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The Role of Non-Structural Mitigation Elements in Enhancing the Effectiveness of Disaster Risk Reduction: A Health Perspective on Community Preparedness and Resilience

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Abstract

Landslides frequently occur in hilly areas of Indonesia, including the Poncol District, Magetan Regency, causing significant material losses, fatalities, and socio-economic impacts. Structural mitigation is often unsustainable for communities with limited resources. This study aims to develop a non-structural mitigation model based on community empowerment, integrating risk mapping, capacity building, local wisdom, and inclusive planning to enhance community resilience and adaptation in various regions. This research employs a cross-sectional analytical survey design in Genilangit Village, Poncol, Magetan, involving 150 respondents selected through proportional stratified random sampling. Data were collected using a Likert scale questionnaire, analysed with descriptive statistics and path analysis using Partial Least Squares (PLS). Findings indicate that non-structural mitigation effectiveness has an R-Square of 0.483, explaining 48.3% of the variability. Disaster education and mitigation planning have limited influence, with R-squares of 0.065 and 0.042, respectively. Local wisdom-based mitigation significantly enhances mitigation effectiveness (coefficient 1.201; T-statistic 4.885), whereas identification and mapping show a significant negative effect (coefficient -0.867; T-statistic 3.146). From a health perspective, landslides pose indirect risks, including injuries, disease outbreaks, and psychological stress. This study highlights the need for integrating health aspects into non-structural mitigation strategies. Strengthening risk identification, incorporating disaster education into curricula, community involvement, and addressing health vulnerabilities are essential for improving mitigation effectiveness. An integrated approach ensures resilience and overall well-being in disaster-prone communities, promoting sustainable and community-driven disaster preparedness efforts.

Keywords: *Community Empowerment, Disaster Education, Landslide, Local Wisdom, Mitigation Planning, Non-Structural Mitigation.*

Introduction

Indonesia, as a country prone to natural disasters, has unique geographical and geological characteristics [1]. Its location between three world plates—the Eurasian, Indo-Australian, and Pacific plates—causes this region to be frequently hit by various disasters, ranging from earthquakes, tsunamis, volcanic eruptions, to landslides [2]. Magetan Regency, especially Poncol District, is an area that has a high risk of landslides, particularly in Genilangit Village, which experiences landslides of various scales almost every year.

In facing high disaster risks, Indonesia has implemented various steps, including through Law Number 24 of 2007, which mandates that disaster management is a joint responsibility of the government, private sector, and community. This community-based approach is reinforced by the recommendations of the 2005-2015

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"Hyogo Framework for Action," which emphasises the need for proactive actions to build disaster resilience [3]. However, disaster management strategies often still focus on reactive responses and do not integrate long-term mitigation involving community preparedness. In this context, the best solution that has emerged is a community-based mitigation approach [4], especially to reduce the risk of landslides in vulnerable areas such as the Poncol District. This approach allows the community to play an active role as a subject who understands and utilises local resources to reduce the impact of disasters. However, this effort still faces several limitations, particularly in terms of the lack of community understanding of non-structural mitigation techniques, low monitoring capacity, and the lack of integration of local policies in mitigation.

From a health perspective, landslides not only pose a threat to physical infrastructure and economic stability but also significantly impact public health. Landslides can result in injuries, fatalities, and disruption of access to essential health services, especially in remote areas like the Poncol District. Furthermore, landslides often lead to secondary health issues, such as the spread of infectious diseases due to contaminated water sources, poor sanitation, and overcrowded evacuation shelters. Psychological stress and trauma are also common among affected populations, particularly vulnerable groups such as children, the elderly, and pregnant women. Therefore, integrating health aspects into disaster mitigation strategies is crucial to ensure holistic community resilience.

The purpose of developing a community-based non-structural disaster mitigation model is to address these limitations. This development aims to enhance community preparedness in facing landslide risks through risk mapping, strengthening community capacity, and integrating local practices into mitigation planning. The model is designed not only to mitigate physical risks but also to protect public health by emphasising preventive measures, public health education, and access to healthcare during and after disasters.

