginal land, had a poverty line of only 18.48 USD per capita/month in 2019 (before COVID-19), below Indonesia's national average of 27.03 USD per capita/month. The community's economic condition deteriorated, with economic growth declining to -0.69% at the start of the pandemic in 2020. Identifying the economic resilience index using spatial geographical analysis is essential for disaster risk reduction at the research site.

Economic resilience refers to the capacity to quickly recover from external shocks, reallocate resources, modify the industrial structure, and undergo continual transformation and upgrading [7]. The intensity and duration of crises and shocks vary, as do their effects on regional economies and resilience [8]. Each crisis and shock has unique characteristics, and certain regions are more resilient to the ongoing effects of multiple crises (economic crises, natural disasters, and terrorist acts) worldwide. In other words, the capacity of various locations to endure and recover from shocks varies. Different conditions and handling of economic resilience are evident in each region [9], as seen in the Gunungsewu Karst Area in Girisubo District, which features unique environmental variations with karst hilly landforms.

Despite the COVID-19 pandemic emerging in 2019, there has been limited research on its impact. Previous studies on economic resilience through spatial analysis have primarily focused on natural disasters such as eruptions and floods [10] and [11]. The application of spatial technologies, particularly geographic information systems, to assess economic resilience during COVID-19 has not been extensively explored. When studies do exist, they often rely on mathematical calculations without incorporating a geographical spatial approach [12]. Additionally, the development of economic resilience factors has predominantly focused on socio-economic aspects, neglecting physical environmental conditions [13] and [14]. Most research on economic resilience during COVID-19 has been conducted in developed countries like Italy, Germany, Austria, and Canada [15] and [16]. In contrast, studies in developing countries, particularly Indonesia, remain limited, especially in the Gunungsewu Karst Area, Gunungkidul. This region features unique environmental characteristics, including landforms of solutional origin such as karst hills, and in the southern part, coastal alluvial plains. Gunungsewu's distinct geographical conditions are recognized as part of the UNESCO Global Geopark and Regional Network [17] and [18]. Thus, there is a gap in existing research that addresses economic resilience using a comprehensive geographical approach during the COVID-19 pandemic in the marginal lands of the Gunungsewu Karst Area, Gunungkidul, Indonesia.

The definition of economic resilience in this study is the ability to protect oneself or restore economic conditions during the COVID-19 disaster by effectively optimizing geographical resources to support sustainable development [15]. The economic resilience index (ERI) is compiled using a mixed-methods approach, incorporating both qualitative and quantitative methods [19]. This approach provides comprehensive information for identifying the economic resilience of the study location. The Analytic Hierarchy Process (AHP) is used to weight economic resilience factors, with expert assessments considered. The economic resilience factors include not only economic conditions but also natural resources. The six factors of economic resilience are socio-economic conditions, infrastructure, institutions, communities, the use of natural resources, and the use of information and communication technology. Data was collected using questionnaires from a sample of 49 households selected through probability sampling techniques.

Questionnaire data was processed using SPSS software, followed by geospatial information technology to produce a spatial distribution map. Geographic Information Systems (GIS) technology provides information that is easily understood by the community, government, and stakeholders [20] and [21]. Identifying an economic resilience index with a spatial geographical approach using GIS in the marginal lands of Gunungsewu Karst, Girisubo, Gunungkidul, Indonesia, represents a novel approach in research, aimed at reducing disaster risk and supporting community welfare. Therefore, this study aims to identify the economic resilience index using spatial analysis for decision-making to reduce the risk of COVID-19 disasters in the marginal land of the Gunungsewu Karst Area, particularly in Girisubo District, Gunungkidul, Indonesia.

2. Methodology

2.1 Research Location

Gunungsewu is a Javanese word that means "a thousand mountains." It is the largest karst area in Java, Indonesia, covering about 1,300 km^2. Karst regions have unique ecosystems encompassing physical, biotic, and social aspects [18]. The Gunungsewu Karst Area is characterized by distinct geomorphological features, both on the surface (exokarst), such as dolines, uvalas, poljes, dry valleys, karst lakes, and subsurface (endokarst), including underground rivers. Geomorphologically, the Gunungsewu karst is of tertiary age, located in the southern zone of Java, bordering the Indian Ocean, and stretching across the Bantul, Gunungkidul, Wonogiri, and Pacitan areas. The unique characteristics of the Gunungsewu karst have led to its recognition as a Global Geopark Network (GGN) by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) since 2015 [22]. A geopark is an area that features significant geological elements, including archaeological, ecological, and cultural values, with local communities involved in protecting and enhancing the function of natural heritage.

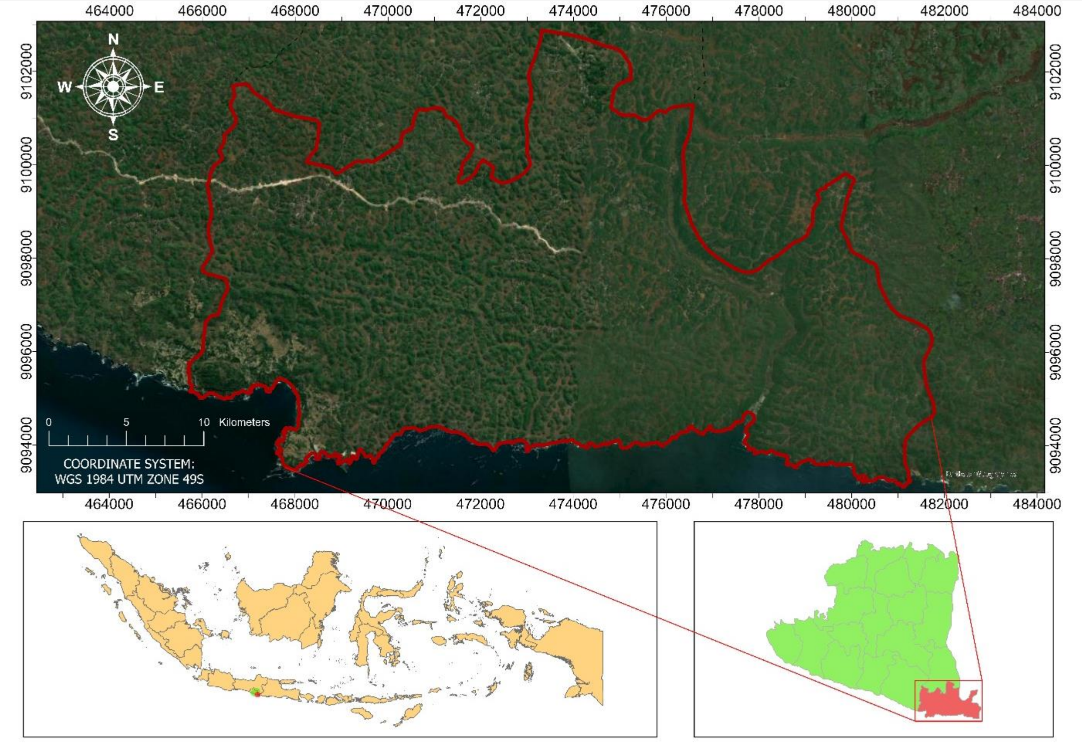

Figure 1: Girisubo District, Gunungkidul Regency, Indonesia

Girisubo District in the Gunungsewu Karst Area has distinctive geographical conditions, dominated by karst hills and coastal alluvial plains in the southern part. The district comprises eight villages: Nglindur, Balong, Jepitu, Pucung, Jerukwudel, Songbanyu, Karangawen, and Tileng [23]. However, this study area was severely affected by the COVID-19 pandemic, making it necessary to identify the economic resilience index for disaster risk reduction. The description of the study area is shown in Figure 1.

