Community Vulnerability to Natural Disasters: Policy Implications in Indonesia

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Abstract

This research investigates the vulnerability of communities in Central Sulawesi, Indonesia to natural disasters and the policy implications for disaster mitigation. Given Indonesia's geological position, it is prone to various natural disasters, with recovery often being a lengthy process. The study identifies social, economic, and environmental factors that influence vulnerability and evaluates the effectiveness of policy interventions in areas such as risk assessment, early warning systems, infrastructure planning, community empowerment, social protection, and climate change adaptation. A quantitative research method, including surveys and data analysis, is employed to measure these dimensions using a Likert scale. The findings provide valuable insights into community vulnerability and offer policy recommendations for disaster mitigation. The study underscores the need for an integrated approach that considers the local context, community participation, and effective communication to ensure the success of these policy interventions.

Keywords: *Disaster Mitigation, Community Vulnerability, Natural Disasters*

Introduction

Indonesia, which is known as a country prone to natural disasters, is at the confluence of three important tectonic plates: the Pacific plate, the Indo-Australian plate, and the Eurasian plate. This geological position means that the country experiences frequent violent seismic events, including earthquakes and volcanic eruptions. Apart from these seismic hazards, Indonesia also faces various other types of natural disasters such as tsunamis, typhoons, and droughts. During 2022 and 2023, Indonesia experienced a total of 2,963 disaster events. Central Java Province recorded the highest number of disaster events with 1,345 incidents, while Riau Province recorded the lowest number of disaster events with only 1 incident(BNPB 2023). This information can be seen in the following image:

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Data on disaster events in Indonesia for 2022-2023
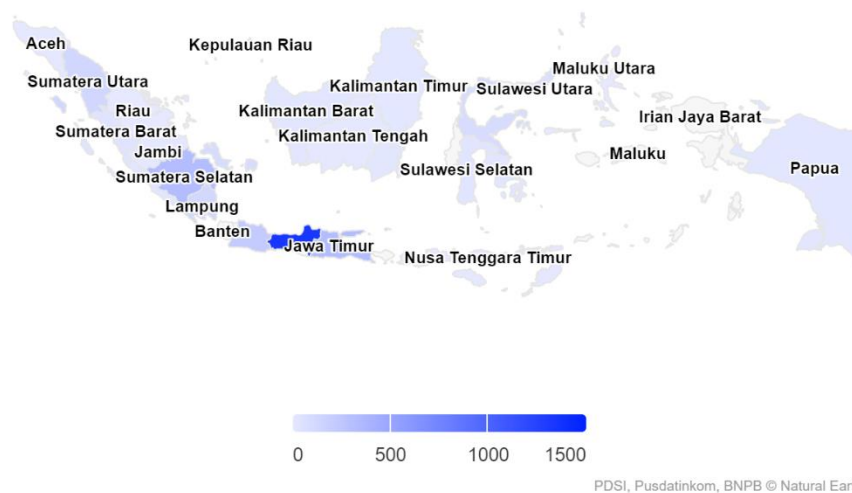
Source: Indonesian Disaster Information Data, BNPB.

The impact of natural disasters on the lives of people in affected areas is enormous, and the recovery process that takes a long time is also closely related to the level of exposure to disasters.(Kusumastuti et al. 2014). Exposure refers to factors such as people, buildings and infrastructure networks that are affected by a particular natural disaster. In addition, economic and natural environmental aspects can also be part of the exposure that is not explored in this report. Exposure includes the extent to which these elements are within the potential impact area of a natural hazard(Dwyer, Zoppou, and Nielsen 2004). In addition, the impact of natural disasters is also often associated with the concept of vulnerability, which comes from the Latin word "vulnerare" which means "hurt". The understanding of vulnerability varies depending on the context in which it is applied. Initially, vulnerability was defined as the potential for loss when a natural disaster occurs(Cutter 1996a). Wisner et al.(2004)defines vulnerability as the characteristics of individuals or groups in terms of their ability to anticipate, cope with, survive and recover from the effects of natural disasters. adger(1999)perceive vulnerability as the state of being vulnerable to harm resulting from exposure to stresses associated with environmental and social change, and a lack of adaptive capacity. Flanagan et al.(2020)viewing vulnerability as the extent to which individuals or entities are likely to be negatively affected. Birkmann(2006)and Adder(2006)discuss many other definitions of vulnerability in their work.

Natural hazards, exposures and vulnerabilities are interrelated and interact in the context of natural disasters. Natural hazards pose a potential risk, whereas exposure indicates the extent to which the elements are present in the affected area. Vulnerability reflects the ability of these elements to deal with the impact of natural disasters that may occur(Dwyer, Zoppou, and Nielsen 2004). For more details, the relationship between these three factors can be seen in the following figure:

The risk pyramid visually represents three different factors that contribute to risk: hazard, exposure and vulnerability, presented in a three-dimensional (3D) format.
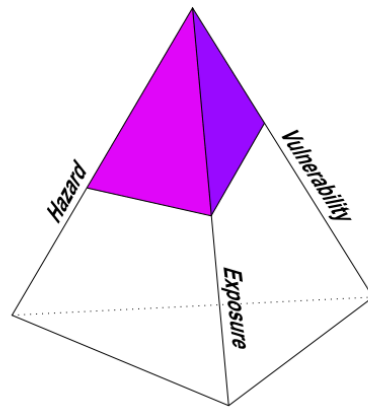
Source: Dwyer, Zoppou, and Nielsen(Dwyer, Zoppou, and Nielsen 2004)

In the Indonesian context, people's vulnerability to natural disasters varies from country to country. As a country located on the Pacific Ring of Fire, Indonesia faces various types of natural disasters, including earthquakes, volcanic eruptions, floods, landslides, tsunamis, and extreme weather.(Kusumastuti et al. 2014). The level of vulnerability of the Indonesian people to natural disasters is influenced by several factors. Social factors such as level of education, awareness, and disaster preparedness skills play a role in determining a community's ability to respond to and recover from disasters. Economic factors such as poverty levels, economic inequality, and access to natural resources also have an impact on people's vulnerability to disasters. Environmental factors also play an important role. Climate change, deforestation, environmental degradation and unregulated urbanization all contribute to increased disaster risks and exacerbate societal vulnerabilities.