The novelty of this research lies in the non-structural disaster mitigation model, which emphasises a participatory community approach, allowing residents to actively engage in landslide risk mitigation. This model integrates relevant local practices and local wisdom, systematically involves aspects of education and outreach to build a culture of disaster preparedness, and addresses health vulnerabilities. In this scheme, the development of a community-based model focuses on:

1. Identification and mapping of landslide risks in the Poncol District to identify health vulnerabilities and evacuation routes.
2. Increasing community capacity and knowledge through training on disaster preparedness and first aid.
3. Implementation of local wisdom-based mitigation strategies that include traditional practices for health and safety.
4. Evaluation of preparedness through periodic monitoring and simulation, incorporating health response drills to strengthen emergency medical response.

By integrating health aspects into non-structural mitigation, this model seeks to protect lives, promote well-being, and ensure community resilience in landslide-prone areas.

Materials and Methods

This research method is an analytical survey with a cross-sectional design, aimed at studying the correlation between non-structural disaster mitigation elements and the effectiveness of mitigation through one-time data collection (point time approach) [5]. The independent variable is the non-structural mitigation element, while the dependent variable is the effectiveness of disaster mitigation.

The study population included the residents of Genilangit Village, Poncol District, Magetan

Regency, totalling 3,668 people or 1,034 heads of families (KK). The sample size was determined using the Rule of Thumb method [6], which is based on the number of analysis parameters between variables, namely 7 influence paths and 4 error paths, with a total of 11 paths. A sample size of 150 respondents was obtained. The sampling technique used was proportionate stratified random sampling [7], ensuring proportional representation of each level of society.

The independent variables consist of aspects of community-based non-structural mitigation, including:

1. Identification and mapping: Efforts to identify and map high-risk areas for landslides and health risks.
2. Community knowledge: Level of community awareness and understanding of disaster preparedness, including health risks and first aid.
3. Local wisdom: Incorporation of traditional practices and values that promote safety and health.
4. Legal discipline: Compliance with regulations related to disaster risk reduction.
5. Environmental balance: Practices ensuring sustainable land use to prevent disasters.
6. Environmental carrying capacity: Understanding and maintaining the limits of local environmental resources.

The intervention variables include:

1. Community awareness: Levels of public understanding and preparedness for disaster and health emergencies.
2. Monitoring of landslide-prone areas: Ongoing observation of risk areas, including health vulnerabilities.
3. Mitigation planning and budgeting: Community involvement in creating actionable and sustainable mitigation plans, integrating health priorities.
4. Disaster education for students: Awareness and knowledge-building initiatives in schools that include health and safety components.

The dependent variable is the effectiveness of disaster mitigation, including the community’s ability to respond to disasters in a way that minimises physical, social, and health impacts.

The research instrument was a Likert Scale questionnaire [8], which measured respondents' perceptions of these variables. The instrument was tested for validity and reliability before use, using validity tests and Cronbach's Alpha to ensure consistency and accuracy of the data.

Statistical analysis included:

1. Descriptive analysis to summarise respondent characteristics, such as demographic information and health-related preparedness.
2. Correlation analysis to explore relationships between variables.
3. Path analysis to test the direct and indirect effects of independent variables on the dependent variable.

The classical assumption tests (e.g., normality, multicollinearity, and heteroscedasticity tests) were conducted to ensure the fulfilment of path analysis requirements. The significance level was set at $\alpha = 0.05$ [9].

From a health perspective, this study also assessed how community-based non-structural mitigation efforts impact public health outcomes. For instance, the ability to reduce injuries, prevent disease outbreaks in disaster aftermaths, and ensure access to healthcare during emergencies were considered key indicators of mitigation effectiveness. This holistic approach integrates disaster management and public health priorities, aiming to build a resilient and healthy community in landslide-prone areas.

