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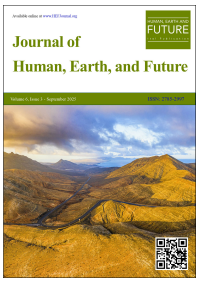

Empowering Resilience: Factors Influencing Community Willingness in Disaster Training Initiatives

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Abstract

Community-Based Disaster Management (CBDM) emphasizes the centrality of local participation in efforts to build resilience and reduce disaster risks. While the Sendai Framework for Disaster Risk Reduction 2015–2030 advocates inclusive and community-driven preparedness strategies, empirical research on the determinants of an individual's willingness to engage in disaster management training remains underdeveloped. This study addressed this gap by examining the willingness of community members to participate in disaster preparedness programs, as well as identifying the socio-demographic and psychosocial factors that influence this willingness. Guided by the Theory of Planned Behavior (TPB), this study conceptualized willingness as an element shaped by the attitude toward disaster preparedness, subjective norms, and perceived behavioral control. Variables such as age, gender, income, and education were investigated as moderating factors. Findings suggest that higher educational attainment is associated with greater awareness and readiness to engage in training, while older age groups tend to demonstrate stronger participation, possibly due to enhanced life experiences and risk perception. This study contributes theoretically and practically by integrating behavioral insight with disaster policy frameworks. It offers evidence-based recommendations for designing targeted and culturally appropriate training programs that create proactive community engagement and advance the Sendai Framework's objectives.

Keywords: Disaster Preparedness; Community-Based Disaster Management; Theory of Planned Behavior; Sendai Framework.

1. Introduction

Natural disasters, ranging from meteorological and geophysical events to biological and climatological hazards, pose persistent threats to economic development, human well- being, and environmental sustainability, particularly in developing countries [1]. These disasters not only cause extensive loss of life and property but also disproportionately affect vulnerable populations lacking adequate resources for recovery and resilience [2]. Malaysia recorded over 51 natural disasters between 1998 and 2018 that affected more than 3 million people, caused over 280 deaths, and

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resulted in economic losses exceeding RM8 billion. Floods alone accounted for 60% of reported disasters in 2018, thus highlighting the urgent need for effective community-based disaster preparedness initiatives [3].

The Sendai Framework for Disaster Risk Reduction 2015–2030, conceptualised in response to the increasing frequency and intensity of disasters, emphasizes the empowerment of communities through inclusive participation, awareness-building and preparedness training. Community-Based Disaster Management (CBDM) is now widely recognized as an effective approach for mitigating disaster risks. However, a critical gap remains in understanding what drives community members to actively engage in such initiatives. Moreover, there is limited empirical research on the willingness of individuals to participate in disaster management training, particularly in developing countries like Malaysia.

This present study integrated the Theory of Planned Behavior (TPB) and the Sendai Framework for Disaster Risk Reduction as its conceptual foundation to address this gap. The TPB provides a behavioral lens through which individual participation in disaster management training can be understood and posits that behavioral intentions are shaped by attitudes toward behavior, perceived social norms, and perceived behavioral control. These constructs are critical for explaining the psychological mechanisms behind an individual's decision to engage in preparedness activities. The Sendai Framework complements these mechanisms by emphasizing the institutional and policy-level imperatives of inclusive and community-centered approaches to disaster risk reduction while advocating greater public awareness, education, and training as strategic priorities. This study combined these two frameworks and investigated individual-level determinants of willingness to participate as well as placed such behaviors in the broader policy agenda of community empowerment. In addition, sociodemographic variables such as age, gender, income, and education were examined as potential influencers of behavioral intention, thereby offering a multidimensional understanding of community engagement in disaster preparedness programs [4].

A consensus is emerging among scientists about the increasing severity of certain natural disasters because these disasters now bear the fingerprint of climate change.According to a special report by the Intergovernmental Panel on Climate Change (IPCC) 2012, the frequency, scale, severity, duration, and/or timing of several different types of major weather-related events have been affected by climate change [5]. Natural disasters have taken a huge toll on human lives, leading to innumerable casualties and affecting 4.4 billion people between 1998 and 2017. According to the World Health Organization, 90,000 people die from non-communicable diseases (NCD), and 160 million suffer from NCDs each year. The number and intensity of natural disasters have grown considerably in the past 50 years, causing grave concern among governments across the globe [6].

Consequently, millions of people have suffered and died due to natural disasters, including hurricanes, typhoons, floods, and earthquakes in Malaysia. Figure 1 shows the frequency of natural disasters that had affected Malaysia from 1980 to 2020. The National Disaster Management Agency (NADMA) reported that Malaysia had experienced 51 natural disasters from 1998 to 2018, impacting over 3 million people and resulting in more than 280 deaths, while incurring RM8 billion in losses [7]. In 2018 alone, 110 natural disasters were reported across Malaysia, with 60% of them being floods [8]. This highlights the severity of disasters, especially floods, in Malaysia, which not only result in the loss of lives but also cause infrastructural and environmental damage.

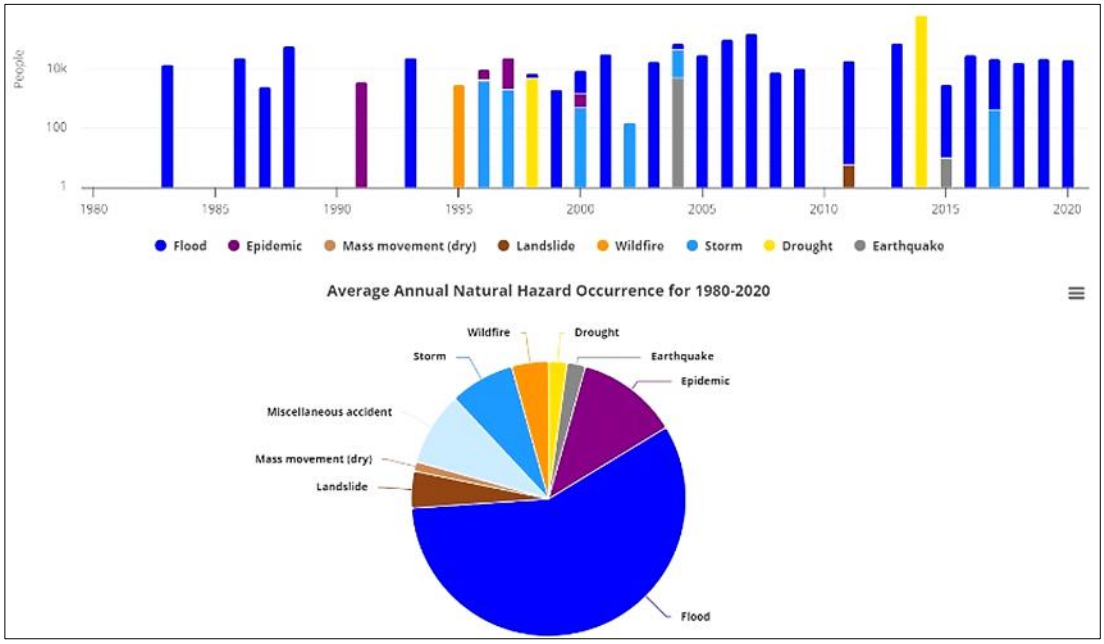

Figure 1. Frequency of natural catastrophes that affected Malaysia from 1980 to 2020 [9]

Table 1. Some of the Greatest Disasters in Malaysia in the Last Decade

Disaster	Year	Economic Loss (MYR)	Affected People	Source
Flood	Nov 2024	177 million in agro-food	137,410	[7]
Floods and Landslides	Dec 2022	622. 4 million	46,630	[10]
Flash Flood	Dec 2021	6.5 billion	62,999	[11]
Flood	Dec 2016	48.7 million	25,000	[12, 13]
Floods and Landslides	Nov 2014	1 billion	230,000	[14]

Malaysia does not experience many changes in temperature throughout the year, although the climate varies around the country because of its tropical location. Peninsular Malaysia has a cool and wet climate on the west and a hot and dry climate on the east, whereas East Malaysia has a different climate variety. Different terrain elevations have different climates, including the highlands, lowlands, and the coast. Malaysia experiences two monsoon seasons, namely the Southwest Monsoon (April–September) and Northeast Monsoon (October–March) [15]. Disasters, whether natural or man-made, can directly or indirectly result in losses of homes, property, and infrastructure. Direct losses are the immediate impact of disasters, such as direct market and non-market damages. Market losses refer to the loss of value in commodities and services, whereas non-market direct losses are those that cannot be replaced or substituted through the market. Higher-order or indirect losses are those that are not directly caused by the disaster but are a consequence of it [16]. The fast-growing natural calamities that have occurred due to global warming have also had a huge impact on nature. "*Urban population explosion, dilapidated infrastructure, environmental degradation, poverty, and diseases create a compounded problem that has of late become more complex to address and manage in the context of what could be termed as cyclical disasters, such as droughts and floods*" [17].