2.2 Research Design

This study used a mixed methods research design, incorporating both quantitative and qualitative approaches. A qualitative approach was employed to explain the phenomenon in depth through in-depth interviews with experts and field surveys to document conditions. A quantitative approach was used for further data collection, employing questionnaires with closed questions related to the condition of economic resilience factors [24]. The research is divided into three main stages: input, process, and output. The first stage, input, involves developing economic resilience factors based on previous research through a literature review. Factors in economic resilience include socioeconomic conditions [25], infrastructure [26], the role of government /institutional factors [27] and [28], communities [27], the use of information and communication technology [29], and the use of natural resources [30]. The economic resilience factors developed in this study complement previous research that focused only on non-physical environmental factors. The factors used are more comprehensive, considering both physical and non-physical environmental conditions through a geographical approach. The second stage, the process, involves assessing AHP to obtain scores and weight factors through expert brainstorming. Experts selected for input are those working or conducting studies related to economic resilience in disaster conditions. Seven experts were selected from fields relevant to the research objective, such as geography, planning, health, government/policy making, and academia. Data were then collected through closed-question questionnaires in Girisubo, Gunungkidul using interview techniques. The data were processed statistically using Statistical Product and Service Solution (SPSS) 25 software and spatial analysis was conducted using ArcGIS 10.8 software to obtain a distribution map of the community's economic resilience index. The research output is a map of the economic resilience index during COVID-19 in the Marginal Land Gunungsewu Karst Area, Girisubo District, Gunungkidul Regency, Indonesia. The research flow is illustrated in Figure 2.

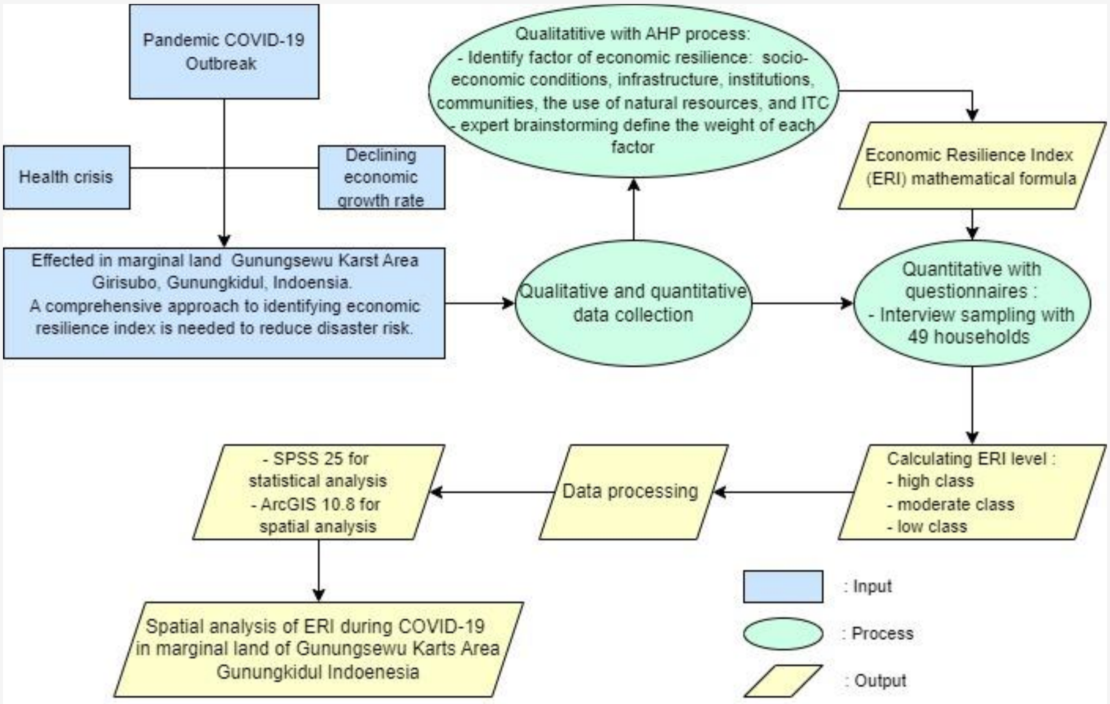

Figure 2: Research flowchart

2.3 Research Samples and Data Collection

The research population consisted of households living at the study site. The total population was 8,108 households, but the study used a sample determined by the Isaac and Michael formula with a 5% error rate. The sample size was 49 households. Probability sampling techniques were used to save time and effort while still obtaining optimal data. The households samples were taken proportionally from 8 villages locations in Girisubo District to ensure the data obtained represents the actual conditions. Data collection was conducted in June 2022, during the COVID-19 pandemic, adhering to health protocol procedures. After the questionnaire data filling was completed, the data input process and statistical tests are carried out using SPSS 25 software. To assess the quality of the questionnaire data, validity tests were conducted using the product moment Pearson correlation, resulting in a Sig. (2-tailed) value of 0.000, indicating validity (Sig. $<$ 0.05). The reliability test, using Cronbach's Alpha, yielded a value of 0.814, which is greater than 0.60, indicating realistic data [31].

Data collection was carried out using questionnaires containing questions covering several variables in economic resilience: socioeconomic conditions, infrastructure, the role of government, communities, the use of information and communication technology, and the use of natural resources. Previous studies provided the basis for the factors used in this study. Previous research on economic resilience often focused solely on socioeconomic aspects while this study complemented the economic resilience factors by also considering the physical condition of the environment, such as the use of natural resources. Previous studies were limited to one to three factors, but this study is more comprehensive, incorporating six factors to identify economic resilience. A comparison of economic resilience factors used in this study with those in previous studies can be seen in Table 1. The economic resilience factor that was built complements the economic resilience factor in previous research by involving non-physical environmental and physical environmental factors.

The score and weighting values of the economic resilience index are obtained using AHP, resulting in a mathematical formula to calculate the economic resilience index. The weighting values are derived from the assessments of experts working in fields related to economic resilience. Six experts participated, comprising one government official, two academics, two industry professionals, and one health expert. The assessment was conducted using a comparative scale from 1 to 9, including categories such as equal important for 1, slightly more important of 3, strongly important for 5, very strongly important for 7, absolutely important for 9, and intermediate for 2,4,6,8 [32].