Risk, mitigation and hazard potential are interrelated in the conceptualization. Risk represents the objective likelihood of a hazard event, whereas mitigation measures aim to reduce the risk and its impact. Hazard potential is influenced by geographic filters, including the location and situation of a place, as well as the social structure of the community. Social structure includes a community's experience with hazards and their capacities to respond, cope, recover, and adapt, which are influenced by economic, demographic, and housing factors. The interaction between social and biophysical vulnerability contributes to the overall vulnerability of a place. As explained in the following figure(Cutter, Boruff, and Shirley 2003).

Figure Hazards-of-Place Vulnerability Model
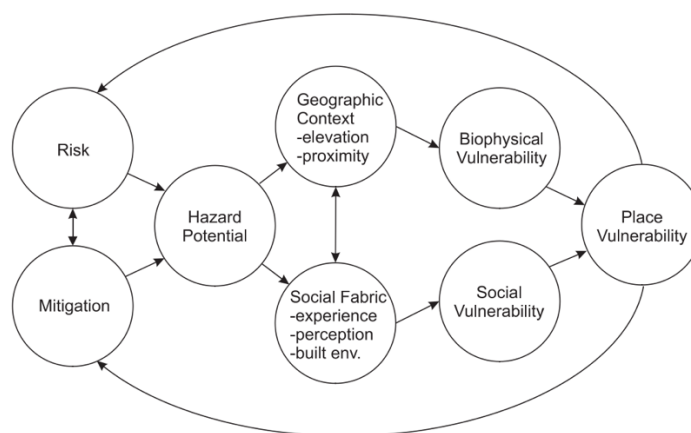
Source: Cutter, Boruff, and Shirley(Cutter, Boruff, and Shirley 2003)*Modified from Cutter(1996b)*

However, even though the community's vulnerability to natural disasters is increasingly apprehensive, a comprehensive understanding of the factors that influence this vulnerability is still limited. Apart from the Indonesian government's acknowledgment of the importance of social vulnerability assessment in disaster management, as stated in Law no. 24 of 2007 concerning Disaster Management, research conducted in Indonesia in this field is still limited(Siagian et al. 2014). In addition, current policies have not fully addressed this issue effectively. Therefore, more in-depth research is needed to identify the factors that contribute to the vulnerability of society to natural disasters in Indonesia and analyze relevant policy implications. Because a deep understanding of this will help the government to develop a comprehensive framework or policy to minimize the negative impacts of disasters. In addition, an understanding of the level of risk must also be followed up with an assessment of the level of resilience to disasters(Kusumastuti et al. 2014).

Implementing effective policies in this area is critical for Indonesia. By conducting rigorous risk assessments, developing robust early warning systems, ensuring resilient infrastructure, empowering communities, providing social protection mechanisms, and integrating climate change adaptation measures, countries can increase their capacity to survive and recover from natural disasters.(Kryspin-Watson et al. 2020). In addition, the lack of effective policies in key areas such as risk assessment, early warning systems, infrastructure planning, community empowerment, social protection, and climate change adaptation is hindering Indonesia's progress in reducing societal vulnerabilities and achieving sustainable development.(Djalante et al. 2012). The absence of a coherent policy framework exacerbates the country's vulnerability to natural disasters, placing society at significant risk. In short, the issues revolve around limited understanding of societal vulnerabilities, inadequate implications of comprehensive policies, and the critical need to implement effective policies in Indonesia. By addressing these challenges, countries can take significant steps to reduce society's vulnerability to natural disasters and ensure a resilient and sustainable future(Mardiah, Lovett, and Evanty 2017).

So this study aims to identify and evaluate the factors that contribute to the vulnerability of society to natural disasters in Indonesia, including socio-economic, environmental and geographical aspects. This research will also analyze the role of policy interventions in reducing risk and addressing the impact of natural disasters, and identify key policy areas that can increase community resilience, such as infrastructure, early warning systems, community empowerment, social protection, and climate change adaptation. With a better understanding of people's vulnerability to natural disasters, this research provides relevant policy guidance for protecting people and mitigating them in Indonesia.

Methods

This research methodology focuses on identifying and evaluating the factors that contribute to the vulnerability of society to natural disasters in Indonesia. This approach covers socio-economic, environmental and geographical aspects, with the application of a quantitative approach(Amri and Giyarsih 2022). The collection and analysis of numerical data from various sources such as surveys, databases and official records was carried out to understand the challenges faced and identify evidence-based strategies. In the context of a study on community vulnerability to natural disasters in Central Sulawesi, a quantitative approach will be used. Numerical data will be collected and analyzed from multiple sources, enabling an in-depth understanding of the environmental sustainability challenges and other factors faced by the city(Rezvani et al. 2023)**.**

The application of quantitative data analysis will enable researchers to identify significant trends, patterns and challenges in the factors that influence the vulnerability of society to natural disasters in Indonesia(Sarker et al. 2020). This approach is capable of formulating

strategies that include focused interventions, policy recommendations, and community participation initiatives, all of which are based on insights gained from analysis of quantitative data. Overall, the use of a quantitative approach in this study will provide a solid basis for understanding these conditions(Astuti, Werdhiana, and Wahyono 2021). By collecting and analyzing numerical data, the aim of this research is to contribute valuable knowledge and insights for policy makers, city officials and stakeholders. This will assist them in making informed decisions and taking effective actions towards a more sustainable future in Central Sulawesi. The research will cover the following steps:

Study Design

Research samples will be taken from the community with the aim of exploring the concept of community vulnerability and analyzing the impact of natural disasters on Indonesia. This research will also evaluate the policy implications needed to reduce these impacts.

Data and Sample Selection

This research applies the sample selection method using a purposive sampling technique, which is a strategic approach in determining the sample according to the characteristics predetermined by the researcher.(Hennink and Kaiser 2022). In this method, respondents are deliberately selected based on characteristics or criteria that are considered relevant and important to answer research questions. The sample selection process was not done randomly; instead, the researcher fully controls this process to ensure that the sample drawn is representative of the population that has the characteristics sought(Shaheen and Pradhan 2019).

This approach allows researchers to gain deeper and qualitative insights into the characteristics and responses of people who are vulnerable to disasters in Central Sulawesi. Nonetheless, it is important to recognize that the results from a purposively selected sample may have limitations in terms of generalizability to the entire population. Therefore, careful and contextual interpretation of the findings is essential in this kind of research.