Results

Respondent Characteristics Data

The distribution of respondents by age shows that the 31-40 age group dominates, with

56 respondents (37.3%). This group is followed by 32 respondents aged 41-50 (21.3%) and 28 respondents aged 20-30 (18.7%). The >50 age group includes 23 respondents (15.3%), while the <20 age group has the fewest respondents, with 11 respondents (7.3%). This shows that the majority of respondents are of productive age, especially in the 31-40 age range. Based on the results of the study, the distribution of respondents by gender shows that the majority of respondents are male, with 97 respondents (64.7%), while women are 53 respondents (35.3%). This shows that male participation is more dominant than female participation in this study. The results of the analysis show that the majority of respondents have an elementary school/junior high school education level (64.0%), followed by respondents with a high school education level (34.7%). Respondents with a college education level are the smallest group, which is only 1.3%. This finding shows that most respondents have a basic to secondary education background, with a very small proportion continuing to higher education.

The distribution of respondents' jobs shows that the majority of respondents work as farmers, which is 66 people (44.0%). Self-employed work is in second place with 44 people (29.3%). Respondents working in the private sector are 21 people (14.0%), followed by other groups with 18 people (12.0%). Meanwhile, civil servants are the category with the smallest number, which is only 1 person (0.7%). This data shows the dominance of jobs in the agricultural sector in the population studied, followed by the informal sector, such as the self-employed. Based on the results of descriptive statistical analysis, the characteristics of respondents related to the length of residence in disaster-prone areas show that the number of respondents analysed is 150 people. The length of residence in the area has a range of 60 years, with a minimum value of 1 year and a maximum of 61 years. The mean length of stay of respondents was 36.09 years, with a standard deviation of 13.55, indicating a significant variation in length of stay among respondents. The variance of 183.669 indicates a relatively significant level of data spread, indicating that there is a significant difference between one respondent and another in terms of length of stay in disaster-prone areas.

Variable Description Data

The results of the descriptive statistical analysis show the average value (Mean), standard deviation (Std Deviation), and minimum and maximum ranges for each research variable. In general, the average value of all variables ranges from 18.68 to 33.52, with the lowest minimum value in the Mitigation Planning and Budgeting variable (12.00) and the highest maximum value in the Disaster Education variable (40.00). The variable with the highest average value is Disaster Education (Mean = 33.52, Std. Deviation = 4.25), indicating that the disaster education aspect receives relatively good attention compared to other variables. Conversely, the variable with the lowest average value is Mitigation Planning and Budgeting (Mean = 18.68, Std. Deviation = 3.25), indicating that this aspect may require further improvement in the development and implementation of mitigation programs. The variable with the highest standard deviation is Identification and Mapping (Std. Deviation = 4.61), which reflects a greater variation in respondents' responses to this variable.

Path Analysis Results

Initial Model Results

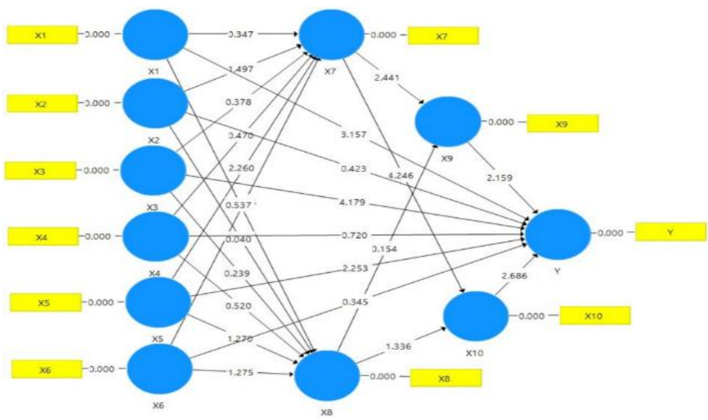

Figure 1. Calculate Algorithm Output [10]