According to Que et al, disaster prevention initiatives can only succeed at the community level if local needs are specifically addressed [18]. Government and institutional initiatives alone are often paltry; at best, they are merely episodic responses during times of crisis. Therefore, Community-Based Disaster Management (CBDM) was fashioned as the offspring of local knowledge and organization, mainly dealing with lesser or moderate risks that are recurrent or chronic [19]. The five-year period (2005 to 2010), which was part of the United Nations decade-interim program for disaster risk reduction, actually left UN input and orientation completely unchanged. The only difference was that an increasing number of people at local levels gradually began to recognize this fact for themselves. It is characteristic of a top-down approach whereby local viewpoints and requirements are neglected, while local resources and potential capacity are undervalued. The most effective community-based disaster reduction program emerges from the full participation of those at risk in all levels of accountability, including formulation, decision- making, and implementation [20]. Vasileiou et al. and other scholars have rightly pointed out that disaster management should not be compartmentalized but rather combined with people's socio-economic activities [21]. It is generally agreed now that community participation or community-based activities can increase post-disaster resilience [22, 23]. Community organizations and activities rooted deeply in a locality's society and culture express people's genuine needs and priorities [22]. This allows problems to be accurately identified and defined, while responsive actions are created and implemented.

Public participation is considered a cornerstone of disaster risk management. The Sendai Framework represents the core principles that people should adopt and practice for disaster prevention [24]. Studies in Malaysia have shown that local community involvement can greatly enhance the effectiveness of flood mitigation measures [25]. Islam et al. [26] argued that the involvement of local communities in flood mitigation efforts results in longer-term and location-specific solutions that are not only technically sound but also provide positive results. Communities themselves possess plenty of local knowledge, such as the dynamics of rivers, previous experiences of flooding, and the location of the most dangerous flood-prone areas [27]. This public discourse garners community involvement, since those living in an affected area tend to provide better cooperation pre- and post-flood. This vacuum exists in areas where community-based action and climate disaster programs exist in Malaysia. Even though there was a three-hour lag between the earthquake and the arrival of the first tsunami wave at Malaysia's shores during the 2004 tsunami, both victims and officials were overwhelmed. It was found that most of the victims could have been rescued if the authorities had sounded timely tsunami warnings and appropriate plans had been emplaced for such an eventuality [28, 29].

Despite this study recognizing various climate-related hazards, events such as floods and landslides are a priority based on historical occurrences, severity, and community impact in Penang. Therefore, this study aimed to analyze the risks, vulnerabilities, and adaptation strategies related to unexpected disasters, especially flood events and landslides, in the Malaysian context.

This study had two primary objectives:

1. To assess the willingness of community members to participate in disaster management training programs.
2. To identify the socio-demographic and psychosocial factors that influence the willingness of community members to participate in disaster management training programs.

This study aimed to theoretically contribute towards disaster behavioral research by addressing these objectives and designing a more targeted and effective community training intervention in line with the Sendai Framework.

This study analyzed people's opinions, perspectives, and experiences to understand how they evaluate the risk of natural disasters and what they do to prevent them. It focused on the side effects of disasters in order to add to the existing *corpus* of knowledge on people's physical and psychological susceptibility by providing a detailed examination of climate-related disasters and highlighting the vulnerability to such events. Furthermore, it underlines the rising prevalence and severity of climate change-related disaster events in Malaysia while providing substantial analytical insight into the probability and magnitude of climate-related disasters, which are essential for developing effective risk management strategies. It emphasizes the significance of public perception and awareness in disaster management, thus seeking to improve community involvement and preparedness for emergencies, such as floods. Consequently, it is unquestionable that a system is required to assess the risk and susceptibility of people to the occurrence of an unexpected disaster event (both directly and indirectly), mainly the adaptive capability and measures for mitigating climate-related effects. This would result in the proper implementation of disaster-related protocols and procedures, particularly in the context of dealing with flood risks.

2. Literature Review

Malaysia is situated in the Southwest Pacific Ring of Fire in Southeast Asia; hence, the country is prone to natural phenomena like floods, tsunamis, landslides, cyclones, forest fires, earthquakes, and smog. According to the World Risk Report 2019, Malaysia is a high-risk country and ranked 71 in terms of disaster risk among 180 countries [30]. Malaysia was considered a medium-risk country and ranked 91 based on a previous evaluation in 2012 [30]. Malaysia's shift in the global risk classification category is partly attributed to heightened risk exposure, especially over the past 10 years. In the last two decades, Malaysia has recorded 51 natural disaster incidents that have affected 3 million people and caused US$2 billion worth of damage [31]. In light of the increasing occurrence of natural disasters, it is necessary to establish a national disaster risk assessment center in order to understand and identify the hazardous level of disasters and the vulnerability of the social and economic system as well as other institutions [32].

Adeagbo et al. [33] reported that the most frequently occurring natural disaster in Malaysia is floods, which affect 47% of the homes, 41% of household assets, and 45% of children's education. Respondents who spent more than RM200,000 for replacing and repairing post-flood disaster damage were severely affected by their low-income source, considering that rural dwellers earned less than urban dwellers. Research on the impact of natural disasters, such as China's Wenchuan earthquake, on people's well-being showed that rural populations, the elderly, and persons with lower education and no social insurance were more vulnerable to the earthquake's impact [34]. The findings indicate that post-disaster policy should be people-oriented when applied to marginalized communities, while emphasizing process and heterogeneity over a rather static economic dimension. Al-Amin et al. [17] noticed that a significant proportion of respondents were willing to engage in flood mitigation activities, such as insurance/coverage and volunteer work.

The 2004 tsunami was a natural disaster that profoundly impacted the Malaysian people's way of life, homes, and belongings. In Indonesia, the Indian Ocean tsunami resulted in the highest number of victims in recent history, as the local populace could not evacuate on-time. Nakai & Nakano [35] studied villages in Langkawi that were affected by the 2004 tsunami, and the findings led to the development of an integrated tsunami emergency response plan at the community level throughout Malaysia. Surveys were conducted to assess the locals' preparedness, awareness, and vulnerability in the event of a tsunami. Subsequently, relevant education and training programs were created and implemented to enhance their knowledge through various means, including religious sermons, posters, and public seminars. A tsunami evacuation strategy was also designed and tested in the coastal towns with support from local emergency agencies and NGOs. The Ministry of Education (MOE) and the United Nations Children's Fund (UNICEF) launched a community-centric project in Kuala Muda, Kedah, in 2006, and the findings indicated insufficient insurance, lack of expertise, and delayed warnings. The study provided new procedural and theoretical frameworks for examining climate risks and valuable insight for decision-makers in similar communities [36].

Jacob et al. [37] found that behavioral, normative, and control beliefs significantly predicted respondents' intentions to undertake structural flood protection activities, with normative views being the most influential. This provides insight into elements that promote effective public health communication. Bin & Polasky [38] used the hedonic property price function to study the impact of flood hazards on residential property value. They found that houses in floodplains had lower market value and experienced a greater price reduction post Hurricane Floyd than

those outside the floodplain. According to Berlemann, hurricane risk harms human well-being in impoverished nations with limited protection measures [39]. The impact of hurricane risk on life satisfaction is less significant in developed nations. The study also highlighted that disaster risk significantly impacts individual well-being, especially in low-developed contexts, and stressed the need for better preparedness and prevention measures. Rehdanz conducted a study on the impact of the Fukushima nuclear accident on Japanese individuals' subjective well-being using panel data from 5,979 interviews pre- and post-accident. The results showed significant well-being effects proportional to proximity to the site, which could equal to 72% of annual household income [40]. Numerous studies on natural disasters in Malaysia had not focused much on community-based preventative activities related to disasters, such as floods and tsunamis. Since floods and tsunamis differ from other disasters for various reasons, local knowledge of these events must be well understood and explored. A top-down strategy is not feasible; instead, a bottom-up approach that includes community participation in disaster prevention efforts should be examined using disaster management frameworks.