Population and sample This study will focus on communities in Central Sulawesi who are vulnerable to natural disasters and their impacts. The total population of people in Central Sulawesi is around 3,021 million people(BPS Central Sulawesi, 2020). In order to take samples that can represent the population well, the Krejcie and Morgan methods will be applied. Although the number of samples taken is not always the same as the total population, this method ensures factual verification by meeting the minimum requirements of 1,000 sample members or 1 per 1,000 of the population. It is hoped that this approach will provide deeper insight into the level of vulnerability of people in Central Sulawesi to natural disasters and their impacts.

The criteria for selecting this sample had been explicitly determined beforehand by the researcher. In this context, the sample taken is limited to the Central Sulawesi population which is known to experience a significant level of vulnerability to disasters. Community vulnerability is measured through factors that include geographic location, socio-economic conditions, infrastructure, and other factors that affect their capability to face and respond to disasters. Researchers selected this sample with special considerations related to the context of the Central Sulawesi region and the characteristics of its people who are vulnerable to disasters.

In this case, the population measured is a community that is vulnerable to disasters in Central Sulawesi, with a total population of 3,021,849 people.(BPS Central Sulawesi, 2020). Researchers decided to take a sample of 349 respondents for this study. This sample size is based on considerations involving the acceptable error rate, desired level of confidence, and the resources available to conduct the research. It is important to remember that larger sample sizes tend to give more accurate results and generalize better to the population. . However, considering resource constraints and practical constraints, the

researcher must strike a balance between a sample size that is large enough to produce reliable results and a sample size that still allows for efficient implementation.

Taking a sample of 349 respondents in this case could be the right step if adequate statistical calculations have been carried out to ensure the desired level of accuracy. However, keep in mind that the greater the difference between the sample size and the population size, the more careful and thorough statistical analysis is required to interpret the results correctly.

Measurement Instruments

Community resilience (Scherzer, Lujala, and Rød 2019) namely as an indicator (X1). This measuring instrument uses a 5-point Likert scalean instrument used to measure the extent to which a community or society has the capability and capacity to face, respond to, and recover from the effects of a disaster. This tool aims to identify factors that influence the level of community resilience to disasters, so that it can assist in planning, policy development, and interventions to increase community resilience.

Early warning system (Klein et al. 2021)namely as an indicator. This measurement tool uses a 5-point Likert scale. The early warning system measurement tool is an instrument used to measure the effectiveness and efficiency of the early warning system in providing accurate and timely information to the public about the threat of disaster or other dangerous events. The early warning system aims to provide warnings before a disaster occurs, so that people can take appropriate preventive or response actions.

Infrastructure planning (Klein et al. 2021)namely as an indicator. This measuring instrument uses a 5-point Likert scale.instrument used to measure aspects related to infrastructure planning, development, and evaluation. Infrastructure includes various physical facilities such as roads, bridges, buildings, transportation systems, clean water, sanitation, and many more. This measuring tool assists in identifying needs, measuring performance, and optimizing the use of resources in infrastructure planning and development.

Social protection (Sverke et al. 2019)namely as an indicator. This measuring instrument uses a 5-point Likert scale.instrument used to measure the effectiveness and response of social protection programs in emergency or disaster situations. The aim is to evaluate the extent to which social protection programs are able to provide the support needed by individuals, families and communities affected by disasters. This measuring tool helps in identifying successes, gaps, as well as challenges that may arise in providing social protection during periods of crisis.

Climate change adaptation (Scott, Hall, and Gössling 2019)namely as an indicator. This measuring instrument uses a 5-point Likert scale.an instrument used to measure the extent to which a society, community, or organization is able to adapt to the impacts of climate change during a disaster or emergency situation. Adaptation to climate change in a disaster context involves taking steps to reduce their vulnerability to the impacts of climate change that could exacerbate an emergency situation. This measurement tool helps in evaluating the effectiveness of adaptation and response plans in dealing with crisis situations caused by natural disasters.

Community empowerment (Khalid et al. 2019)namely as an indicator. This measuring instrument uses a 5-point Likert scale.an instrument used to measure the extent to which communities have the knowledge, skills, and capacity to actively participate in decision-making, response, and recovery processes during emergency or disaster situations. Community empowerment in disaster contexts focuses on enabling communities to take an active role in protecting themselves, responding effectively, and contributing to recovery efforts.

Data Analysis

In the early stages of this research, data collection will be carried out through conducting a survey which will be given to people in Central Sulawesi who are vulnerable to natural disasters. The main objective of this survey is to understand in more depth the factors that cause community vulnerability to natural disasters that may occur in the area. The survey will be carefully designed to cover key aspects, such as the level of community knowledge about disasters, preparations that have been made, access to emergency information, and preparedness in responding to disasters.

The quantitative research method bases its approach on collecting data in the form of numbers through surveys, observations, or the use of secondary data sources, such as official government reports, databases, or previous research. This approach allows researchers to apply statistical analysis to understand the relationships that exist between the variables described in the research context(Pappas and Woodside 2021). In the realm of research on community vulnerability to natural disasters, this quantitative method has the capability to explore interrelated dimensions, including variables such as community vulnerability, effectiveness of early warning systems, infrastructure planning strategies, community empowerment efforts, social protection mechanisms, and adaptation to climate change(Hair Jr. et al. 2021).

This method refers to a systematic approach in designing survey questionnaires that comprehensively covers related aspects. Numerical data obtained through surveys will enable descriptive statistical analysis to provide a detailed description of the distribution, range, and central tendency of the observed variables(Tun, Madanian, and Mirza 2021). In addition, inferential analysis through the method of hypothesis testing and regression analysis can enable a more in-depth study of the causal relationship between these variables. The results of this analysis, in turn, can be interpreted scientifically and significantly, support the formation of strong conclusions, and provide solid policy recommendations based on empirical evidence.(Katsaliaki, Galetsi, and Kumar 2021).

Therefore, quantitative research methods become a vital approach in gaining valuable insights about the vulnerability of society to natural disasters and the policy implications needed(Coccia 2021). By combining this method with careful interpretation and contextualization of the findings, this research can make a significant contribution in advancing the understanding of disaster preparedness and mitigation efforts in the Central Sulawesi region.