Based on the results of the measurement model reliability test in Table 1, all constructs are declared reliable with Composite Reliability and Cronbach's Alpha values that meet the threshold, except for construct X4, which has a Composite Reliability value of 0.60 and a Cronbach's Alpha of 0.55, so it is declared unreliable. Construct Y shows the highest reliability with a Composite Reliability value of 0.93 and a Cronbach's Alpha of 0.90, indicating very good measurement consistency in the construct. Constructs that have Composite Reliability and Cronbach's Alpha values above 0.7 are considered reliable, indicating that the construct has good internal consistency. If the Composite Reliability or Cronbach's Alpha value is below 0.7, the construct is considered unreliable. In this table, construct X4 has a value below the standard, indicating that this construct may need to be further evaluated or modified. Modifications are made until no Composite Reliability or Cronbach's Alpha values are found below 0.7. The results of the modifications are carried out gradually by eliminating construct variables with values below the standard, namely, less than 0.7. Construct variables that have values less than 0.7 are construct variables X2, X4, X5, and X6.

Final Model Results

The results of this path analysis aim to identify the direct relationship between the independent variables and the dependent variables in the research model that has been developed. The analysis was carried out using a statistical approach to test the path coefficient (β), T-statistic value, and P-value as indicators of the significance of the relationship between variables. The final results of modelling through path analysis are as shown in Figure 2, below.

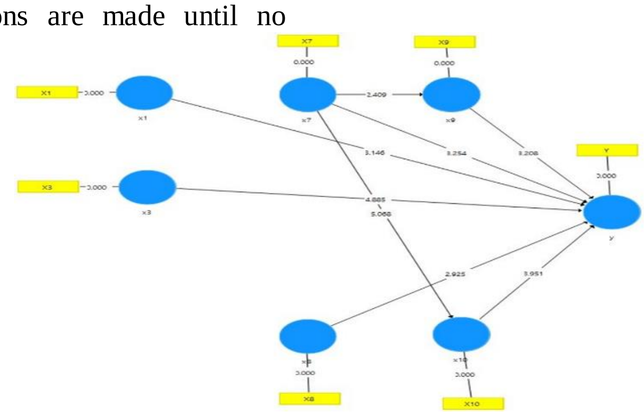

Figure 2. Calculate Bootstrapping Output [10]

Table 1. Path Coefficient

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T-Statistic**	**P-Values**
Identification and mapping→effectiveness of non-structural mitigation	-0.867	-0.881	0.276	3.146	0.002
Local wisdom-based mitigation→effectiveness of non-structural mitigation	1.201	1.216	0.246	4.885	0.000
Community concern→effectiveness of non-structural mitigation	-0.100	-0.102	0.031	3.254	0.001
Monitoring in Landslide-Prone Residential Areas→effectiveness of Non-Structural Mitigation	-0.124	-0.126	0.043	2.925	0.004
Mitigation planning and budgeting →effectiveness of non-structural mitigation	0.120	0.118	0.037	3.208	0.001
Disaster education for students has →effectiveness of non-structural mitigation variables	0.367	0.367	0.093	3.951	0.000
Community Concern→Disaster Education for Students	-0.246	-0.248	0.049	5.068	0.000
Community Concern→Mitigation Planning and Budgeting	0.204	0.204	0.085	2.409	0.016

Based on Table 1, it is explained that overall, the results of the hypothesis, namely, the results of the analysis, show that identification and mapping have a significant negative effect on the effectiveness of non-structural mitigation with a path coefficient of -0.867 and a T-statistic value of 3.146 (p = 0.002). Mitigation based on local wisdom has a significant positive effect on the effectiveness of non-structural mitigation with a path coefficient of 1.201 and a T-statistic value of 4.885 (p = 0.000). Community concern has a significant negative effect on the effectiveness of non-structural mitigation with a path coefficient of -0.100 and a T-statistic value of 3.254 (p = 0.001). Monitoring in landslide-prone residential areas has a significant negative effect on the effectiveness of non-structural mitigation with a path coefficient of -0.124 and a T-statistic value of 2.925 (p = 0.004). Mitigation planning and budgeting have a significant positive effect on the effectiveness of non-structural mitigation with a path coefficient of 0.120 and a T-statistic value of 3.208 (p = 0.001). Disaster education for students has a significant positive effect on the effectiveness of non-structural mitigation with a path coefficient of 0.367 and a T-statistic value of 3.951 (p = 0.000). Community awareness has a significant negative effect on disaster education for students with a path coefficient of -0.246 and a T-statistic value of 5.068 (p = 0.000). Community awareness has a significant positive effect on mitigation planning and budgeting, with a path coefficient of 0.204 and a T-statistic value of 2.409 (p = 0.016).