Table 2 is based on the community and presents the determinants of their participation in natural disasters.

Table 2. Determinants of community participation during natural disasters

Determinants	Sources	Summary
Awareness and Knowledge	[41-45]	Disaster education plays an important role in disaster management, and people's awareness can help in achieving effective results in disaster prevention.
Perception of Risk	[46-48]	Knowledge of the connection between disaster risk reduction and risk perception has greatly advanced throughout time. Natural disasters cause harm and loss, and can influence people's subjective perceptions on the nature of common and severe future disasters.
Institutional Support	[49-51]	Several institutions, like government agencies, NGOs, and religious organizations, have a huge impact and provide assistance post-disaster in terms of rehabilitation and other aspects.
Information Access	[52-54]	Although there were barriers to information access in earlier times, the internet and social media help provide prompt access to disaster-related information.
Resources and Capacity	[49, 55, 56]	Capacity and resources are important in pre- and post-disasters. A well-established infrastructure is needed for this purpose.

2.1. Theoretical Framework

2.1.1. Theory of Planned Behavior and the Sendai Framework

The Theory of Planned Behavior (TPB) is a model used for measuring and promoting preparedness and response in the case of climate disasters. It consists of three constructs, namely beliefs, subjective norms, and perceived behavioral control [37]. Attitudes towards climate change are strongly linked to the probability of taking preventative action. It has been suggested that education can build concern and a commitment to action. Subjective norms, channeled via friends, family, or community leaders, are also an important feature of climate action. Social movements and locally organized initiatives help set the stage for individuals to engage in actions that build resilience to climate change.

Perceived behavioral control represents the actions people might take in response to a climatic crisis. Access to support and information can enhance perceived behavioral control and increase motivation towards active participation. The TPB believes that policymakers and organizations can design interventions by considering attitudes, subjective norms, and perceived control to promote actions that combat the climate disaster phenomenon. Public awareness campaigns about the risks and preparedness for climate change can significantly change perception and community participation. The TPB is an important theoretical model that explains the determinants of preparedness, response, and resilience to a climate disaster [57].

Several adaptation theories have been created and tested in the past to help understand how communities act and why they prepare for disasters caused by climate change. These include the Protection Motivation Theory (PMT), Person Relative to Event Theory, Transtheoretical Model (TTM), Social-Cognitive Preparation Model, and the Community Engagement Theory. There is some indication of an insufficient understanding of how these models might clarify behavioral changes when adapting to natural disasters. Fundamentally, the goals and perceptions of control assessed by the prepared households strongly correlated with climate disaster adaptation-readiness actions. Furthermore, the TPB incorporates components that motivate individuals to adopt behaviors and innovations by forming intentions and shifts in attitudes, thereby creating possibilities to prepare for climate-related disasters [58].

The TPB presents a model that assesses the influence of risk perception and risk experience on human behavior. Society-based activities aimed at preventing or mitigating climate disasters are considered the dependent factor for comprehending risk perception, while the desire to engage in flood protection efforts is designated as an independent variable. The objective is to evaluate risk perception about climate disasters, experiences of flood risk, and subjective norms, as well as governmental and social initiatives as independent factors that influence the inclination to participate

in disaster prevention activities. The program revealed the correlation between dependent and independent factors along with insight into the effects of climate disasters and related challenges. However, the TPB framework needs another strategy rooted in local communities and their participation in climate disaster prevention activities.

The Sendai Framework for Disaster Risk Reduction (SFDRR) was the bedrock of global disaster management strategies from 2015 to 2030, just like TPB. Incorporating the Sendai Framework together with the TPB will form a unified macroscopic provision for climate disaster prevention initiatives. The Sendai Framework includes seven global targets related to disaster prevention, equally applicable to national and local strategies with the aim of reducing disaster risks. This framework, established in 2015 during the 3rd UN World Conference on Disaster Risk Reduction, is one of the most recent international initiatives aimed at reducing disaster risks [59]. According to UNISDR [60], SFDRR is an attempt to proactively manage all risks, whether newly emerging or long-established risks, by integrating each element of society in that far-ranging goal. In addition to insuring against the effects of danger for patients, the caregiving staff considered the changes that can be made to decrease risk exposure and vulnerability while at the same time upping preparedness. This will help ensure a more effective and timely response to disasters. Although the Sendai Framework's applicability extends to a broad range of hazards that differ widely in scale, frequency, and manner of origin [61], it is particularly well suited to natural disasters.

According to the framework, local, national, regional, and global focus are the four core priorities of governance relevant to its application [62]. The first two priorities require sound knowledge of disaster risks and expensive investment incentives for risk governance. This is followed by the third priority, which advocates intentional investment for reducing risks and building better resilience. Given its various scales and local governance, it can be useful for studying local community participation in disaster prevention programs. The four aspects of the Sendai Framework are useful for disaster prevention and community participation [63].

Understanding disaster risk is the primary aspect, since risk awareness is essential for conceptualizing prevention. Strengthening governance is crucial since local authorities and communities play a vital role in disaster management and should be included when acquiring local knowledge alongside existing research. Moreover, investment in resilience is important and can be linked to preventive measures for establishing infrastructure through public and private investment that can be helpful during or after any disaster. Enhancing disaster preparedness is a critical aspect of the Sendai Framework, as it also supports recovery, rehabilitation, and reconstruction post-disaster. Using the combined frameworks of the TPB and the Sendai Framework, Figure 2 provides a broader perspective of disaster management through researchers and local knowledge [64].

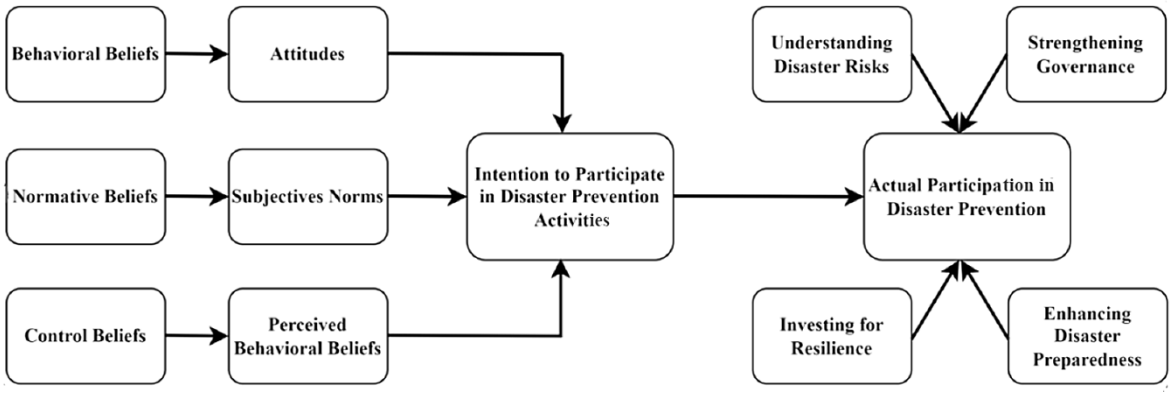

Figure 2. Conceptual Framework

Inclusion of the Sendai Framework for Disaster Risk Reduction into the Theory of Planned Behavior is an instrumental step to linking global-level DRR priorities with a well-known scientific behavioral framework. The Sendai Framework, adopted in 2015, presents a framework for implementing comprehensive action over the next 15 years for preventing new and reducing existing disaster risks by adhering to four priorities, namely understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience, and enhancing disaster preparedness for an effective response [65]. Rather than being incorporated as an independent variable in the Theory of Planned Behavior's structural model, the guiding principles of the Sendai Framework provide a moral canvas from which to draw item scales and theoretical constructs regarding behavioral beliefs, especially risk perception and community participation [66]. This operationalization is consistent with the Sendai Framework's targets and capitalizes on TPB's power to explain the psychological predictors of disaster preparedness and mitigation's function [67]. It is important to note that the Sendai Framework's priorities were not independently measured as separate concepts but were used to guide the adaptation and contextualization of TPB constructs. This methodological decision considers the Sendai Framework to be a supra-structural set of principles, whereas the TPB is a grounded model for predicting an individual's behavior.