Table 1: Summary of literature review for economic resilience factors

Author(s)	Factor					
	Socio-economic (SE)	**Infrastructure (IF)**	**Institution (IN)**	**Community (CM)**	**The use of information and communication technology (ICT)**	**The use of natural resources (NR)**
Graziano [25]	√					
Permatasari [26]		√				
Cutter [27]	√		√	√		
Estoque and Murayaman [28]			√			
Mahmood et al., [29]					√	
Cimellaro and Martinelli [30]						√
Economic Resilience factors in this study	√	√	√	√	√	√

The results of the weight assessments were validated using a contingency test to ensure data accuracy. Various processes, such as pairwise comparison matrices, were employed to correlate criteria. The consistency index (*CI*) can be calculated using the equation below (Equation 1). Here are the equations examined in the study:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

Equation 1

Where, n is the number of influencing elements and λ_{max} is the dominant eigenvalue of the matrix, which is calculated from the pairwise matrix. As stated by Saaty, less should be the acceptable degree of consistency less than 0.1. To determine the inconsistency of the matrix assessment, the consistency ratio (*CR*) was used to analyze the consistency of the factors that were received from the expert assesments which can be formulated by Equation 2 [32]:

$$CR = \frac{CI}{RI} < 0.1$$

Equation 2

Where, consistency index is *CI* and random index is *RI*. The low ratio of less than 0.1 shows that the weight assigned to each element is appropriate. The following equation 2 was initially used to determine the consistency ratio (*CR*). In this study the online AHP calculator available at https://bpmsg.com/ahp/ahp-calc.php ICT was used to determine the criteria weight and the *CR* value. The weight of each factor becomes a multiplier with the score value obtained in the field, through the *ERI* mathematical formula using Equation 3:

$$ERI = \sum_{i=1}^{n} w_i R_i$$

Equation 3

Where, W_i is the weight of the factor and R_i is the score obtained in the field. Then ERI values were divided into three classes based on the area's economic resilience susceptibility zone: high, moderate, and low. The three-class division aligns with the scope of the research area at the village level which represents the condition of the *ERI* of households spatially in accordance with the research objectives [26]. This classification facilitates understanding the distribution of households economic resilience. Spatial data processing was conducted using Geographic Information Systems to obtain data on the distribution of economic resilience indices. Data analysis was carried out both qualitatively and quantitatively. The output includes further analysis of the distribution map of the community's economic resilience index at the research location.

3. Results and Discussion

3.1 Respondents' Profile in Gunungsewu Karst Area

The study sample comprised 49 respondents, all of whom were heads of households. Table 2 presents the educational backgrounds of the respondents. Education plays a crucial role in improving the quality of life as the intellectual abilities gained through education can also support economic activities [33]. Education allows individuals to gain knowledge and insight for self-development, which in turn supports economic resilience, particularly during disasters such as the COVID-19 pandemic.

Table 2: Respondents' profile

Attribute	Characteristic	Frequency (households)	Percentage (%)
Education	No schooling	4	8.16
	Elementary school graduates	17	34.69
	Junior high school graduates	14	28.57
	Senior high school graduates	12	24.49
	Bachelor's degree and higher	2	4.08
	Total	**49**	**100**
Income	< 113.98 USD	40	81.63
	113.98 USD – 227.92 USD	7	14.29
	> 227.92 USD	2	4.08
	Total	**49**	**100**
Types of job	Formal sector (e.g., civil servant, Police/Military, private company)	2	4.08
	Informal sector (e.g., farmers, drivers, fishermen, construction workers, traders)	47	95.92
	Total	**49**	**100**

Field data indicate that educational attainment at the research site is suboptimal, with most respondents (34.69%) only elementary school graduates, while only 4.08% have obtained undergraduate degrees. The limited number of higher education graduates at the research site may be due to financial constraints, lack of motivation, and limited access to information.

The 2021 regional minimum wage for Gunungkidul district was 113.98 USD. Our data reveal that 81.3% of respondents earn below this wage (Table 4). Only 4.08% of respondents earned more than 227.92 USD, which was twice the regional minimum wage. Respondents' monthly income is derived from productive economic activities [34]. This income supports economic resilience during the COVID-19 pandemic. Respondents used their income to purchase basic necessities, which was crucial for survival during the COVID-19 pandemic. Field data indicate a need to increase household income for sustainable community welfare. The majority of respondents (95.92%) worked in the informal sector, including farmers, fishermen, construction workers, drivers, and lumberjacks. Only 4.08% of respondents were employed in the formal sector, working as teachers and village officials. During the COVID-19 pandemic, formal sector workers continued to receive wages despite working from home due to physical activity restrictions. This was not the case for informal workers, who had to continue their economic activities. However, agricultural activities could still continue as they did not involve crowds[35]. The community in the Gunungsewu karst area relied on natural resources for survival during the COVID-19 pandemic.

3.2 Spatial Analysis of Economic Resilience Index during COVID-19 in Marginal Lan Gunungsewu Karst Area

Economic resilience in this study refers to the ability to survive economically during or after environmental disruptions, particularly the COVID-19 disaster, by considering various economic resilience factors through a geographical approach. The study focuses on the community's ability to maintain economic stability during the COVID-19 pandemic and considers six factors: socioeconomic conditions, infrastructure, the role of government, communities, the use of information and communication technology (ICT), and the use of natural resources. The research site, the Gunungsewu karst area, was chosen for its distinctive natural features, and the geographical approach enhances the comprehensiveness of the findings. The six factors are integrated into a mathematical formula for the economic resilience index by multiplying the weight of each factor. Socioeconomic conditions are critical, including indicators such as economic assets and household dependents. The assumption is that better economic conditions, characterized by sufficient asset ownership and fewer household dependents, contribute to stronger economic resilience. Infrastructure, such as transportation access, supports economic activities, enhancing economic resilience. The government's role is vital in providing support to improve the community's economy during the pandemic through assistance programs and community empowerment initiatives. Community support is crucial, especially for self-isolating COVID-19 patients who need help with daily needs like food, water, and medicine.

The use of ICT, such as the internet for e-commerce, can boost economic income. The utilization of natural resources, like water and crops, supports economic resilience by reducing reliance on external goods.

The weight factors defined for each factor class show varying degrees of impact on each factor. Economic resilience index (ERI) map, obtained from the results of weighting factors and sub-factors according to data in the field. The equation of integration of all factors to produce ERI is shown below (Equation 4):

$$ERI = 0.452NR + 0.175IF + 0.152IN + 0.099CM + 0.063SE + 0.058ICT$$

Equation 4

Based on the consistency calculation, a CI value of 0.546 was obtained, with a random index value of 1.24 resulting in a CR of 0.044. This calculation is a calculation from the AHP proirity calculator [36]. The CR value of 0.044, being less than 0.1, indicates that the data was consistent, allowing the next analysis process to proceed. The weight factors that were established for every factor class revealed varying degrees of impact within and derived from a pairwise comparison matrix (Table 3). The highest weight is assigned to the the use of natural resources factor (0.452), while the lowest weight is assigned to the use of ICT (0.058). The AHP-derived weights of each sub-factors are illustrated in Table 4. Total of the sub-factors that used in ERI were 12 sub-factors. The CR value for each sub-factor was 0.00, it can be concluded that the data was consistent because the CR value being less than 0.1, indicate that the data was consistent. Based on the data calculation with six constituent factors, it was found that the distribution of the economic resilience index varied in Girisubo District. The classification was divided into three classes, namely low, moderate, and high. The decision to use three classes in the ERI was based on an empirical approach. The region in the study area is characterized by a homogeneous socio-economic and demographic profile, along with similar natural resources. This uniformity, which includes shared occupations, socio-economic statuses, relatively identical landforms, and land cover conditions, justifies a more generalized classification. By employing only three classes, the author can focus the analysis more effectively, providing clearer insights into the area's resilience. This approach is well-suited to the specific characteristics of the field location and ensures that the classification is representative.