In addition, this survey will also examine the policy implications needed to reduce the impact of natural disasters in the region(Floridi et al. 2021). From the results of the data analysis, crucial factors will be identified that need attention in designing more effective disaster mitigation policies(Pan and Zhang 2021). The implications of this policy can range from developing disaster-resilient infrastructure, increasing community capacity in dealing with disasters, to efforts to strengthen early warning systems and emergency response plans.(Sun, Bocchini, and Davison 2020).

The results of this survey will provide deeper insight into the condition of people who are vulnerable to natural disasters in Central Sulawesi, as well as provide concrete directions for policy making. With this accurate and detailed information, it is hoped that mitigation and response measures for disasters can be directed in a more precise and timely manner, which will ultimately improve the safety, preparedness and welfare of the community in facing the threat of natural disasters.(Trafimow 2019).

Inferential Analysis

In order to explore the significant challenges in reducing community vulnerability to disasters and the factors that influence them, this study adopts an inferential statistical method by applying correlation analysis and regression analysis.(Mind'je et al. 2019). This

approach is used to explore the relationship that may exist between the variables that have been determined in this study(Nicholson et al. 2019). These variables involve community vulnerability, effectiveness of early warning systems, infrastructure planning strategies, community empowerment efforts, social protection mechanisms, and adaptation to climate change.

Through correlation analysis, this study seeks to find out the extent of the linear or non-linear relationship between these variables. The results of this analysis can help identify whether there is a positive or negative correlation between community vulnerability and other variables, providing insight into the interdependence of these factors.(Tang et al. 2019).

Meanwhile, by applying regression analysis, this study can measure the effect of the independent variables on the dependent variable in more detail(Zitnik et al. 2019). For example, the extent to which the effectiveness of early warning systems can affect the level of community vulnerability to natural disasters. In this context, regression analysis will help in understanding how significant the influence of these variables is on other variables.

The application of this inferential statistical technique will provide a strong scientific basis for this research(Peng and Tao 2022). The results of the correlation analysis and regression analysis will provide a deeper understanding of the complex relationships that exist between these variables(Hair et al. 2019). Therefore, this quantitative approach is an invaluable tool in uncovering the dimensions of community vulnerability to natural disasters and relevant policy implications in the Central Sulawesi region.

Path Analysis

The comparative analysis approach is an essential instrument in order to compare practices and the level of community vulnerability to various types of natural disasters. The aim is to highlight the significant challenges that need to be overcome in efforts to reduce the vulnerability of communities to disasters in the Central Sulawesi region, in contrast to the situation in other regions for comparison. This method facilitates an in-depth understanding of the dynamics of natural disasters as well as effective mitigation measures in various contexts(Stolle et al. 2020).

Comparative analysis at the level of practices involves comparing the mitigation and response initiatives adopted by the Central Sulawesi region with the comparison areas. Within this framework, comparisons are made to evaluate the extent to which mitigation strategies, policies and infrastructure have been successful in reducing the impact of natural disasters. For example, it can be evaluated whether the effectiveness of the early warning system is higher in a comparison area, and what are the factors that influence this(Anjomshoae et al. 2021).

In addition, a comparative analysis of community vulnerability will reveal patterns of differences in the factors influencing vulnerability between Central Sulawesi and other regions. Variables such as socio-economic characteristics, education level, and access to health services and information will be the focus of this analysis(Yigitcanlar et al. 2020).

Through this approach, the research will gain deeper insight into what has worked or needs to be improved in various contexts. These findings can provide valuable information to guide mitigation policies and practices in Central Sulawesi(Trias and Cook 2021). Thus, comparative analysis provides an important scientific basis for strengthening community resilience and reducing the impact of natural disasters in the region(Astuti, Werdhiana, and Wahyono 2021).

Results and Discussion

This study analyzes independent variables consisting of four main dimensions, namely early warning systems, infrastructure planning, social protection, and climate change adaptation, with the aim of exploring the concept of community vulnerability to natural disasters and formulating essential policy implications in efforts to mitigate the impact of disasters in the region. Central Sulawesi, Indonesia. The dimension of the early warning system considers the effectiveness and reach of warning tools and communication mechanisms that support rapid response to disaster threats. Infrastructure planning focuses on the design and construction of disaster-resistant facilities to minimize physical and economic risks. Social protection embraces strategies to protect vulnerable groups through the development of inclusive social and evacuation programs. Climate change adaptation includes transforming policies and practices to deal with changing disaster patterns triggered by global climate change. This research explores the complexity of community vulnerability in a multidimensional framework that reflects the interaction between social, economic, and environmental factors. By integrating the findings from these independent variable dimensions, this research will provide valuable guidance for the development of relevant policies and mitigation measures to protect the people of Central Sulawesi from the adverse effects of natural disasters. This research explores the complexity of community vulnerability in a multidimensional framework that reflects the interaction between social, economic, and environmental factors. By integrating the findings from these independent variable dimensions, this research will provide valuable guidance for the development of relevant policies and mitigation measures to protect the people of Central Sulawesi from the adverse effects of natural disasters. This research explores the complexity of community vulnerability in a multidimensional framework that reflects the interaction between social, economic, and environmental factors. By integrating the findings from these independent variable dimensions, this research will provide valuable guidance for the development of relevant policies and mitigation measures to protect the people of Central Sulawesi from the adverse effects of natural disasters.

Table 1. Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Means	std. Deviation
Early Warning System	349	12	25	20.54	1939
Infrastructure Planning	349	12	25	20.91	2076
Social Protection	349	14	25	20.89	2024
Climate Change Adaptation	349	14	25	20.40	1,709
Community Resilience	349	14	25	20.98	1,742
Community empowerment	349	12	25	20.47	1859

Table 1 suggests a significant comparison between the levels of respondents' perceptions of the relevant dimensions in this study. In a very prominent view, the level of perceptions of Infrastructure Planning significantly exceeds perceptions of Early Warning Systems, Community Resilience, Community Empowerment, Social Protection, and Climate Change Adaptation. These results encourage the interpretation that the majority of respondents seem to direct greater attention to the dimensions of infrastructure planning in the context of natural disaster mitigation efforts.