3. Data Collection and Methodology

This study utilized cross-sectional survey data to investigate the risks, vulnerabilities, and adaptation methods associated with unforeseen disasters, such as major flooding events in Malaysia. It also used people's perspectives and experiences to understand their perception of natural disaster risks and their preventive measures. The survey was divided into sections that addressed sociodemographic factors, household preparedness, community risk readiness, and participants' previous encounters with natural disasters. Participants responded to dichotomous-scale inquiries about household involvement in disaster prevention actions. The study evaluated disparities based on sociodemographic factors, such as gender, age cohort, nationality, ethnicity, educational attainment, income bracket, employment status, state of residence, and length of residence. Data were obtained through a household survey carried out in Paya Terubong and Georgetown districts, based on the recommendations of Penang's disaster management agency. The geographical area is small, compact, and highly populated; thus, any disaster event could lead to more challenges.

This quantitative research design study adopted the semi-structured survey method involving 400 communities. Participants were strategically selected from urban and peri-urban areas within Penang, Malaysia, using the cluster sampling method. However, it is crucial to acknowledge potential limitations concerning the regional representativeness of the findings.

Community members (Malaysians) aged 18 to 65 years and older residing in MUKIM 13 Paya Terubong, Penang, were interviewed for the quantitative part of this study. The survey did not include non-Malaysian residents of MUKIM 13 Paya Terubong. The samples were taken from the Penang area and comprised varied neighborhoods to reflect various demographic backgrounds. This method might make the findings less generalizable to other locations in Malaysia or other countries, although this method provides a good local representation. This study was controlled for important demographics (age, education, income, and gender) in the regression to minimize bias.

The survey was purposefully quantitative-based with some room for respondents' explanations, although the semi-structured tools for quantitative assessment seem to be an unusual methodology. Logistic regression was applied to analyze the impact of climate disasters, integration of adaptive risk management, and intention to participate in disaster prevention activities. This process facilitated analytical and practical rigor in the viability of the study. The model was used to determine the most significant determinants of participation in disaster prevention activities and examine the effects of a unit shift in the independent variable on the probability of household preparedness. The results were analyzed using the B-coefficient, odds ratio, and significance level.

Several risk perception variables were considered in this study, such as RPCD = Risk Perception of Climatic Disaster, PDRE= Previous Disaster Risk Experience, SN= Subjective Norm, G&S = Government & Society and IPDPA= Intention to Participate in Disaster Prevention Activities, and PDPA= Participation in Disaster Prevention Activities.

The model that predicted the response variable (Participation in Disaster Prevention Activities) was calculated using the independent factors in the following form:

$$\textit{Logit (PDPA)} = \beta_0 + \beta_1 \textit{RPCD} + \beta_2 \textit{PDREX} + \beta_3 \textit{SN} + \beta_4 \textit{G\&S} + \beta_5 \textit{IPDPA} + \varepsilon_i$$

4. Results

The study was based in Penang state, which is geographically divided into two parts, namely the mainland and the island (Figure 3). The mainland of Penang has three main districts, which are Seberang Perai Utara, Seberang Perai Tengah, and Seberang Perai Selatan. The mainland and the island have highlands and lowlands that are connected by rivers. The mainland has more lowlands than highlands, while the island has more highlands than lowlands. The elevation between the highlands and the lowlands is one of the reasons that cause natural disasters, like floods. The presence of elevated lands in both areas increases the risk of flooding, especially during a heavy downpour. Moreover, coastal proximity and slopes escalate the risk of landslides, flash floods, and coastal erosion. The rivers often tend to overflow because of the delicate topography of the area. As they are connected to the overall highland and lowland areas, the water level rises and can lead to various disasters, such as floods and landslides. The maps (Figure 4) provide an in-depth visualization of the geographical location and topography, especially the flood-prone areas in Penang.

The maps also demonstrate the geographic distribution of flood-affected areas in Penang, with fluctuating degrees of severity. These maps provide users with knowledge of the extent and reach of flood-affected areas. They assist in appraising the impact of natural disasters on communities and infrastructure by overlaying sociodemographic data layers. This topographic information and analysis from these studies can be used to assess severely flood-prone areas, thus allowing the stakeholders to tactfully distribute resources during climate disasters. It also helps curate an early warning system that grants timely precautionary steps. These maps can serve as visual communication when engaging with communities in the disaster-prone areas that could generate an effective response and time-minded recovery pre- and post-climate disasters.

Figure 3. Map of Penang

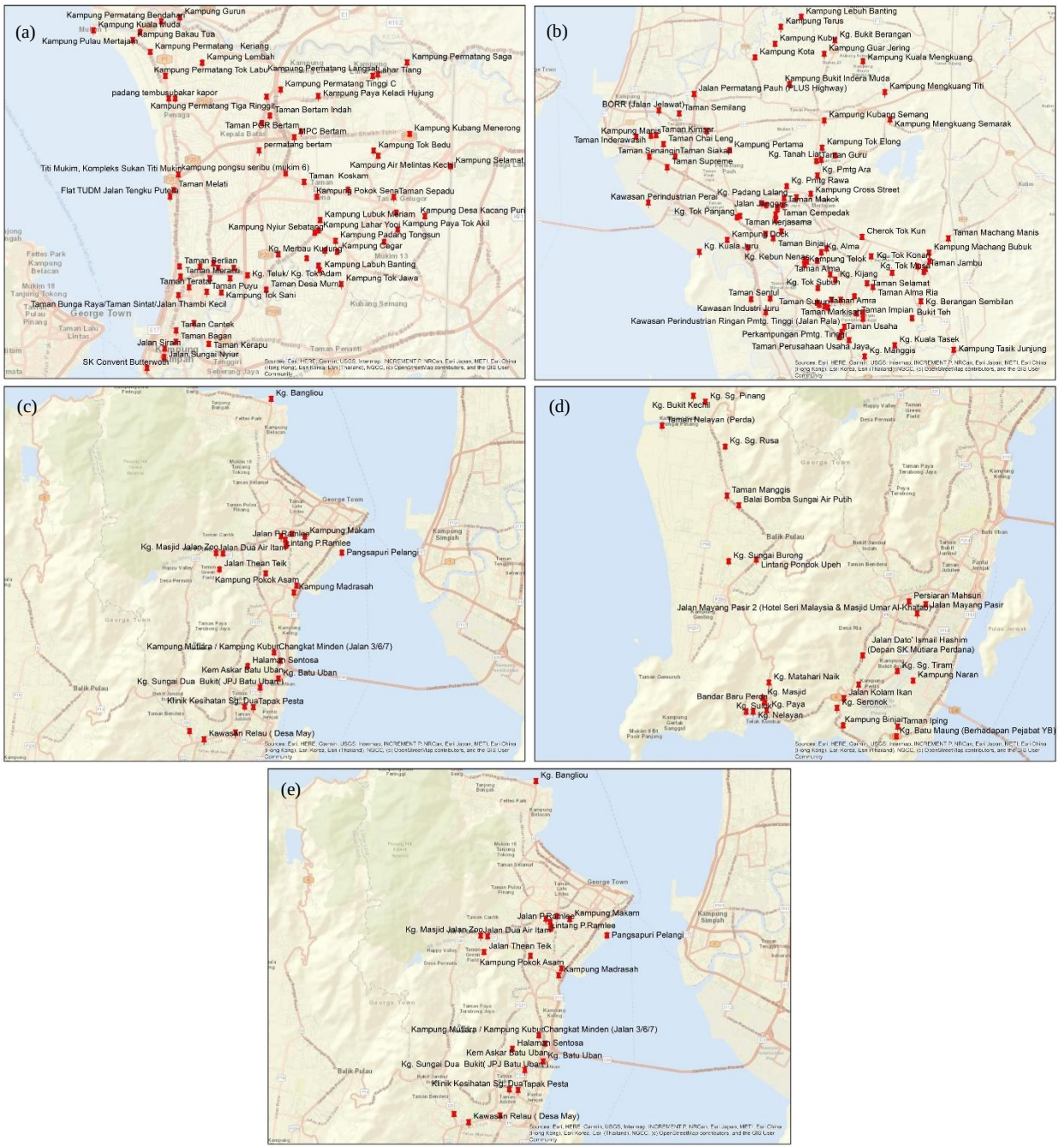

Figure 4. Flood-prone areas in Penang (a) North Seberang Perai; (b) Central Seberang Perai; (c) South Seberang Perai; (d) Southwest Region; (e) Northeast Region