Table 3: Pairwise comparison matrix, factor weights, and consistency ratio of economic resilience factors

Factors	SE	IF	IN	CM	NR	ICT	Weight	Rank
Socio-economic (SE)	1	1/3	1/3	1	1/7	1	0.063	5
Infrastructure (IF)	3	1	1	3	1/4	3	0.175	2
Institutions (IN)	3	1	1	1	1/2	2	0.152	3
Communities (CM)	1	1/3	1	1	1/6	3	0.099	4
The use of natural resources (NR)	7	4	2	6	1	6	0.452	1
The use of ICT (ICT)	1	1/3	1/2	1/3	1/6	1	0.058	6
CR = 0.044								

Table 4: The weight of sub-factors of economic resilience index

Factors	Sub-factor	Municipality	
		Weight	Rank
Socio-economic	Economic assets	0.702	1
	Household dependents	0.298	2
The use of technology	The use of communication technology	0.541	1
	Internet access	0.459	2
Infrastructure	Road type	0.526	1
	Transportation access	0.474	2
The use of natural resources	Crops production	0.861	1
	Water utilization	0.382	2
Communities	Disaster resilience community	0.630	1
	Community participation	0.370	2
Institutions	Assistance program implementation	0.515	1
	Socialization of community empowerment	0.485	2

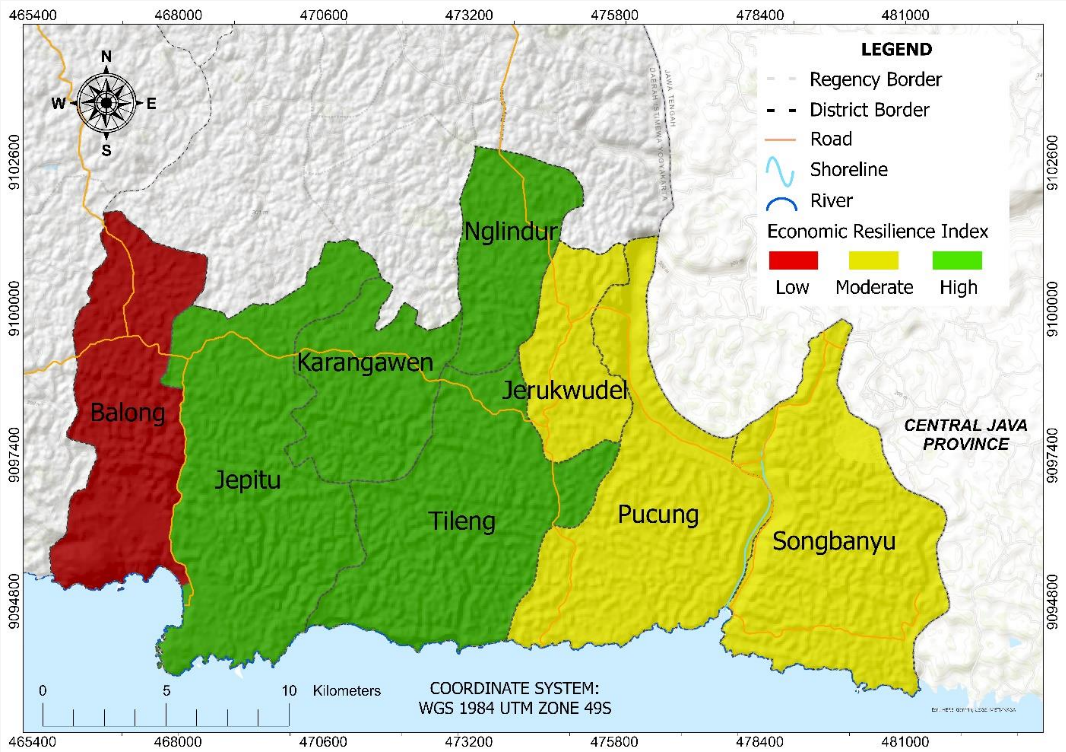

Figure 3: Distribution of economic resilience index during COVID-19 in Gunungsewu Karst, Girisubo District, Gunungkidul Regency, Yogyakarta, Indonesia

The classification interval consists of a high class with a score of 0.374–0.418, a medium class with a score of 0.330–0.373, and a low class with a score of 0.284–0.329. The high classification consisted of 50% or 4 villages (Jepitu, Karangawe, Nglindur, and Tileng), the moderate classification consisted of 37.5% or 3 villages (Pucung, Songbanyu, Jerukwudel), and the low classification consisted of 12.5% or 1 village (Balong). The highest percentage was the high class with 50%, while the lowest was the low class with only 12.5%. It can be concluded that the economic resilience of the community during the COVID-19 pandemic is dominated by high economic resilience classification. The distribution map of the economic resilience index can be seen in Figure 3.

Economic resilience with a high classification was found in 50% of the villages, specifically in Jepitu, Karangawe, Nglindur, and Tileng (Figure 3). High economic resilience indicates a strong economic ability to face the COVID-19 disaster. People make optimal use of physical and non-physical resources to survive despite the pandemic. High economic resilience dominates this study location. However, data shows that 92.3% of respondents have a monthly income of less than 113.98 USD, which is below the regional minimum wage.

This is a notable finding; even though people have low incomes below regional wages, they demonstrate high economic resilience, especially during the COVID-19 pandemic. This suggests that low income does not necessarily correlate with low resilience. The economic hardships experienced by people in Gunungkidul have become a daily reality, enhancing the community's resilience in difficult situations as they are accustomed to facing challenges. This condition unconsciously trains people to develop high mental resilience[37].

The fulfillment of people's daily food needs during the COVID-19 pandemic can be supported through the use of local natural resources [38]. A vast majority of residents (96.15%) in economically resilient areas have utilized natural resources for agricultural production, including planting rice and crops such as cassava, peanuts, and corn. Various crops from agricultural, plantation, and horticultural production that grow at the research site are used by the community to meet their daily food needs, with the surplus harvest traded in other regions. The sale of agricultural products from one household at the research location even reached 793 USD in one harvest season (with three harvests per year). In the fisheries sector, the community engages in freshwater aquaculture, cultivating catfish, tilapia, and gourami.

Water sources such as those from the Regional Drinking Water Company, underground rivers, and rainfed water are also utilized. The abundance of natural resources provided by nature and effectively utilized by the community is crucial for sustaining economic resilience. The availability of these resources is supported by the unique environmental characteristics and landforms of the research location.