Table 2. reliability

Reliability Statistics

Cronbach's Alpha	N of Items
.648	6

Table 2 in this study reflects the reliability evaluation of the main variables, namely Infrastructure Planning, Early Warning Systems, Community Resilience, Community Empowerment, Social Protection, and Climate Change Adaptation. The table is used to measure the extent to which these variables are able to provide consistent and stable results in various contexts of time and situations. Reliability, as a measure of consistency and stability, becomes essential in validating the validity of variable measurements. By analyzing the reliability data in Table 2, researchers can identify whether the measurement of these variables can be relied upon as the right indicators to represent the intended concept.

Table 3. Correlations

CORRELATIONS

		1	2	3	4	5	6
Early Warning System	Pearson Correlation	1	.322**	.232**	089	.327**	-.015
	Sig. (2-tailed)		.000	.000	095	.000	.786
	N	349	349	349	349	349	349
Infrastructure Planning	Pearson Correlation	.322**	1	.381**	091	.467**	.137*
	Sig. (2-tailed)	.000		.000	089	.000	011
	N	349	349	349	349	349	349
Social Protection	Pearson Correlation	.232**	.381**	1	.221**	.287**	.211**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	349	349	349	349	349	349
Climate Change Adaptation	Pearson Correlation	089	091	.221**	1	.113*	.512**
	Sig. (2-tailed)	095	089	.000		.034	.000
	N	349	349	349	349	349	349
Community Resilience	Pearson Correlation	.327**	.467**	.287**	.113*	1	.128*
	Sig. (2-tailed)	.000	.000	.000	.034		.017
	N	349	349	349	349	349	349
Community empowerment	Pearson Correlation	-.015	.137*	.211**	.512**	.128*	1
	Sig. (2-tailed)	.786	011	.000	.000	.017	
	N	349	349	349	349	349	349

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 3 presents the results of bivariate correlations between six main variables, namely Infrastructure Planning, Early Warning Systems, Community Resilience, Community Empowerment, Social Protection, and Climate Change Adaptation, using statistical methods such as the Pearson correlation coefficient. This method is a valuable instrument in identifying linear relationships between these variables. The Pearson correlation coefficients in this table indicate the degree and direction of the linear relationship between each pair of variables, illustrating the extent to which changes in one variable can be proportionally related to changes in other variables.

Table 4. T test for the dependent variable Community resilience

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	std. Error	Betas		
1	(Constant)	8,569	1,376		6,225	.000
	Early Warning System	.164	044	.182	3,697	.000
	Infrastructure Planning	.309	043	.368	7,097	.074
	Social Protection	082	044	095	1855	.000
	Climate Change Adaptation	043	048	042	.894	.000

a. Dependent Variable: Community Resilience

Table 4 showst-test results comparing early warning systems, infrastructure planning, social protection, and climate change adaptation to community resilience. Which is where infrastructure planning is not significant to community resilience.

Table 5. T test for the dependent variable Community Empowerment

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	std. Error	Betas		
1	(Constant)	8,193	1,447		5,663	.000
	Early Warning System	-.105	047	-.110	-2,262	.073
	Infrastructure Planning	082	046	092	1,798	.000
	Social Protection	085	047	093	1835	.000
	Climate Change Adaptation	.536	051	.493	1,534	.000

a. Dependent Variable: Community Empowerment

Table 5 showst-test results comparing early warning systems, infrastructure planning, social protection, and climate change adaptation to community resilience. Which is where the early warning system is not significant for community empowerment.

Table 6. F test for the dependent variable Community Resilience

ANOVAa

Model		Sum of Squares	df	MeanSquare	F	Sig.
1	Regression	278,203	4	69,551	30,765	.000b
	residual	777,694	344	2,261		
	Total	1055,897	348			

a. Dependent Variable: Community Resilience
b. Predictors: (Constant), Climate Change Adaptation, Early Warning Systems, Social Protection, Infrastructure Planning

In order to provide a deeper understanding of the discrepancy between popular expectations and actual findings regarding shifts in societal resilience, we have undertaken a more detailed investigation. The core focus of this study is to test the hypotheses that have been proposed. This exploratory approach is followed up by making use of statistical

analysis known as one-way ANOVA. This methodological approach allows us to make comparisons between the responses given by relevant respondents to the questions posed in the survey, which relate to the changes identified in the societal context. Through this approach,

Table 6 depicts the results of the ANOVA analysis which showed a significant difference in the survey responses to the series of questions presented. These findings highlight that the dynamics of change in community resilience is far more complex than initial assumptions. These findings indicate that certain factors have a significant impact on community resilience in facing the questions that have been analyzed.

Table 7. F test for the dependent variable Community Empowerment

ANOVAa

Model		Sum of Squares	df	MeanSquare	F	Sig.
1	Regression	343,808	4	85,952	34,418	.000b
	residual	859,063	344	2,497		
	Total	1202,871	348			

a. Dependent Variable: Community Empowerment

b. Predictors: (Constant), Climate Change Adaptation, Early Warning Systems, Social Protection, Infrastructure Planning

Table 7 describes the results of the ANOVA analysis which confirms that there are significant differences in the responses related to the concept of community empowerment to the series of questions that have been tested. This finding reveals that the variation in responses to the questions is not the result of random variation, but has deep statistical significance. These results prove that the various responses to these questions have a strong meaning from a statistical point of view. These findings provide an understanding that the dynamics of community responses to the concept of community empowerment is more complex than one might anticipate. Therefore,

Based on the results of the research data, the response given by respondents to the concept of community resilience shows a substantial picture of the complexity of community vulnerability to natural disasters in the Central Sulawesi region, Indonesia. This study has a focused objective of identifying and evaluating factors that contribute to shaping the level of community vulnerability to existing natural disaster threats, by accommodating socio-economic, environmental and geographical aspects.(Hansson et al. 2020).The data obtained from the survey indicate that the responses expressed by the respondents through their responses to the concept of community resilience provide a deeper view of the complexity of the interrelationships between the identified factors. This response reflects the community's understanding of the relationship between socio-economic aspects which include financial readiness and capacity, environmental aspects which include adaptation to changes in the natural environment, and geographical factors which characterize the risk of natural disasters that may occur in the Central Sulawesi region. This understanding is reflected in the respondents' responses. described their commitment to understanding the importance of collective efforts in reducing people's vulnerability to natural disasters.