4.1. Socio-Demographic Analysis

The survey involved 400 respondents (see Table 3), with ages ranging from 18 to over 65, whom 219 (54.8%) were male and 181 (45.2%) were female. The age breakdown was 8 respondents (2%) between 18 to 20, 73 (18.3%) between 21 and 34, 122 (30.5%) between 35 and 49, 102 (25.5%) between 50 and 64, and 95 (23.8%) were 65 years or older. The racial breakdown of the participants included 227 Malay respondents (56.8%), 130 Chinese respondents (32.5%), 38 Indian respondents (9.5%), and five respondents (1.3%) from other races. Respondents' housing type showed that 274 (68.5%) resided in flats, 69 (17.3%) in landed houses, 22 (5.5%) in terrace houses, 21 (5.3%) in condominiums, 11 (2.8%) in apartments, 2 (0.5%) in shophouses, and 1 (0.3%) in a bungalow. Respondents' education level showed that only 1 (0.3%) held a PhD, 7 (1.8%) held a Master's degree, 30 (7.5%) held a Bachelor's degree, 65 (16.3%) held a Diploma or STPM/STAM/Matriculation certificate, 158 (39.5%) had completed SPM/SPVM, 72 (18%) had completed PT3/PMR, 55 (13.8%) had completed UPSR, and 12 (3%) had no formal education. As for the income level, 123 respondents (30.8%) reported receiving no income, 172 (43%) earned 2,560 MYR or less, 38 (9.5%) earned between 2,561 MYR and 3,439 MYR, 24 (6%) earned between 3,440 MYR and 4,309 MYR, 18 (4.5%) earned between 4,310 MYR and 5,249 MYR, 6 (1.5%) earned between 5,250 MYR and 6,339 MYR, 8 (2%) earned between 6,340 MYR and 7,689 MYR, 5 (1.3%) earned between 7,690 MYR and 9,449 MYR, 5 (1.3%) earned between 9,450 MYR and 11,819 MYR, and lastly, only one person earned 15,870 MYR or more.

This study employed the Tolerance and Variance Inflation Factor (VIF) to assess the level of multicollinearity among the predictor variables. Variance Inflation Factor (VIF) and Tolerance values were computed to identify multicollinearity, with a VIF exceeding 10 and Tolerance below 0.1 signifying possible concerns necessitating additional examination. However, since all Tolerance values were above 0.1 and all VIF values remained below 10, multicollinearity was not observed in the data.

Table 3. Sociodemographic analysis

		Frequency	Percent
Gender	Man	219	54.8
	Women	181	45.2
Age Group	18 - 20 years	8	2
	21 - 34 years	73	18.3
	35 – 49 years	122	30.5
	50 - 64 years	102	25.5
	65 years/ and above	95	23.8
Race	Malay	227	56.8
	Chinese	130	32.5
	Indian	38	9.5
	Other	5	1.3
Types of Houses	Flats	274	68.5
	Condominium	21	5.3
	Landed house	69	17.3
	Shophouse	2	0.5
	Terrace	22	5.5
	Bungalow	1	0.3
	Apartment	11	2.8
Level of education	PhD	1	0.3
	Master	7	1.8
	Degree	30	7.5
	Diploma STPM/STAM/Matric	65	16.3
	SPM/SPVM	158	39.5
	PT3/PMR	72	18
	UPSR	55	13.8
	None	12	3

Income Group	No income	123	30.8
	2,560MYR and below	172	43
	2,561MYR – 3,439 MYR	38	9.5
	3,440MYR – 4,309 MYR	24	6
	4,310MYR – 5,249MYR	18	4.5
	5,250MYR – 6,339MYR	6	1.5
	6,340MYR – 7,689MYR	8	2
	7,690MYR – 9,449MYR	5	1.3
	9,450MYR – 11,819MYR	5	1.3
	15,870MYR and above	1	0.3

Table 4. Multicollinearity test

Variable	Collinearity Statistics	
	Tolerance	VIF
Subjective Norm	0.851	1.175
Risk Perception of Climatic Disaster	0.957	1.045
Government & Society	0.76	1.316
Intention to Participate in Disaster Prevention Activities	0.747	1.339
Previous Disaster Risk Experience	0.905	1.105

Table 5. Omnibus Test of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	29.269	5	<.001
	Block	29.269	5	<.001
	Model	29.269	5	<.001

Table 5 presents the Omnibus Tests of Model Coefficients for evaluating the significance of independent factors when predicting the dependent variable. The *p*-values are below 0.001, which indicates that the independent factors exert a statistically significant influence on the dependent variable. The significant Omnibus Test result confirms that the logistic regression model with all predictors fits the data well, and demonstrates that the variables collectively have strong predictive power. This indicates that community participation is influenced not by a single factor alone but by the combined effect of multiple sociodemographic variables, validating the overall relevance of the model.

The Hosmer-Lemeshow test is a statistical procedure employing the Chi-square (X^2) to evaluate how well the model fits the data. The null hypothesis asserts that the model aligns closely with the data. The null hypothesis will be rejected if sufficient evidence is present, typically when the *p*-value is below 0.05; otherwise, it will be accepted. Results shown in Table 6 indicate a significance level of 0.456, which exceeds the threshold of 0.05, and this indicates that the model is well-suited.

Table 6. Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7.769	8	0.456

The logit analysis results (see Table 7) depict the calculated factor scores for variables that affect participation in disaster prevention activities. A positive coefficient indicates that the probability of participating in disaster prevention activities is positively influenced by the independent variables, while a negative coefficient suggests that higher values of these variables decrease the likelihood of community participation in disaster prevention activities. Variables that were statistically significant at the 5% level were subjective norms and intention to participate in disaster prevention activities. Conversely, several variables were not statistically significant, including risk perception of climatic disasters, previous disaster risk experience, well as government and society. Similarly, the findings reflect an anticipated change in the log-odds of residents' recycling behavior for each additional unit increase in the explanatory variables, assuming other factors remain constant. Table 7 shows a positive coefficient for subjective norms, indicating that each additional unit increases the log odds of participation in disaster prevention activities by 0.692,

with statistical significance at the 5% level. Likewise, experience in disaster risks suggests that the odds of household participation in disaster prevention activities increase by approximately 1.08 times for each additional experience of disaster risk. Conversely, coefficients for variables, such as risk perception of climate disasters, government and society, and intention to participate in disaster prevention activities, show a negative impact on actual community participation in disaster prevention activities. However, only the intention to participate in disaster prevention activities was statistically significant at the 5% level.

Table 7. Binary Logistic Regression Result

Variables	Coefficient	S.E.	Wald	Exp (B)	P-value
Risk Perception of Climatic Disaster	-0.198	0.52	0.145	0.821	0.704
Previous Disaster Risk Experience	0.077	0.24	0.104	1.08	0.747
Subjective Norm	0.692	0.276	6.288	1.998	0.012
Government & Society	-0.079	0.097	0.67	0.924	0.413
Intention to Participate in Disaster Prevention Activities	-0.397	0.134	8.801	0.672	0.003

5. Discussion

This study sheds light on the main determinants of community participation in disaster prevention activities in Penang, Malaysia. Results indicate that subjective norms and intention are important predictors of community participation in disaster prevention activities, which comply with the Theory of Planned Behavior (TPB). Subjective norms, in particular, are positively related to participation, which indicates that social influences, including those exerted by peers and community expectations, play an important role in influencing individuals to participate in disaster preparedness behavior. On the contrary, risk perception of climate disasters and perception of the resilience support rendered by the government and society were not statistically significant. This could be due to the absence of trust and communication with the relevant institutions. These results provide a reference for the behavior and social mechanisms in DRRM.

The results align with previous research emphasizing the importance of social influence on disaster-preparedness behavior. Subjective norms were identified as a crucial factor that influences adaptive behaviors of people in flood-prone areas [37]. This study also supported the findings of Tsai et al. [41] and Oktari et al. [43], who highlighted the necessity of community-driven approaches and localized knowledge in disaster prevention. However, the insignificant role of risk perception in this study contrasts with findings by Marshall [48] and Brown et al. [47], who noted a strong connection between perceived risk and disaster preparedness. This divergence could reflect regional differences or cultural nuances in understanding and responding to disaster risks.