Research locations with high economic resilience are situated in areas with karst landforms (Figure 4), which have biodiversity that can be utilized by the community for agriculture and plantations. Additionally, the southern region features a coastal alluvial landform, with the coastline supporting coastal activities. Landforms influenced by river systems have fertile soil, making them suitable for agriculture. The existing conditions at the research site support the population's livelihood, with 73.07% of the community employed as farmers. This aligns with previous research indicating that livelihoods are often determined by the potential of natural resources [39]. The presence of coastal areas in the community environment also supports the potential of the region as a tourism area. Although the COVID-19 pandemic has hampered local tourism, the community can still utilize coastal resources to meet their needs, such as easily obtaining marine fish.

Medium economic resilience accounts for 37.5% and includes the villages of Pucung, Songbanyu, and Jerukwudel (Figure 3). This classification indicates an economic resilience that is neither particularly strong nor weak but capable of surviving the COVID-19 pandemic. These communities require effective management to support their economic resilience and prevent deterioration. Although most households have lower incomes, some earn above the regional minimum wage. Income distribution shows that 11.1% of households earned above the regional minimum wage, 27.7% earned at the minimum wage, and 61.1% earned below the minimum wage. Despite the dominance of lower-income households, some earn above the regional minimum wage. In terms of health, 100% of household members have adhered to the government's call to participate in the COVID-19 vaccination. However, 22.3% of household members suffer from conditions such as gout and hypertension, which can hinder productivity and exacerbate health issues if infected with COVID-19.

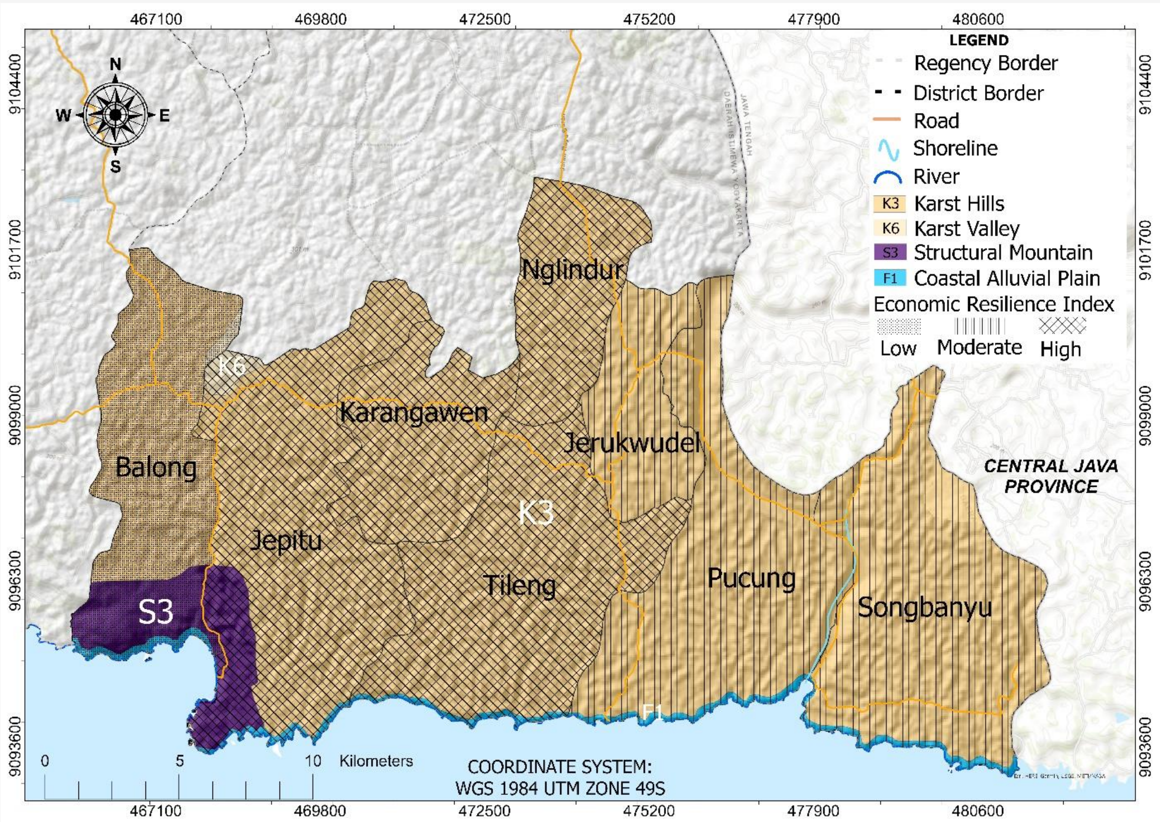

Figure 4: Distribution of the economic resilience index overlaid with the landforms of the Girisubo Area, Gunungkidul Regency, Yogyakarta, Indonesia

Additionally, congenital diseases can worsen health outcomes if a person contracts COVID-19. The utilization of natural resources needs improvement, as the average income from agricultural production is only 84.36 USD per harvest season. The utilization of natural resources for agriculture reached only 77.7%, lower than in regions with high economic resilience. Production is limited to crops such as cassava, corn, and peanuts. The utilization of paddy rice farming was also low, at just 11.1%. Landform conditions in areas with moderate resilience include karst hills and coastal alluvial plains in the south (Figure 4). These characteristics are similar to those in regions with high economic resilience. In Songbanyu and Pucung Villages, coastal areas are utilized by the community for fishing. Field data shows that 22.2% of households were engaged in fishing. The COVID-19 pandemic and the implementation of physical distancing have hampered interactions among people. This has negatively affected the coastal tourism sector in these areas. However, coastal communities continued to sustain their livelihoods by effectively utilizing natural resources to meet their daily food needs during the COVID-19 pandemic. This situation highlights the effective optimization of natural resources during disasters at the research site.

Economic resilience with a low classification is only found in one village, Balong Village, with a percentage of only 12.5%. This classification indicates a condition of very limited economic resilience during the COVID-19 pandemic. If this condition is left unchecked, it may lead to other economic issues, such as poverty. Based on socioeconomic characteristics, 100% of the heads of households in this region were elderly, aged between 60 and 72 years. When viewed in terms of health and work productivity, these individuals generally experience a decline compared to those under the age of 60. This finding supports the theory of human productivity based on age, which suggests that older individuals may have lower economic resilience [40]. Assistance programs aimed at improving health and enhancing the productivity of the elderly should be implemented to strengthen economic resilience. The elderly head of household's low income is closely linked to their economic condition. According to data, 100% of these households earned less than the regional minimum wage, which was 113.98 USD. In terms of health issues, this region has experienced outbreaks of diseases, including tuberculosis. Tuberculosis attacks the respiratory system and is transmissible, thereby increasing the threat of other infectious diseases during the COVID-19 pandemic. Health problems can hinder work productivity, thereby disrupting the family's financial stability and economic resilience. The infrastructure in this region also required significant improvement. Currently, 100% of the roads were constructed from concrete blocks rather than asphalt, a condition that can hinder the distribution of goods and services, thereby affecting economic activities [41]. Public transportation options in this area were extremely limited, with no access to buses or taxis. Environmental conditions contribute to this situation, as the research site is located in a mountainous region with igneous rocks in the south. The steep terrain complicates vehicle access, further limiting transportation in the area.