Community resilience has a significant role in shaping the level of vulnerability to natural disasters, as reflected in data from research conducted in the Central Sulawesi region, Indonesia. The main objective of this study is to identify and evaluate factors that contribute to shaping community vulnerability to natural disasters, taking into account socio-economic, environmental and geographical aspects. The research data shows that community resilience plays a crucial role in reducing the level of vulnerability to disasters.

natural. Respondents' responses to the dimensions of community resilience reflect their understanding of the importance of having adequate knowledge and preparedness in dealing with the threat of natural disasters. Community resilience, which includes socio-economic aspects,(Huq et al. 2020).Respondents' understanding of the importance of socio-economic factors which include access to financial resources and economic empowerment, environmental aspects which include adaptation to environmental changes, as well as geographical factors that affect the risk of natural disasters, is reflected in their response to community resilience. Research data show that communities that have a better level of resilience in these aspects tend to have lower vulnerability to natural disasters. Respondents' understanding of socio-economic, environmental, and geographical factors that shape community resilience contributes to reducing their vulnerability. against the threat of natural disasters in the region of Central Sulawesi, Indonesia.

Community empowerment has significant implications in shaping the level of vulnerability to natural disasters, in line with findings from research data conducted in Central Sulawesi, Indonesia. This study aims to identify and evaluate the factors that contribute to the level of community vulnerability to natural disasters, taking into account socio-economic, environmental and geographical aspects. The research data shows that community empowerment has a key role in reducing the level of vulnerability to natural disasters. Respondents' responses to the dimensions of community empowerment reflect that people who have access to knowledge, resources, and training that support natural disaster preparedness tend to have lower vulnerabilities.(Islam and Khan 2020). This data indicates that communities who are actively involved in the decision-making process and have a role in planning and implementing disaster mitigation measures, have a lower vulnerability to the threat of natural disasters.

Respondents' understanding of the importance of socio-economic, environmental and geographical aspects in community empowerment is reflected in their response to this dimension(Abukari and Mwalyosi 2020). The results of the study show that people who have access to sufficient economic resources, have awareness of the environment and the ability to adapt to change, and consider geographical factors in disaster mitigation planning, have a lower vulnerability to the threat of natural disasters. Overall, the findings of the research data this provides strong evidence that community empowerment plays an important role in shaping the level of vulnerability to natural disasters. These results illustrate that the active participation of the community in efforts to mitigate and deal with natural disasters has a positive impact on reducing their vulnerability to disaster risk.

In analyzing the role of policy interventions in reducing risk and overcoming the impact of natural disasters on community resilience in Central Sulawesi, several obstacles emerge that need attention. This research aims to identify key policy areas that can increase community resilience, including infrastructure, early warning systems, community empowerment, social protection, and climate change adaptation. However, in the geographic and social context of Central Sulawesi, several obstacles may affect the effectiveness of this policy intervention. One of the main obstacles is the complex topography and high geological risk in Central Sulawesi. The region is prone to earthquakes, liquefaction and landslides, which makes building infrastructure and early warning systems more complicated.(Que et al. 2019).

In addition, Central Sulawesi has communities that are scattered in remote areas and difficult to reach. This geographical factor can hinder the accessibility and implementation of community empowerment and social protection programs. Efforts to achieve community participation in policies and programs can be more complex in these remote areas. Another challenge is the level of community awareness and understanding of disaster risk and climate change. Even though there are efforts to increase community knowledge, some groups may still not be aware of the importance of climate change

adaptation and empowerment in dealing with disasters. Effective education and communication are needed to build better understanding among the people(Juma and Khademi-Vidra 2019). In the face of constraints such as complex topography, limited accessibility, and varying levels of public awareness, the role of policy interventions in reducing risk and overcoming the impact of natural disasters in Central Sulawesi needs to be analyzed carefully. In identifying key policy areas that can enhance community resilience, an approach that takes into account the local geographical, social and cultural context is essential. By understanding and overcoming these constraints, policies can be designed and implemented more effectively to increase the resilience of communities in Central Sulawesi to the risks and impacts of natural disasters.

The main challenges in policy interventions to reduce risk and overcome the impact of natural disasters include several critical aspects that have been identified through the results of this research. First, in implementing policy interventions such as disaster-resilient infrastructure and early warning systems, challenges arise from Indonesia's diverse geographical and topographical complexities. A region prone to natural disasters such as Central Sulawesi has its own challenges in planning and building strong infrastructure and an effective warning system. The ability to overcome these geographical constraints is important in ensuring the success of policy interventions(Eriksen et al. 2021).Aspects of community empowerment and social protection face challenges in overcoming socio-economic disparities and accessibility. In the case of Indonesia, especially in remote areas, people with economic limitations and limited access may also have limited access to empowerment and social protection programs. Increasing participation and equity in access to policy interventions is important in maintaining the continuity and effectiveness of disaster risk reduction efforts.

Climate change adaptation and the factors that contribute to community vulnerability, such as socio-economic, environmental and geographical aspects, are related to challenges in increasing public awareness and understanding. This research shows that the level of public knowledge and understanding of climate change and the factors of vulnerability still varies. Communicating the impact of climate change effectively and providing relevant education to the community can help improve adaptive capacity(Panoutsou et al. 2021). Overall, policy interventions to reduce risk and overcome the impact of natural disasters and increase community resilience are faced with complex challenges involving geographical, socio-economic and environmental aspects. In designing and implementing this policy, an integrated approach is needed that takes into account the local context, community participation, and effective communication so that these efforts can be successful and have a significant positive impact in dealing with the threat of natural disasters in Indonesia, especially in Central Sulawesi.

The results of this study provide a rich picture of the role of policy interventions in reducing risk and overcoming the impact of natural disasters and the factors that contribute to the vulnerability of society to natural disasters in Indonesia, particularly in Central Sulawesi. In analyzing the role of policy interventions, this research finds that policy actions directed at improving infrastructure, early warning systems, community empowerment, social protection, and climate change adaptation play an important role in reducing disaster risks and addressing their impacts.(Yaacoub et al. 2020). Research data indicate that the implementation of this policy intervention is related to increasing community resilience to natural disasters. In terms of identifying and evaluating factors that contribute to community vulnerability to natural disasters, this study reveals that socio-economic, environmental and geographical aspects play a significant role.