This present study underscored the influence of sociodemographic factors on disaster preparedness behaviors. Variables such as age, gender, income, and education level significantly affected community participation in disaster prevention activities. Respondents with higher educational qualifications exhibited greater awareness and readiness to engage in disaster prevention efforts, which highlights the importance of educational interventions. Age-related variations were also observed, with middle-aged and older individuals demonstrating higher participation levels than younger respondents, likely due to greater life experience and risk perception [68].

Gender differences were apparent, with men more frequently participating in physically based disaster preparedness activities, while women often took on organizational or supportive roles in the community [69]. Income disparities revealed that higher-income households were better equipped to implement disaster preparedness measures, thus suggesting a need to address economic inequalities when accessing resources. These findings stress the importance of tailoring disaster management programs to meet the diverse needs of various demographic groups to ensure that interventions are inclusive and equitable. Policymakers can develop more targeted strategies to enhance community engagement in disaster prevention activities by understanding these socio-demographic dynamics [70].

Most participants who were not intending to engage in disaster prevention activities in some cases had mentioned at least one of a series of obstacles. The most common problems identified were not knowing how to be prepared or pondering that evacuation is the best solution, feeling that individual efforts would be ineffective since an individual cannot realistically mitigate major disasters, dependence on governmental intervention by thinking that disaster management is the sole responsibility of government agencies, and resource constraints (time, money, and physical incapability). These results, expressed in low scores, further emphasized the need for targeted educational messages, building trust in institutions, and an inclusive program designed to overcome psychological and structural barriers towards participation.

Results of this study show a significant relationship with previous studies conducted based on the Theory of Planned Behavior to predict preparedness to face disasters. The significant influence of subjective norms on community involvement is consistent with findings by Jacob et al., who highlighted the centrality of social norms and

expectations in creating adaptive attitudes towards flood events in Canada [37]. At the same time, Oktari et al. highlighted the importance of social cohesion and local networks in reinforcing the resilience of communities pre- and post-disasters [43]. Conversely, this present study's empirical results differ from previous literature, including Work [48], which asserted that risk perception was a strong predictor of preparedness behavior. Against such findings, this present study found that even if respondents had a general awareness of disaster risks, such awareness was not met with appropriate action, implying a gap between awareness and action in the Malaysian context.

While some factors influencing community participation in disaster prevention initiatives are consistent with the findings of this study, many are not. Previous empirical investigations have repeatedly stressed the importance of understanding local contexts and cultural nuances when formulating effective disaster management strategies [63]. This is made more pressing by the fact that local residents have evidenced their collective ability to address their problems through mutual assistance based on early rescue and relief [69]. The need for community members to actively participate in the development of disaster management practices is emphasized, and initiatives by government agencies or organizations will most probably not gain people's support [64]. Studies have highlighted the significance of community-based disaster preparedness interventions. This current study, grounded in the Sendai Framework for Disaster Risk Reduction and underpinned by the Theory of Planned Behavior, had examined in greater depth the roles of attitude, subjective norms, and behavioral control. The literature also supports the value of public engagement for building trust, facilitating activities responsive to local needs and consistent with community values, building ownership, and enhancing the effective implementation of activities [65]. These results are consistent with the current study's focus on the value of instigating community engagement to strengthen disaster-related resilience and minimize vulnerability.

5.1. Theoretical and Practical Implications

The findings contribute to a broader application of the TPB in disaster management and confirm its effectiveness in predicting community participation. This study emphasizes the importance of addressing social and psychological factors in disaster risk reduction strategies by highlighting the significance of subjective norms and the intention to participate. The results suggest that while the TPB provides a solid framework, integrating it with the Sendai Framework's elements could enhance its applicability by incorporating governance and community-specific variables. This combined approach could offer a more comprehensive understanding of the drivers of disaster preparedness, particularly in regions with complex sociocultural dynamics, such as Malaysia.

These findings significantly affect disaster risk management policies and practices in Malaysia. The strong influence of subjective norms suggests that interventions should leverage community networks and local leaders to build a preparedness culture. Public education campaigns should focus on enhancing social cohesion and collective responsibility for implementing disaster prevention. In addition, the lack of significant findings regarding institutional support highlights the need to improve trust in the government and enhance the visibility and effectiveness of disaster management initiatives. Policymakers should prioritize community-driven approaches that integrate local knowledge to ensure that disaster prevention measures are context-specific and culturally sensitive. Malaysia can strengthen its community resilience and better prepare for climate-related disasters by addressing these factors.

6. Conclusion

This study offers valuable insight into factors that influence community participation in disaster prevention initiatives, particularly in the Penang state. It highlights the significance of subjective norms and the intention to participate as key predictors of disaster preparedness by integrating the TPB with the Sendai Framework's elements. It also emphasizes the influence of socio-demographic factors, thus underscoring the need for interventions tailored to the unique characteristics of diverse communities. However, the study's geographic focus on Penang may limit the generalizability of its findings. Moreover, the reliance on self-reported data raises the potential for bias, as participants might overstate their preparedness or intention to participate in disaster prevention activities.

Future research should broaden its scope to include other regions in Malaysia and beyond, thereby capturing a wider range of cultural, geographical, and socio-economic contexts. Incorporating additional psychological and sociocultural factors, such as emotional responses, trust in institutions, and cultural influences, could enhance the public's understanding of community participation. Institutional trust assessments will offer a finer perspective on the community's experiences and how they are engaged by institutions responsible for their safety and welfare during emergencies. One limitation was the absence of directly measuring this variable in this study, hence highlighting a key area for future research directions. Longitudinal studies would be beneficial in tracking behavioral and perceptual changes over time, especially in response to ongoing disasters or policy interventions. Comparative studies across different regions and countries could investigate how the localized context influences the effectiveness of disaster management strategies, which could eventually provide valuable insight for policymakers.

Overall, this study has contributed towards expanding the *corpus* of knowledge on disaster risk reduction by offering actionable insight for practitioners and policymakers. It underscores the importance of community-driven approaches, building trust in institutions, and promoting inclusive participation to enhance disaster resilience. Disaster management strategies in Malaysia and similar contexts can become more effective and sustainable by addressing the identified limitations and incorporating future research directions that would position the country as a regional leader in climate disaster prevention and preparedness.

7. Declarations

7.1. Author Contributions

Conceptualization, U.S.S. and S.R.R.; methodology, U.S.S. and S.R.R.; software, A.N.D.; validation, R.F.R.B. and T.M.L.; formal analysis, U.S.S. and S.R.R.; investigation, U.S.S.; resources, S.R.R.; data curation, S.R.R. and A.N.D.; writing—original draft preparation, U.S.S. and S.R.R.; writing—review and editing, R.F.R.B., S.P., and T.M.L.; visualization, U.S.S.; supervision, T.M.L. and M.S.S.; project administration, M.S.S.; funding acquisition, S.R.R. All authors have read and agreed to the published version of the manuscript.

7.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.4. Ethical Approval

Researchers obtained ethical approval from Universiti Sains Malaysia's ethics board Jawatankuasa Etika Penyelidikan Manusia (JEPEM). Approval number USM/JEPeM/PP/23030249 which dictated the research has been conducted with proper consent and guidelines.

7.5. Informed Consent Statement

Not applicable.

7.6. Declaration of Competing Interest

The authors declare that there are no conflicts of interest concerning the publication of this manuscript. Furthermore, all ethical considerations, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

8. References

[1] Laframboise, N., & Loko, B. (2012). Natural Disasters: Mitigating Impact, Managing Risks. IMF Working Papers, 12(245), 1. doi:10.5089/9781475512717.001.

[2] Keen, M., Freeman, P. K., & Mani, M. (2003). Dealing with Increased Risk of Natural Disasters: Challenges and Options. IMF Working Papers, 03(197), 1. doi:10.5089/9781451860030.001.

[3] Clarke, D., de Janvry, A., Sadoulet, E., & Skoufias, E. (2015). Disaster Risk Financing and Insurance: Issues and Results. Report on a workshop held at the Ferdi, June 4 and 5, 2015.

[4] Kumar, A., Diksha, D., Pandey, A. C., & Khan, M. L. (2020). Urban Risk and Resilience to Climate Change and Natural Hazards: A Perspective from Million-Plus Cities on the Indian Subcontinent. Techniques for Disaster Risk Management and Mitigation, 33–46, 33–46. doi:10.1002/9781119359203.ch3.