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Tuberculosis attacks the respiratory system and is transmissible, thereby increasing the threat of other infectious diseases during the COVID-19 pandemic. Health problems can hinder work productivity, thereby disrupting the family's financial stability and economic resilience. The infrastructure in this region also required significant improvement.

Currently, 100% of the roads were constructed from concrete blocks rather than asphalt, a condition that can hinder the distribution of goods and services, thereby affecting economic activities [41]. Public transportation options in this area were extremely limited, with no access to buses or taxis. Environmental conditions contribute to this situation, as the research site is located in a mountainous region with igneous rocks in the south. The steep terrain complicates vehicle access, further limiting transportation in the area. Structural landforms in the southern part of Balong village limit land utilization, as shown by field data indicating that land management is restricted to the agricultural production of rice and crops. Plantation, horticulture, and fishery production were not observed in the household samples at the study site. Agricultural production was limited to one harvest per year, with incomes ranging from 49.12 USD to 306.96 USD. This finding highlights how environmental factors and the lack of economic optimization can contribute to low economic resilience in an area.

The structural landform in the southern part of Balong Village, characterized by igneous rocks, hinders farmers from cultivating a variety of crops. However, the coastal alluvial landforms in the southern region offer potential for optimization as a source of economic livelihood for the community.

Table 4 provides a description of the conditions across different classifications of economic resilience during the COVID-19 pandemic at the research site. The classifications—low, medium, and high—offer an overview of the area's condition based on field documentation. The descriptions of respondents' residences, which serve as visual evidence of the economic resilience classifications. In areas classified as low, residential houses are predominantly semi-permanent structures made of wood, situated in rocky and steep environments (Figure 5). In contrast, medium-classification areas have houses that are in relatively good condition, with available land for vegetable cultivation to meet daily food needs (Figure 6). Areas with high economic resilience are characterized by permanent houses that are well-constructed and located in fertile environments suitable for various agricultural activities, including plantation and horticulture (Figure 7). The study results indicate that high economic resilience dominates the research location. However, low and medium economic resilience levels are still present.

Table 4: Description of economic resilience conditions at the research site

Classification	Percentage (%)	Landform characteristics
Low	12.5	Karst hill, structural mountain, and coastal alluvial plain
Moderate	37.5	Karst hill and coastal alluvial plain
High	50	Karst hill and coastal alluvial plain

Figure 5: Sample of house conditions with low economic resilience in Balong Village: A semi-permanent house constructed entirely of wood

Figure 6: Sample of house conditions with moderate economic resilience in Pucung Village: A semi-permanent house but mixed with permanent material on the wall

Figure 7: Sample of house conditions with high economic resilience in Nglindur Village: Solidly built houses with adequate infrastructure

The analysis of the economic resilience index, which incorporates six factors assessed during COVID-19, can support government policies aimed at economic recovery post-pandemic. Various policy implementations have contributed to enhancing economic resilience. For instance, in the health sector, the mass administration of COVID-19 vaccines, including three booster doses, was conducted to strengthen community resistance to the virus [42]. In infrastructure, the construction of the South Coast Road (*Jalur Pantai Selatan*, or *Pansela*), a national program connecting Kulon Progo Regency, Bantul Regency, and Gunungkidul Regency, has been initiated. This road will improve transportation access between regions, thereby making the distribution of goods and services more efficient [43] and [44]. Additionally, the road connects to the southern coastal area, promoting coastal tourism and optimizing coastal natural resources. The Gunungsewu Karst Area, for example, can be further developed as a Geopark tourism site post-COVID-19. Empirical data on economic conditions post-COVID-19 indicate significant improvement. The economic growth rate in Gunungkidul Regency, which was -0.68% in 2020 during the pandemic, increased to 5.04% in 2023. The poverty line also rose from 18.48 USD during the pandemic to 23.49 USD in 2023. These economic achievements demonstrate that the implementation of appropriate policies can effectively support community economic resilience after a disaster, particularly in the context of the COVID-19 pandemic [45].

4. Conclusion

The research addresses a significant gap by focusing on a marginalized area with unique geographic and socio-economic challenges to identify and analyze the spatial characteristics of the economic resilience index during COVID-19 pandemic. Identifying economic resilience- the ability to survive economically during environmental disruptions, such as the COVID-19 disaster, especially in marginalized communities- is a solution for supporting policymakers in providing appropriate measures to reduce disaster risk. The results showed that 81.36% of respondents from marginal land had an income less than the regional minimum wage, with a monthly income of less than 113.98 USD. The highest percentage of education attainment was elementary school graduates, and 95.92% of the workforce was in the informal sector. The economic resilience index is formulated by identifying socio-economic conditions, infrastructure, the role of government, community existence, ICT utilization, and natural resource utilization. The use of AHP to weigh economic resilience factors and GIS for spatial analysis demonstrates a robust methodological framework. The mixed-method approach enriches the data's depth, potentially offering a more comprehensive understanding of the community's economic resilience.

Based on the results, the economic resilience index is divided into three classifications based on spatial data distribution: high-class resilience (0.374–0.418), moderate-class resilience (0.330–0.373), and low-class resilience (0.284–0.329). High-class resilience dominated the research location with 50%, while low-class resilience accounted for only 12.5%. These findings indicate that despite the COVID-19 pandemic, the research location in the marginal area of Girisubo Gunungkidul Karst Area did not experience significant economic disruption. Although located in a karst area with dry land characteristics, the community can optimize natural resources in their surroundings. This optimization helps the community meet their daily food needs through agricultural land management, resulting in rice and crop production, plantations, and horticultural crops. Water resources are utilized for freshwater fish fisheries. This aligns with the population's livelihood, which is predominantly farming. The existence of coastal alluvial plains on the south side of the research site is utilized by fishermen to catch sea fish. Resource utilization helps meet daily food needs during the COVID-19 pandemic, and some crops are traded.

The data from this study can be used as a reference for policies aimed at recovering economic conditions post-COVID-19. The government has implemented various policies to enhance economic resilience, including health sector initiatives like the COVID-19 vaccine, infrastructure projects such as the construction of the South Coast Road (*Jalur Pantai Selatan, or Pansela*), and the development of potential tourism in the Geopark Gunungsewu Karst Area. The data indicate an improvement in economic conditions, with an economic growth rate increase of 5.04% and a poverty line rise of 23.49 USD per capita/month in 2023 after COVID-19.

This research highlights the importance of identifying economic resilience indices through geographic approaches in both theory and practice. This approach provides comprehensive results by considering the physical and non-physical conditions of research respondents. The findings contribute to the body of knowledge, particularly in using natural resources for community survival. Policymakers can utilize the results of this research as a reference for policies aimed at reducing disaster risk, especially for pandemics. However, this study has limitations, including its focus solely on the Girisubo Karst Area District and the use of only six constituent factors in economic resilience. Future research could explore other locations and additional factors.