Data analysis shows that people with better socio-economic conditions tend to have higher resilience to natural disasters. Likewise, understanding of the environment and ability to adapt to climate change also affect the level of community vulnerability. In addition,

geographical factors, such as geographical locations that are vulnerable to natural disasters, also contribute to community vulnerability(Maulidia et al. 2019)The results of this research provide a holistic view of how policy interventions can have a positive impact on reducing risk and overcoming the impact of natural disasters, as well as factors that need to be considered in efforts to increase community resilience to disasters. The implications of these findings provide valuable directions for the formulation and implementation of policies that are more effective in dealing with the threat of natural disasters in Indonesia, especially in the Central Sulawesi region. By utilizing the results of this research, policy makers and practitioners can design strategies that are more precise and focused on protecting and strengthening community resilience in dealing with disaster risks and their impacts.

Conclusions

This research explores the concept of community vulnerability to natural disasters in Indonesia and discusses the policy implications for mitigating the impact of these disasters. It highlights key policy areas that can increase community resilience, including risk assessment, early warning systems, infrastructure planning, community empowerment, social protection, and climate change adaptation. Comparative analysis is an important scientific basis for strengthening community resilience and reducing the impact of natural disasters in Central Sulawesi. This can provide valuable information to guide policy and mitigation practices in the region. The study used a quantitative approach, including purposive sampling, to collect and analyze data on community vulnerability to natural disasters in Central Sulawesi. This approach enables a comprehensive understanding of the socio-economic, environmental, and geographic aspects of vulnerability. However, it is important to recognize that the results obtained from purposive sampling may have limitations in terms of generalizability to the entire population. Future research can focus on further exploring the factors that contribute to community vulnerability and designing more effective disaster mitigation policies. This could include developing disaster-resilient infrastructure, building community capacities, strengthening early warning systems, and planning emergency response. In addition, qualitative research methods can be used to gain deeper insight into the characteristics and responses of vulnerable communities in Central Sulawesi.

References

Abukari, H., & Mwalyosi, R. B. (2020). Local Communities' Perceptions about the Impact of Protected Areas on Livelihoods and Community Development. Global Ecology and Conservation, 22, e00909.

Adger, W. N. (1999). Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. World Development, 27(2), 249–269.

Adger, W. N. (2006). Vulnerabilities. Global Environmental Change, 16(3), 268–281.

Amri, I., & Giyarsih, S. R. (2022). Monitoring Urban Physical Growth in Tsunami-Affected Areas: A Case Study of Banda Aceh City, Indonesia. Geojournal, 87(3), 1929–1944.

Anjomshoae, A., Hassan, A., Wong, K. Y., & Banomyong, R. (2021). An Integrated Multi-Stage Fuzzy Inference Performance Measurement Scheme in Humanitarian Relief Operations. International Journal of Disaster Risk Reduction, 61, 102298.

Astuti, N. M. W., Werdhiana, I. K., & Wahyono, U. (2021). Impacts of Direct Disaster Experience on Teachers' Knowledge, Attitudes and Perceptions of Disaster Risk Reduction Curriculum Implementation in Central Sulawesi, Indonesia. International Journal of Disaster Risk Reduction, 53, 101992.

Birkmann, J. (2006). Measuring Vulnerability to Promote Disaster-Resilient Societies: Conceptual Frameworks and Definitions. In Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies (pp. 9–54).

BNPB. (2023). Data and Information on Disaster in Indonesia.

BPS, Central Sulawesi province. (2020). Population of Central Sulawesi Province Population Census 2020.

Coccia, M. (2021). High Health Expenditures and Low Exposure of Population to Air Pollution as Critical Factors That Can Reduce Fatality Rate in COVID-19 Pandemic Crisis: A Global Analysis. Environmental Research, 199, 111339.

Cutter, S. L. (1996a). Vulnerability to Environmental Hazards. Progress in Human Geography, 20(4), 529–539.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards. Social Science Quarterly, 84(2), 242–261.

Cutter, S. L. (1996b). Vulnerability to Environmental Hazards. Progress in Human Geography, 20(4), 529–539.

Djalante, R., Thomalla, F., Sinapoy, M. S., & Carnegie, M. (2012). Building Resilience to Natural Hazards in Indonesia: Progress and Challenges in Implementing the Hyogo Framework for Action. Natural Hazards, 62(3), 779–803.

Dwyer, A., Zoppou, C., & Nielsen, O. (2004). Indicator Selection. In Quantifying Social Vulnerability: A Methodology for Identifying Those at Risk to Natural Hazards (pp. 8–17).

Eriksen, S., et al. (2021). Adaptation Interventions and Their Effect on Vulnerability in Developing Countries: Help, Hindrance or Irrelevance? World Development, 141, 105383.

Flanagan, B. E., et al. (2020). A Social Vulnerability Index for Disaster Management. Journal of Homeland Security and Emergency Management, 8(1).

Floridi, L., Cowls, J., King, T. C., & Taddeo, M. (2021). How to Design AI for Social Good: Seven Essential Factors. In Ethics, Governance, and Policies in Artificial Intelligence (pp. 125–151).

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to Use and How to Report the Results of PLS-SEM. European Business Review, 31(1), 2–24.

Hair Jr., J. F., et al. (2021). An Introduction to Structural Equation Modeling. In Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook (pp. 1–29).

Hansson, S., et al. (2020). Communication-Related Vulnerability to Disasters: A Heuristic Framework. International Journal of Disaster Risk Reduction, 51, 101931.

Hennink, M., & Kaiser, B. N. (2022). Sample Sizes for Saturation in Qualitative Research: A Systematic Review of Empirical Tests. Social Science & Medicine, 292, 114523.

Huq, M. E., et al. (2020). Measuring Vulnerability to Environmental Hazards: Qualitative to Quantitative. In Environment, Climate, Plants and Vegetation Growth (pp. 421–452).

Islam, M. R., & Khan, N. A. (2020). Threats, Vulnerability, Resilience and Displacement among the Climate Change and Natural Disaster-Affected People in South-East Asia: An Overview. In Climate Change Mitigation and Sustainable Development (pp. 111–138).

Juma, L. O., & Khademi-Vidra, A. (2019). Community-Based Tourism and Sustainable Development of Rural Regions in Kenya; Perceptions of the Citizenry. Sustainability, 11(17), 4733.