Discussion

The Influence of Identification and Mapping on the Effectiveness of Non-structural Mitigation

The results of the analysis show that identification and mapping have a significant negative effect on the effectiveness of non-structural mitigation, with a path coefficient of -0.867 and a T-statistic value of 3.146 ($p = 0.002$). This finding underscores the critical challenges in ensuring the accuracy and reliability of identification and mapping processes in disaster mitigation efforts. From a health perspective, inaccurate identification and mapping can have severe implications for public health outcomes during and after disasters. For instance, the failure to properly identify vulnerable populations, such as pregnant women, children, and the elderly, or to map health facility locations accurately, can hinder effective healthcare delivery during emergencies. A study by Smith et al. (2019) emphasised that inaccurate data collection in the identification phase not only disrupts mitigation planning but also compromises timely access to healthcare services in affected areas, exacerbating morbidity and mortality rates during disasters [11]. Moreover, Zhang et al. (2021) highlighted the mismatch between identification outputs and subsequent mitigation actions as a critical factor that confuses communities and undermines their preparedness. In their study, disaster-prone areas were inaccurately mapped, leading to misplaced resources and ineffective health interventions. For example, health resources, such as mobile clinics or emergency medical supplies, were deployed to low-risk areas, leaving high-risk areas underserved during critical periods [12]. Further analysis reveals that this negative effect could also be linked to the lack of community involvement in the identification and mapping process. Community-based participatory approaches are essential for ensuring the inclusion of local knowledge and health needs, which are often overlooked in top-down approaches. Without input from the community, particularly regarding local health risks and vulnerabilities, the identification process can result in data that does not reflect the reality on the ground. This can limit the effectiveness of mitigation strategies in addressing health-related disaster risks, such as disease outbreaks, injuries, and disruptions to essential health services. To improve the effectiveness of non-structural mitigation, several recommendations can be made:

Use of Geospatial Technology

Integrating advanced geospatial tools, such as Geographic Information Systems (GIS) and satellite imagery, can improve the accuracy of mapping disaster-prone areas and associated health risks.

Community Participation

Actively involving the community in the identification and mapping process can ensure that local health vulnerabilities, such as high-density areas or regions lacking healthcare facilities, are accurately documented.

Interdisciplinary Collaboration

Collaboration between disaster management experts, healthcare professionals, and local authorities is crucial to align identification outputs with health-based mitigation strategies.

Regular Updates and Monitoring

Disaster risk maps should be reviewed and updated regularly to incorporate new data and reflect changing conditions, ensuring that mitigation strategies remain relevant and effective. Ultimately, addressing the limitations in identification and mapping is essential not only for improving the overall effectiveness of non-structural mitigation but also for safeguarding the health and well-being of communities in disaster-prone areas.