Acknowledgements

We would like to thank the Indonesia Endowment Funds for Education (LPDP) and the Center for Higher Education Funding (BPPT) for supporting this research.

References

[1] Dube, K., Nhamo, G. and Chikodzi, D., (2021). COVID-19 Pandemic and Prospects for Recovery of the Global Aviation Industry. *Journal of Air Transport Management*, Vol. 92(10), 10–22. https://doi.org/10.1016/j.jairtraman.2021.102022.

[2] Saravanan, V. and Garren, S. J., (2021). Baseline Framework for Assessing Community Resilience Using a Balanced Index Approach and Spatial Autocorrelation in the Mill river Watershed, Nassau County, New York. *International Journal of Disaster Risk Reduction*, Vol. 66(2), 1–15. https://doi.org/10.1016/j.ijdrr.2021.102621.

[3] Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., Niu, P., Zhan, F., Ma, X., Wang, D., Xu, W., Wu, G., Gao, G. F. and Tan, W., (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *New England Journal of Medicine*, Vol. 382(8), 727–733. https://doi.org/10.1056/nejmoa2001017.

[4] Shereen, M. A., Khan, S., Kazmi, A., Bashir, N. and Siddique, R., (2020). COVID-19 Infection: Origin, Tansmission, and Characteristics of Human Coronaviruses. *Journal of Advanced Research*, Vol. 3(1), 115–123. https://doi.org/10.1016/j.jare.2020.03.005.

[5] Horne, R., Willand, N., Dorignon, L. and Middha, B., (2021). Housing Inequalities and Resilience: The Lived Experience of COVID-19. *International Journal of Housing Policy*, Vol. 10(3), 1–15. https://doi.org/10.1080/19491247.2021.2002659.

[6] Map of Covid-19 Spread in Special Region of Yogyakarta. *Yogyakarta Health Office.* [Online]. Available: https://corona.jogjaprov.go.id. [Accessed May 1, 2023].

[7] Dormady, N., Roa-Henriquez, A. and Rose, A., (2019). Economic Resilience of the Firm: A Production Theory Approach. *International Journal of Production Economics*, Vol. 208(2), 446–460. https://doi.org/10.1016/j.ijpe.2018.07.017.

[8] Hu, X., Li, L. and Dong, K., (2022). What Matters for Regional Economic Resilience Amid COVID-19? Evidence from Cities in Northeast China. *Cities*, Vol. 120(7), 103–120. https://doi.org/10.1016/j.cities.2021.103440.

[9] Rose, A., (2011). Resilience and Sustainability in the Face of Disasters. *Environmental Innovation and Societal Transitions*, Vol. 1(1), 96–100. https://doi.org/10.1016/j.eist.2011.04.003.

[10] Loi, D. T., (2023). Assessment of Urban Flood Vulnerability Using Integrated Multi-parametric AHP and GIS. *International Journal of Geoinformatics*, Vol. 19(6), 1–16. https://doi.org/10.52939/ijg.v19i6.2689.

[11] Utami, W., Sugiyanto, C., Rahardjo, N., Juliyani, A., Richasari, D. S. and Nurhadi, N., (2023). Spatial Analysis of the Semeru Eruption Disaster Area. *International Journal of Geoinformatics*, Vol. 19(8), 54–66. https://doi.org/10.52939/ijg.v19i8.2783.

[12] Pintilescu, C. and Viorică, D., (2019). Current Methodological Approaches in Economic Resilience Analysis. Empirical Findings in the EaP Countries. In G. *Resilience and the EU's Eastern Neighbourhood Countries: From Theoretical Concepts to a Normative Agenda*, Vol. 3, Rouet and G. C. Pascariu, Ed. German: Springer International Publishing, 2019, 321-348.

[13] Yotha, N., Phimha, S., Prasit, N., Senahad, N., Sirikarn, P. and Nonthamat, A., (2023). Spatial Association Patterns with Cultural and Behaviour with the Situations of COVID-19. *International Journal of Geoinformatics*, Vol. 19(4), 51–63. https://doi.org/10.52939/ijg.v19i4.2637.

[14] Rahmadana, M. F. and Sagala, G. H., (2020). Economic Resilience Dataset in Facing Physical Distancing during COVID-19 Global Pandemic. *Data in Brief*, Vol. 32(2), 1–15. https://doi.org/10.1016/j.dib.2020.106069.

[15] Settels, J. and Böckerman, P., (2023). The Effects of COVID-19-Era Unemployment and Business Closures Upon The Physical and Mental Health of Older Europeans: Mediation Through Financial Circumstances and Social Sctivity. *SSM - Population Health*, Vol. 23(2), 1–11. https://doi.org/10.1016/j.ssmph.2023.101419.

[16] Desson, Z., Lambertz, L., Peters, J. W., Falkenbach, M. and Kauer, L., (2020). Europe's Covid-19 Outliers: German, Austrian and Swiss Policy Responses During The Early Stages of The 2020 Pandemic. *Health Policy and Technology*, Vol. 9(4); 405–418. https://doi.org/10.1016/j.hlpt.2020.09.003.

[17] Ford, D. and Williams, P., (2007). *Karst Hydrogeology and Geomorphology*.West Sussex, England: John Wiley and Sons Ltd.

[18] Soeroso, A., Rahardjo, N. and Turgarini, D., (2023). Green Tourism Planning for Coastal Development in Gunungsewu Geopark, Indonesia. *International Journal of Geoinformatics*, Vol. 19(6), 91–101. https://doi.org/10.52939/ijg.v19i6.2701.

[19] Wang, X., Wang, L., Zhang, X. and Fan, F., (2022). The Spatiotemporal Evolution of COVID-19 in China and Its Impact on Urban Economic Resilience. *China Economic Review*, Vol. 74(10), 1–21. https://doi.org/10.1016/j.chieco.2022.101806.

[20] Truong, P. M., Le, N. H., Hoang, T. D. H., Nguyen, T. K. T., Nguyen, T. D., Kieu, T. K., Nguyen, T. N., Izuru, S., Le, V. H. T., Raghavan, V., Nguyen, V. L. and Tran, T. A., (2023). Climate Change Vulnerability Assessment Using GIS and Fuzzy AHP on an Indicator-Based Approach. *International Journal of Geoinformatics*, Vol. 19(2), 39–53. https://doi.org/10.52939/ijg.v19i2.2565.

[21] Kim, S. J., Lim, C. H., Kim, G. S., Lee, J., Geiger, T., Rahmati, O., Son, Y. and Lee, W. K., (2019). Multi-temporal Analysis of Forest Fire Probability Using Socio-economic and Environmental variables. *Remote Sensing*, Vol. 11(1), 1–19. https://doi.org/10.3390/rs11010086.

[22] Marfai, M. A., Cahyadi, A. and Anggraini, D. F., (2013). Typology, Dynamics, and Potential Disaster in The Coastal Area District Karst Gunungkidul. *Forum Geografi*, Vol. 27(2), 147-160. https://doi.org/10.23917/forgeo.v27i2.2373.