[5] Kousky, C. (2014). Informing climate adaptation: A review of the economic costs of natural disasters. Energy Economics, 46, 576–592. doi:10.1016/j.eneco.2013.09.029.

[6] Sangha, K. K., Russell-Smith, J., Evans, J., & Edwards, A. (2020). Methodological approaches and challenges to assess the environmental losses from natural disasters. International Journal of Disaster Risk Reduction, 49, 101619. doi:10.1016/j.ijdrr.2020.101619.

[7] Hadi. (2022). Ensuring Malaysia's disaster preparedness. Agensi Pengurusan Bencana Negara (NADMA), Malaysia. Available online: https://www.nadma.gov.my/bi/media-en/news/302-ensuring-malaysia-s-disaster-preparedness (accessed on June 2025).

[8] United Nations ESCAP (2020). Malaysia: Resilience Portal. Available online: https://rrp.unescap.org/country-profile/mys (accessed on August 2025).

[9] World Bank. (2025). World Bank Climate Change Knowledge Portal. Vulnerability | Climate Change Knowledge Portal. Available online: https://climateknowledgeportal.worldbank.org/country/malaysia/vulnerability (accessed on August 2025).

[10] ECHO. (2025). Echo flash. Daily Flash. Available online: https://erccportal.jrc.ec.europa.eu/ECHO-Products/Echo-Flash#/daily-flash-archive/4940 (accessed on August 2025).

[11] ADRC. (2022). Malaysia: Flood: 2022. Asian Disaster Reduction Center (ADRC), Kobe, Japan. Available online: https://www.adrc.asia/view_disaster_en.php?Lang=en&Key=2544 (accessed on August 2025).

[12] ADRC. (2017). Malaysia: Flood: 2017. Asian Disaster Reduction Center (ADRC), Kobe, Japan. Available online: https://www.adrc.asia/view_disaster_en.php?Lang=en&Key=2232 (accessed on August 2025).

[13] Bhuiyan, T. R., Er, A. C., Muhamad, N., & Pereira, J. J. (2022). Evaluating the cumulative costs of small-scale flash floods in Kuala Lumpur, Malaysia. Journal of Hydrology, 612, 128181. doi:10.1016/j.jhydrol.2022.128181.

[14] Ruiz Estrada, M. A., Koutronas, E., Tahir, M., & Mansor, N. (2017). Hydrological hazard assessment: THE 2014–15 Malaysia floods. International Journal of Disaster Risk Reduction, 24, 264–270. doi:10.1016/j.ijdrr.2017.06.005.

[15] Rosmadi, H. S., Ahmed, M. F., Mokhtar, M. Bin, & Lim, C. K. (2023). Reviewing Challenges of Flood Risk Management in Malaysia. Water (Switzerland), 15(13), 2390. doi:10.3390/w15132390.

[16] Przyluski, V., & Hallegatte, S. (2010). The economics of natural disasters: Concepts and methods. World Bank Group, Washington D.C., United States.

[17] Al-Amin, A. Q., Nagy, G. J., Masud, M. M., Filho, W. L., & Doberstein, B. (2019). Evaluating the impacts of climate disasters and the integration of adaptive flood risk management. International Journal of Disaster Risk Reduction, 39, 101241. doi:10.1016/j.ijdrr.2019.101241.

[18] Que, T., Wu, Y., Hu, S., Cai, J., Jiang, N., & Xing, H. (2022). Factors Influencing Public Participation in Community Disaster Mitigation Activities: A Comparison of Model and Nonmodel Disaster Mitigation Communities. International Journal of Environmental Research and Public Health, 19(19), 12278. doi:10.3390/ijerph191912278.

[19] Shammin, R., Wang, A., & Sosland, M. (2021). A survey of community-based adaptation in developing countries. Climate Change and Community Resilience: Insights from South Asia, 31–47. doi:10.1007/978-981-16-0680-9_3.

[20] Tozier de la Poterie, A., & Baudoin, M. A. (2015). From Yokohama to Sendai: Approaches to Participation in International Disaster Risk Reduction Frameworks. International Journal of Disaster Risk Science, 6(2), 128–139. doi:10.1007/s13753-015-0053-6.

[21] Vasileiou, K., Barnett, J., & Fraser, D. S. (2022). Integrating local and scientific knowledge in disaster risk reduction: A systematic review of motivations, processes, and outcomes. International Journal of Disaster Risk Reduction, 81, 103255. doi:10.1016/j.ijdrr.2022.103255.

[22] Maskrey, A. (2011). Revisiting community-based disaster risk management. Environmental Hazards, 10(1), 42–52. doi:10.3763/ehaz.2011.0005.

[23] Amin, R., & Shammin, R. (2021). A resilience framework for climate adaptation: The Shyamnagar experience. Climate Change and Community Resilience: Insights from South Asia, 69–84. doi:10.1007/978-981-16-0680-9_5.

[24] Mizutori, M. (2020). Reflections on the Sendai Framework for Disaster Risk Reduction: Five Years Since Its Adoption. International Journal of Disaster Risk Science, 11(2), 147–151. doi:10.1007/s13753-020-00261-2.

[25] Saad, M. S. H., Ali, M. I., Razi, P. Z., & Ramli, N. I. (2024). Flood Risk Management in Development Projects: A Review of Malaysian Perspective within the Sendai Framework for Disaster Risk Reduction 2015-2030. Construction, 4(2), 103–117. doi:10.15282/construction.v4i2.10592.

[26] Islam, M. M., Amir, A. A., & Begum, R. A. (2021). Community awareness towards coastal hazard and adaptation strategies in Pahang coast of Malaysia. Natural Hazards, 107(2), 1593–1620. doi:10.1007/s11069-021-04648-2.

[27] Kamarudin, K. H., Rashid, M. F., & Omar Chong, N. (2022). Local Community Knowledge for Flood Resilience: A Case Study from East Coast Malaysia. International Journal of Built Environment and Sustainability, 9(2), 21–34. doi:10.11113/ijbes.v9.n2.922.

[28] Kiss, B., Sekulova, F., Hörschelmann, K., Salk, C. F., Takahashi, W., & Wamsler, C. (2022). Citizen participation in the governance of nature-based solutions. Environmental Policy and Governance, 32(3), 247–272. doi:10.1002/eet.1987.

[29] Leeonis, A. N., Ahmed, M. F., Halder, B., Mokhtar, M. Bin, Lim, C. K., Juneng, L., & Khirotdin, R. P. K. (2024). Mitigating flood risk at Shah Alam, Malaysia for sustainable development. Discover Sustainability, 5(1), 352. doi:10.1007/s43621-024-00504-y.

[30] Ramli, M. W. A., Alias, N. E., Yusof, H. M., Yusop, Z., & Taib, S. M. (2021). Development of a local, integrated disaster risk assessment framework for Malaysia. Sustainability (Switzerland), 13(19), 10792. doi:10.3390/su131910792.

[31] CEDHA. (2019). Malaysia: Disaster management reference handbook (June 2019) - Malaysia. Center for Excellence in Disaster & Humanitarian Assistance. Available online: https://reliefweb.int/report/malaysia/malaysia-disaster-management-reference-handbook-june-2019 (accessed on August 2025).

[32] OECD. (2015). The Changing Face of Strategic Crisis Management - OECD Reviews of Risk Management Policies. OECD Reviews of Risk Management Policies, 133. Available online: https://www.oecd.org/en/publications/the-changing-face-of-strategic-crisis-management_9789264249127-en.html (accessed on August 2025).

[33] Adeagbo, A., Daramola, A., Carim-Sanni, A., Akujobi, C., & Ukpong, C. (2016). Effects of natural disasters on social and economic wellbeing: A study in Nigeria. International Journal of Disaster Risk Reduction, 17, 1–12. doi:10.1016/j.ijdrr.2016.03.006.

[34] Wang, Z., & Wang, F. (2023). Well-being Effects of Natural Disasters: Evidence from China's Wenchuan Earthquake. Journal of Happiness Studies, 24(2), 563–587. doi:10.1007/s10902-022-00609-z.

[35] Nakai, F., & Nakano, G. (2023). Community-mediated individual disaster preparedness practices: A case study in Kochi, Japan. International Journal of Disaster Risk Reduction, 86, 103532. doi:10.1016/j.ijdrr.2023.103532.