The Influence of Local Wisdom-based Mitigation on the Effectiveness of Non-structural Mitigation

The results of the study demonstrate a significant positive effect of non-structural mitigation on the effectiveness of disaster risk reduction, with a path coefficient of 1.201 and a T-statistic value of 4.885 ($p = 0.000$). This finding underscores the importance of incorporating non-structural measures into disaster management frameworks to complement structural strategies, particularly in health-related disaster contexts. Non-structural mitigation measures, such as community education, training, early warning systems, and spatial risk-based planning, contribute significantly to enhancing community preparedness and resilience. From a health perspective, these measures have profound impacts on minimising disaster-related morbidity and mortality by ensuring timely access to healthcare services and reducing the vulnerability of at-risk populations. For instance, the integration of early warning systems with health education campaigns enables communities to prepare for disasters more effectively, reducing injury rates and the spread of post-disaster diseases. The study aligns with findings by Driessen et al. (2016), who showed that the application of integrated non-structural measures, such as early warning and community training, significantly reduced flood-related health impacts in disaster-prone areas. Early warning systems facilitated rapid evacuation, which minimised casualties, while community training enhanced public knowledge on first aid and disease prevention during floods, thus improving health outcomes [13]. In addition, research by Brouwer et al. (2019) in Rotterdam highlighted that combining non-structural measures like community education with structural strategies, such as building elevation and dry flood-proofing, significantly improved disaster mitigation outcomes. These measures not only reduced economic losses but also decreased disaster-related health burdens, including stress, trauma, and the spread of waterborne diseases, by ensuring adequate preventive measures were in place [14]. Key health-related benefits of non-structural mitigation include:

Improved Public Awareness

Community education programs enhance knowledge about disaster preparedness, such as the importance of clean water and sanitation during floods, reducing the risk of infectious disease outbreaks.

Strengthened Health Infrastructure

Risk-based spatial planning identifies areas requiring improved health facilities, ensuring better accessibility during disasters.

Enhanced Adaptation Capacity

Training programs equip individuals with skills like first aid, enabling communities to address immediate health needs while awaiting professional assistance.

Disaster Resilience in Vulnerable Populations

Targeting interventions toward high-risk groups, such as pregnant women, the elderly, and children, ensures better health outcomes during and after disasters.

To optimise the effectiveness of non-structural mitigation strategies in reducing disaster risks, the following steps are recommended:

Integration of Health and Disaster Management

Strengthen collaboration between health sectors and disaster management authorities to align mitigation efforts with public health priorities.

Community-Driven Approaches

Involve local communities in the design and implementation of mitigation measures, ensuring interventions address specific health vulnerabilities.

Regular Simulation and Training

Conduct periodic disaster response drills that incorporate health emergency scenarios to build community capacity.

Monitoring and Evaluation

Establish systems to continuously monitor and evaluate the effectiveness of non-structural measures, particularly their impact on health outcomes. In conclusion, non-structural mitigation strategies not only enhance the overall effectiveness of disaster risk reduction but also provide significant health benefits by reducing disaster-related morbidity and mortality. These findings emphasise the need for continued investment in community-based approaches to build disaster-resilient health systems and communities.

The Influence of Community Concern on the Effectiveness of Non-structural Mitigation

The study revealed that community concern significantly negatively impacts the effectiveness of non-structural mitigation, with a path coefficient of -0.100 and a T-statistic value of 3.254 ($p = 0.001$). This suggests that, despite the community's awareness of mitigation issues, challenges such as limited knowledge, insufficient resources, and implementation obstacles can undermine the expected positive effects. These findings align with research emphasising that ineffective communication and poor alignment between mitigation policies and local needs can diminish outcomes [15]. Furthermore, the lack of coordination and mismanagement in engaging communities remain critical barriers to effective disaster mitigation strategies [16]. In health-related disaster mitigation, such issues are particularly relevant as insufficient understanding of non-structural mitigation can lead to inadequate community preparedness for health crises during disasters. For instance, the inability to implement health protocols due to resource shortages or unclear communication can exacerbate post-disaster health impacts, including disease outbreaks or malnutrition. This highlights the need for targeted health education programs that integrate disaster preparedness, including first aid and hygiene management, to improve mitigation effectiveness. Additionally, socio-economic disparities often limit the community's capacity to adopt mitigation measures, further compounding health vulnerabilities. Studies also indicate that while communities may show active concern, external factors such as inadequate government support, unclear responsibilities, and funding constraints reduce the overall impact of mitigation efforts [16]. To enhance the effectiveness of non-structural mitigation, it is crucial to implement a more systematic approach that includes:

1. Improving community understanding through disaster health education and training tailored to local contexts.
2. Strengthening collaboration between communities and authorities to ensure alignment of policies with local needs.
3. Allocating adequate resources for health infrastructure and promoting transparency in mitigation planning.
4. Encouraging participatory approaches where community feedback shapes health and disaster mitigation strategies.