[23] Statistics of Gunungkidul Regency. (2022). *Gunungkidul Regency in Figures 2022*. Indonesia: Center of Statistic Gunungkidul.

[24] Mack, N., Woodsong, C., MacQueen, K. M., Guest, G. and Namey, E., (2011). *Qualitative Research Metodology: A Data Collector's Field Guide*. USA: Family Health International.

[25] Graziano, P., (2013). Vulnerability and Resilience of the Economic, Social and Environmental Dimensions of Italian Provinces. *Regional Studies Association European Conference*, Vol. 2(1), 1–28. https://www.regionalstudies.org/wp-content/uploads/2018/07/Graziano2013.pdf.

[26] Permatasari, A. L., Suherningtyas, I. A., Febriarta, E. and Wiguna, P. P. K., (2022). Analysis of Vulnerability to Transmission of the Covid-19 based on Building Function at Padukuhan Mancasan Kleben, Pandowoharjo, Sleman, Yogyakarta. *Forum Geografi*, Vol. 35(2), 170–179. https://doi.org/10.23917/forgeo.v35i2.13755.

[27] Cutter, S. L., (2016). The Landscape of Disaster Resilience Indicators in The USA. *Natural Hazards*, Vol. 80(2), 741–758. https://doi.org/10.1007/s11069-015-1993-2.

[28] Estoque, R. C. and Murayama, Y., (2014). Social-ecological Status Index: A Preliminary Study of Its Structural Composition and Application. *Ecological Indicators*, Vol. 9(4), 183–194. https://doi.org/10.1016/J.ECOLIND.2014.02.031.

[29] Mahmood, R., Zhang, L., Li, G. and Rahman, M. K. (2021). Geo-based Model of Intrinsic Resilience to Climate Change: An Approach to Nature-Based Solution. *Environment, Development and Sustainability*, Vol. 2(1); 1–15. https://doi.org/10.1007/s10668-021-01925-9.

[30] Cimellaro, G. P. and Martinelli, D., (2014). Modeling Economic Dimension of Community Resilience. *Geotechnical, Geological and Earthquake Engineering*, Vol. 33(1), 185–202. https://doi.org/10.1007/978-3-319-06394-2_11

[31] Rogerson, P., (2010). *Statistical Methods for Geography*. New York: SAGE.

[32] Saaty, T., (2004). Fundamentals of the Analytic Network Process: Dependence and Feedback in Decision-making with a Single Network. *Journal of Systems Science and Systems Engineering*, Vol. 13(2), 129– 157.

[33] Scheuer, C., Boot, E., Carse, N., Clardy, A., Gallagher, J., Heck, S., Marron, S., Martinez-Alvarez, L., Masarykova, D., Mcmillan, P., Murphy, F., Steel, E., Ekdom, H. Van. and Vecchione, H., (2021). Disentangling Inclusion in Physical Education Lessons: Developing a Resource Toolkit for Teachers. *Physical Education and Sport for Children and Youth with Special Needs Researches-Best Practices-Situation*, Vol. 2(12), 343–354. https://doi.org/10.2/JQUERY.MIN.JS.

[34] Joseph, R., (2021). The Great Recession and Economic Resilience: A Longitudinal Analysis of Low-Income Households in the United States. *Journal of Social Service Research*, Vol. 47(6), 886–897. https://doi.org/10.1080/01488376.2021.1942394.

[35] Webb, A., McQuaid, R. and Rand, S. (2020). Employment in the Informal Economy: Implications of the COVID-19 Pandemic. *International Journal of Sociology and Social Policy*, Vol. 40(9–10), 1005–1019. https://doi.org/10.1108/IJSSP-08-2020-0371.

[36] Goepel, K. D., (20158). AHP Priority Calculator. *Business Performance Management Singapore*. The International Symposium on the Analytic Hierarchy Process. http://www.isahp.org/uploads/isahp18_proceeding_1370731.pdf.

[37] Sirin Gok, M., Aydin, A., Baga, Y. and Ciftci, B., (2024). The Relationship between the Psychological Resilience and General Health Levels of Earthquake Survivor Nursing Students in Kahramanmaras Earthquakes, the Disaster of the Century. *Journal of Community Psychology*, Vol. 52(3), 498–511. https://doi.org/10.1002/jcop.23110.

[38] Tarra, S., Mazzocchi, G. and Marino, D., (2021). Food System Resilience during COVID-19 Pandemic: The Case of Roman Solidarity Purchasing Groups. *Agriculture (Switzerland)*, Vol. 11(2), 1–19. https://doi.org/10.3390/agriculture11020156.

[39] Fromm, I., (2020). Agricultural Competitiveness, Sustainable Landscapes and Markets: Challenges for Honduran Agricultural Value Chains. *Honduras: Economic, Political and Social Issues*, Vol. 2(2), 67–91. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85115908158&partnerID=40&md5=f89003559071aa24b3ddfe19e49b49c1.

[40] Etindele Sosso, F. A., Kreidlmayer, M., Pearson, D. and Bendaoud, I., (2022). Towards A Socioeconomic Model of Sleep Health among the Canadian Population: A Systematic Review of the Relationship between Age, Income, Employment, Education, Social Class, Socioeconomic Status and Sleep Disparities. *European Journal of Investigation in Health, Psychology and Education*, Vol. 12(8), 1143–1167.

[41] Kadetz, P., (2018). Collective Efficacy, Social Capital and Resilience: An Inquiry into the Relationship between Social Infrastructure and Resilience after Hurricane Katrina. *Creating Katrina, Rebuilding Resilience: Lessons from New Orleans on Vulnerability and Resiliency*, Vol. 2(3), 283–304. https://doi.org/10.1016/B978-0-12-809557-7.00013-2.

[42] Xia, H., Zou, J., Kurhade, C., Cai, H., Yang, Q., Cutler, M., Cooper, D., Muik, A., Jansen, K. U., Xie, X., Swanson, K. A. and Shi, P. Y., (2022). Neutralization and Durability f 2 or 3 Doses of the BNT162b2 Vaccine Against Omicron SARS-CoV-2. *Cell Host and Microbe*, Vol. 30(4), 485–488. https://doi.org/10.1016/j.chom.2022.02.015.

[43] Edy, H., Baiquni, M. and Triatmodjo, B., (2019). Impact of Infrastructure Development Jalur Jalan Lintas Selatan (Jjls) on Changes in Land Use in Gadingsari Village, Sanden District, Bantul Regency, Yogyakarta, Indonesia. *Geosfera Indonesia*, Vol. 4(2), 78-85. https://doi.org/10.19184/geosi.v4i2.10014.

[44] Astuti, B. I. D. and Haryono, E., (2023). An Ecological Study of Karst Landscapes Around the Jalur Jalan Lintas Selatan (JJLS) of Gunungkidul Regency. *IOP Conference Series: Earth and Environmental Science*, *United Kingdom*, *September 7-8*, *2002*, Sumanto J., Eds. United Kingdom: Institute of Physics Publishing (IOP), 2023. 1–15.

[45] Statistics of Gunungkidul Regency, (2024). *Gunungkidul in Figures 2024*. Indonesia: Center of Statistic Gunungkidul.