Katsaliaki, K., Galetsi, P., & Kumar, S. (2021). Supply Chain Disruptions and Resilience: A Major Review and Future Research Agenda. Annals of Operations Research, 1–38.

Khalid, S., et al. (2019). Community Empowerment and Sustainable Tourism Development: The Mediating Role of Community Support for Tourism. Sustainability, 11(22), 6248.

Klein, E. A., et al. (2021). Clinical Validation of a Targeted Methylation-Based Multi-Cancer Early Detection Test Using an Independent Validation Set. Annals of Oncology, 32(9), 1167–1177.

Kryspin-Watson, J., et al. (2020). Strengthening the Disaster Resilience of Indonesian Cities: A Policy Note.

Kusumastuti, R. D., et al. (2014). Developing a Resilience Index towards Natural Disasters in Indonesia. International Journal of Disaster Risk Reduction, 10(PA), 327–340.

Mardiah, A. N. R., Lovett, J. C., & Evanty, N. (2017). Toward Integrated and Inclusive Disaster Risk Reduction in Indonesia: Review of Regulatory Frameworks and Institutional Networks.

Maulidia, M., Dargusch, P., Ashworth, P., & Ardiansyah, F. (2019). Rethinking Renewable Energy Targets and Electricity Sector Reform in Indonesia: A Private Sector Perspective. Renewable and Sustainable Energy Reviews, 101, 231–247.

Mind'je, R., et al. (2019). Flood Susceptibility Modeling and Hazard Perception in Rwanda. International Journal of Disaster Risk Reduction, 38, 101211.

Nicholson, D., Vanli, O. A., Jung, S., & Ozguven, E. E. (2019). A Spatial Regression and Clustering Method for Developing Place-Specific Social Vulnerability Indices Using Census and Social Media Data. International Journal of Disaster Risk Reduction, 38, 101224.

Pan, Y., & Zhang, L. (2021). Roles of Artificial Intelligence in Construction Engineering and Management: A Critical Review and Future Trends. Automation in Construction, 122, 103517.

Panoutsou, C., et al. (2021). Advanced Biofuels to Decarbonize European Transport by 2030: Markets, Challenges, and Policies That Impact Their Successful Market Uptake. Energy Strategy Reviews, 34, 100633.

Pappas, I. O., & Woodside, A. G. (2021). Fuzzy-Set Qualitative Comparative Analysis (FsQCA): Guidelines for Research Practice in Information Systems and Marketing. International Journal of Information Management, 58, 102310.

Peng, Y., & Tao, C. (2022). Can Digital Transformation Promote Enterprise Performance?—From the Perspective of Public Policy and Innovation. Journal of Innovation & Knowledge, 7(3), 100198.

Que, S., et al. (2019). Comparative Study of Factors Affecting Public Acceptance of Mining Projects: Evidence from USA, China, and Turkey. Journal of Cleaner Production, 237, 117634.

Rezvani, S. M. H., Falcão, M. J., Komljenovic, D., & Marques de Almeida, N. (2023). A Systematic Literature Review on Urban Resilience Enabled with Asset and Disaster Risk Management Approaches and GIS-Based Decision Support Tools. Applied Sciences, 13(4), 2223.

Sarker, M. N. I., Peng, Y., Yiran, C., & Shouse, R. C. (2020). Disaster Resilience through Big Data: Way to Environmental Sustainability. International Journal of Disaster Risk Reduction, 51, 101769.

Scherzer, S., Lujala, P., & Rød, J. K. (2019). A Community Resilience Index for Norway: An Adaptation of the Baseline Resilience Indicators for Communities (BRIC). International Journal of Disaster Risk Reduction, 36, 101107.

Scott, D., Hall, C. M., & Gössling, S. (2019). Global Tourism Vulnerability to Climate Change. Annals of Tourism Research, 77, 49–61.

Shaheen, M., & Pradhan, S. (2019). Sampling in Qualitative Research. In Qualitative Techniques for Workplace Data Analysis (pp. 25–51).

Siagian, T. H., Purhadi, P., Suhartono, S., & Ritonga, H. (2014). Social Vulnerability to Natural Hazards in Indonesia: Driving Factors and Policy Implications. Natural Hazards, 70(2), 1603–1617.

Stolle, J., et al. (2020). Engineering Lessons from the 28 September 2018 Indonesian Tsunami: Debris Loading. Canadian Journal of Civil Engineering, 47(1), 1–12.

Sun, W., Bocchini, P., & Davison, B. D. (2020). Applications of Artificial Intelligence for Disaster Management. Natural Hazards, 103(3), 2631–2689.

Sverke, M., et al. (2019). A Meta-Analysis of Job Insecurity and Employee Performance: Testing Temporal Aspects, Rating Sources, Welfare Regime, and Union Density as Moderators. International Journal of Environmental Research and Public Health, 16(14), 2536.

Tang, J., et al. (2019). Crash Injury Severity Analysis Using a Two-Layer Stacking Framework. Accident Analysis & Prevention, 122, 226–238.

Trafimov, D. (2019). A Frequentist Alternative to Significance Testing, p-Values, and Confidence Intervals. Econometrics, 7(2), 26.

Trias, A. P. L., & Cook, A. D. B. (2021). Future Directions in Disaster Governance: Insights from the 2018 Central Sulawesi Earthquake and Tsunami Response. International Journal of Disaster Risk Reduction, 58, 102180.

Tun, S. Y. Y., Madanian, S., & Mirza, F. (2021). Internet of Things (IoT) Applications for Elderly Care: A Reflective Review. Aging Clinical and Experimental Research, 33, 855–867.

Wisner, B. (2004). At Risk: Natural Hazards, People's Vulnerability, and Disasters. Psychology Press.

Yaacoub, J. P., Noura, H., Salman, O., & Chehab, A. (2020). Security Analysis of Drones Systems: Attacks, Limitations, and Recommendations. Internet of Things, 11, 100218.

Yigitcanlar, T., Desouza, K. C., Butler, L., & Roozkhosh, F. (2020). Contributions and Risks of Artificial Intelligence (AI) in Building Smarter Cities: Insights from a Systematic Review of the Literature. Energies, 13(6), 1473.

Zitnik, M., et al. (2019). Machine Learning for Integrating Data in Biology and Medicine: Principles, Practice, and Opportunities. Information Fusion, 50, 71–91.