By addressing these gaps, the synergy between community concern and effective non-structural mitigation can be maximised, leading to improved resilience and better health outcomes during disasters.

The Influence of Monitoring in Landslide-prone Residential Areas on the Effectiveness of Non-structural Mitigation

The study revealed a significant negative effect of monitoring in landslide-prone residential areas on the effectiveness of non-structural mitigation, with a path coefficient of

-0.124 and a T-statistic value of 2.925 (p = 0.004). Although monitoring is a critical component of disaster mitigation, limitations such as inadequate resources, insufficient training, or ineffective implementation can undermine its impact. These findings align with prior studies showing that incomplete integration of monitoring systems with broader mitigation policies may hinder long-term disaster preparedness and response. For instance, Strząbała et al. (2024) emphasised that robust and continuous monitoring in landslide-prone areas is vital for detecting early warning signs and reducing disaster risks through timely interventions [18]. In the health context, ineffective monitoring can exacerbate disaster impacts, such as limited access to health services or delayed evacuations, ultimately increasing risks to physical and mental well-being. Khoei and Mohammad (2023) further demonstrated that advancements in geophysical and geotechnical monitoring technologies significantly enhance early warning accuracy, which can support health-focused mitigation planning [16]. Continuous evaluation of environmental and geotechnical conditions is essential for designing mitigation strategies that address health vulnerabilities, such as disruptions to water sanitation, the spread of vector-borne diseases, or injury risks in disaster scenarios. These findings underscore the need for integrating advanced monitoring systems with community-based education and capacity-building programs. Empowering local communities with health-focused training on disaster risks and response can improve the overall effectiveness of monitoring efforts, ensuring that disaster mitigation strategies are comprehensive, proactive, and health-centred.

Mitigation Planning and Budgeting on the Effectiveness of Non-structural Mitigation

Mitigation planning and budgeting have a significant positive effect on the effectiveness of non-structural mitigation, with a path coefficient of 0.120 and a T-statistic value of 3.208 (p = 0.001). Effective planning and proper allocation of financial resources are crucial for enhancing community resilience and preparedness. Wu et al. (2024) and Nguyen et al. (2024) emphasised that comprehensive and integrated planning, combined with sufficient budgetary allocation, significantly improves disaster mitigation outcomes [19,20]. Integrated planning fosters collaboration among stakeholders, enabling a more coordinated response to disaster risks [19]. Additionally, adherence to international standards in infrastructure management can optimise costs and foster innovation, contributing to more efficient mitigation strategies [15]. Van de Lindt et al. (2022) further highlighted the role of well-designed mitigation plans in reducing economic losses while improving community resilience to disasters [21]. In the health context, proper budgeting enables the allocation of resources for essential measures such as training healthcare workers, equipping health facilities, and conducting community-based preparedness programs. These investments reduce health vulnerabilities, improve response capacity, and mitigate disaster impacts on public health. Thus, strategic mitigation planning and adequate budgeting are essential for building sustainable non-structural mitigation systems that effectively reduce disaster risks and enhance community health and safety.

Disaster Education for Students on the Effectiveness of Non-structural Mitigation

Disaster education for students has been shown to have a significant positive effect on the effectiveness of non-structural mitigation, as indicated by a path coefficient of 0.367 and a T-statistic value of 3.951 (p = 0.000). This finding highlights the crucial role of education in fostering preparedness and risk understanding, particularly among the younger generation, who serve as future agents of change. Disaster education integrated into the school curriculum enhances students' ability to comprehend risks and apply mitigation strategies effectively. For instance, Shibata et al. (2021) found that a participatory, experiential learning approach in schools significantly increased disaster response capacity and community resilience [24]. From a health perspective, disaster education equips students with critical life-saving knowledge, such as first aid, disease prevention, and hygiene practices during disasters, thereby reducing health risks post-disaster. Studies also show that students trained in disaster preparedness contribute to broader community awareness, acting as conduits of knowledge for their families and communities [25]. For example, programs emphasising health-focused disaster preparedness in schools have improved vaccination rates and reduced outbreaks in post-disaster settings [26]. By embedding disaster education into the curriculum, schools can enhance not only disaster resilience but also public health outcomes during emergencies.

Community Concern for Disaster Education for Students

Community awareness has a significant negative effect on disaster education for students, as indicated by a path coefficient of -0.246 and a T-statistic value of 5.068 ($p = 0.000$). This finding highlights the complex interplay between community awareness and the effectiveness of disaster education. Patel et al. (2023) found that while high community awareness enhances individual disaster preparedness, formal disaster education in schools and universities has a more substantial impact on students' preparedness levels [25]. This suggests that community awareness alone may not translate into systematic knowledge transfer to students without formalised education mechanisms. Additionally, research by Brown et al. (2022) emphasised that government support is crucial in implementing disaster education policies, as weak policy frameworks can limit the dissemination of critical information to students and the broader community [26]. Community participation is essential to support disaster education initiatives, ensuring they are contextually relevant and practical. Active involvement of parents, educators, and local leaders can create a more cohesive approach to equipping students with the necessary skills and knowledge for disaster preparedness. Furthermore, integrating health perspectives, such as first aid, sanitation, and psychological resilience training, into disaster education can address both immediate and long-term impacts of disasters on student well-being. Without adequate community support and inclusive policy frameworks, the effectiveness of disaster education efforts remains limited, underscoring the need for stronger collaboration between communities, schools, and policymakers [27].

Public Concern for Mitigation Planning and Budgeting

Community awareness has a significant positive effect on mitigation planning and budgeting, with a path coefficient of 0.204 and a T-statistic value of 2.409 ($p = 0.016$). This finding aligns with previous studies, which show that active community involvement in mitigation planning enhances the relevance and sustainability of mitigation strategies. Communities that are engaged in the planning process often identify priorities more effectively, such as the need for disaster-resilient health facilities and access to emergency medical services. Smith et al. (2020) emphasised that public participation ensures the development of more inclusive health policies, such as improved early warning systems, sanitation, and first aid training [11]. Kim and Lee (2021) also highlighted that community awareness and involvement strengthen local adaptive capacity, particularly in disaster-prone areas, by integrating health concerns such as disease prevention and mental health support into mitigation efforts [29].

Additionally, studies suggest that budgeting becomes more targeted when communities advocate for health-related priorities, such as equipping evacuation shelters with medical supplies and ensuring water and food safety during disasters. This approach not only reduces disaster risk but also minimises secondary health impacts like malnutrition and disease outbreaks. Integrating public health considerations into mitigation planning fosters a holistic and sustainable approach to disaster risk reduction [28,29].

Conclusion

This study concludes that non-structural mitigation elements significantly improve disaster risk reduction, particularly in enhancing community health resilience. Identification and mapping help communities design appropriate strategies, while local wisdom promotes culturally adaptive responses. Community involvement supports effective planning and adherence to health protocols. Disaster education enhances risk awareness, first aid knowledge, and hygiene practices, reducing post-disaster health impacts. Strengthening risk mapping and integrating local wisdom into mitigation efforts are essential. Community participation should be encouraged through health-focused disaster education and inclusive planning. Schools should integrate disaster preparedness and health education to build awareness from an early age. Finally, targeted budget allocation for health infrastructure and training in disaster-prone areas is crucial for effective mitigation.

Conflict of Interest

The authors declare that there is no conflict of interest related to this research.

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