[36] Ahmadun, F. R., Wong, M. M. R., & Mat Said, A. (2020). Consequences of the 2004 Indian Ocean Tsunami in Malaysia. Safety Science, 121, 619–631. doi:10.1016/j.ssci.2019.05.016.

[37] Jacob, J., Valois, P., Tessier, M., Talbot, D., Anctil, F., Cloutier, G., & Renaud, J. S. (2023). Using the theory of planned behavior to identify key beliefs underlying flood-related adaptive behaviors in the province of Québec, Canada. Journal of Flood Risk Management, 16(3), e12906. doi:10.1111/jfr3.12906.

[38] Bin, O., & Polasky, S. (2004). Effects of flood hazards on property values: Evidence before and after hurricane Floyd. Land Economics, 80(4), 490–500. doi:10.2307/3655805.

[39] Berlemann, M. (2016). Does hurricane risk affect individual well-being? Empirical evidence on the indirect effects of natural disasters. Ecological Economics, 124, 99–113. doi:10.1016/j.ecolecon.2016.01.020.

[40] Rehdanz, K., Welsch, H., Narita, D., & Okubo, T. (2015). Well-being effects of a major natural disaster: The case of Fukushima. Journal of Economic Behavior and Organization, 116, 500–517. doi:10.1016/j.jebo.2015.05.014.

[41] Tsai, M. H., Chang, Y. L., Shiau, J. S., & Wang, S. M. (2020). Exploring the effects of a serious game-based learning package for disaster prevention education: The case of Battle of Flooding Protection. International Journal of Disaster Risk Reduction, 43, 101393. doi:10.1016/j.ijdrr.2019.101393.

[42] Johnson, V. A., Ronan, K. R., Johnston, D. M., & Peace, R. (2014). Evaluations of disaster education programs for children: A methodological review. International Journal of Disaster Risk Reduction, 9, 107–123. doi:10.1016/j.ijdrr.2014.04.001.

[43] Oktari, R. S., Shiwaku, K., Munadi, K., Syamsidik, & Shaw, R. (2015). A conceptual model of a school-community collaborative network in enhancing coastal community resilience in Banda Aceh, Indonesia. International Journal of Disaster Risk Reduction, 12, 300–310. doi:10.1016/j.ijdrr.2015.02.006.

[44] Frankenberg, E., Sikoki, B., Sumantri, C., Suriastini, W., & Thomas, D. (2013). Education, vulnerability, and resilience after a natural disaster. Ecology and Society, 18(2), 16. doi:10.5751/ES-05377-180216.

[45] Tanes, Z., & Cho, H. (2013). Goal setting outcomes: Examining the role of goal interaction in influencing the experience and learning outcomes of video game play for earthquake preparedness. Computers in Human Behavior, 29(3), 858–869. doi:10.1016/j.chb.2012.11.003.

[46] Mase, A. S., Gramig, B. M., & Prokopy, L. S. (2017). Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. crop farmers. Climate Risk Management, 15, 8–17. doi:10.1016/j.crm.2016.11.004.

[47] Brown, P., Daigneault, A. J., Tjernström, E., & Zou, W. (2018). Natural disasters, social protection, and risk perceptions. World development, 104, 310-325. doi:10.1016/j.worlddev.2017.12.002.

[48] Marshall, T. M. (2020). Risk perception and safety culture: Tools for improving the implementation of disaster risk reduction strategies. International Journal of Disaster Risk Reduction, 47, 101557. doi:10.1016/j.ijdrr.2020.101557.

[49] Albris, K., Lauta, K. C., & Raju, E. (2020). Disaster Knowledge Gaps: Exploring the Interface Between Science and Policy for Disaster Risk Reduction in Europe. International Journal of Disaster Risk Science, 11(1), 1-12. doi:10.1007/s13753-020-00250-5.

[50] Sheikhi, R. A., Seyedin, H., Qanizadeh, G., & Jahangiri, K. (2021). Role of Religious Institutions in Disaster Risk Management: A Systematic Review. Disaster Medicine and Public Health Preparedness, 15(2), 239–254. doi:10.1017/dmp.2019.145.

[51] Zuccaro, G., Leone, M. F., & Martucci, C. (2020). Future research and innovation priorities in the field of natural hazards, disaster risk reduction, disaster risk management and climate change adaptation: a shared vision from the ESPREssO project. International Journal of Disaster Risk Reduction, 51, 101783. doi:10.1016/j.ijdrr.2020.101783.

[52] Fakhruddin, B., Clark, H., Robinson, L., & Hieber-Girardet, L. (2020). Should I stay or should I go now? Why risk communication is the critical component in disaster risk reduction. Progress in Disaster Science, 8, 100139. doi:10.1016/j.pdisas.2020.100139.

[53] Haer, T., Botzen, W. J. W., & Aerts, J. C. J. H. (2016). The effectiveness of flood risk communication strategies and the influence of social networks-Insights from an agent-based model. Environmental Science and Policy, 60, 44–52. doi:10.1016/j.envsci.2016.03.006.

[54] Hampel, J. (2006). Different concepts of risk - A challenge for risk communication. International Journal of Medical Microbiology, 296(SUPPL. 1), 5–10. doi:10.1016/j.ijmm.2005.12.002.

[55] Bosher, L., Chmutina, K., & van Niekerk, D. (2021). Stop going around in circles: towards a reconceptualisation of disaster risk management phases. Disaster Prevention and Management: An International Journal, 30(4–5), 525–537. doi:10.1108/DPM-03-2021-0071.

[56] Khan, A., Gupta, S., & Gupta, S. K. (2020). Multi-hazard disaster studies: Monitoring, detection, recovery, and management, based on emerging technologies and optimal techniques. International Journal of Disaster Risk Reduction, 47, 101642. doi:10.1016/j.ijdrr.2020.101642.

[57] Prasetya, A. R. A., Rachmawati, T. A., & Usman, F. (2023). A Multicriteria Approach to Assessing Landslide Community Resilience. Case Study: Bumiaji Sub-District. IOP Conference Series: Earth and Environmental Science, 1186(1), 12003. doi:10.1088/1755-1315/1186/1/012003.

[58] Zaremohzzabieh, Z., Samah, A. A., Roslan, S., Shaffril, H. A. M., D'Silva, J. L., Kamarudin, S., & Ahrari, S. (2021). Household preparedness for future earthquake disaster risk using an extended theory of planned behavior. International Journal of Disaster Risk Reduction, 65, 102533. doi:10.1016/j.ijdrr.2021.102533.

[59] Saja, A. M. A., Sahid, M. S. L., & Sutharshanan, M. (2020). Implementing Sendai Framework priorities through risk-sensitive development planning – A case study from Sri Lanka. Progress in Disaster Science, 5, 100051. doi:10.1016/j.pdisas.2019.100051.

[60] UNISDR. (2012). UN International Strategy for Disaster Reduction (UNISDR) | Department of Economic and Social Affairs. Available online: https://sdgs.un.org/statements/un-international-strategy-disaster-reduction-unisdr-8377 (accessed on June 2025).

[61] Wahlström, M. (2015). New Sendai Framework Strengthens Focus on Reducing Disaster Risk. International Journal of Disaster Risk Science, 6(2), 200–201. doi:10.1007/s13753-015-0057-2.

[62] UNDDR. (2016). United Nations Office for Disaster Risk Reduction 2016. UNISDR Annual Report 2015. Available online: https://www.undrr.org/publication/unisdr-annual-report-2015 (accessed on August 2025).

[63] Ha, K. M. (2015). Four models on globalizing disaster management in the Asia-Pacific region: a comparative perspective. Pacific Review, 28(2), 211–235. doi:10.1080/09512748.2014.995123.

[64] Hidayat, B., & Rasadi, A. (2020). Disaster-based participatory development planning. E3S Web of Conferences, 156, 1010. doi:10.1051/e3sconf/202015601010.

[65] Pfefferbaum, B., L. Van Horn, R., & L. Pfefferbaum, R. (2018). Involving Adolescents in Building Community Resilience for Disasters. Adolescent Psychiatry, 8(4), 253–265. doi:10.2174/2210676608666180112123628.

[66] Maly, E., & Suppasri, A. (2020). The Sendai Framework for Disaster Risk Reduction at Five: Lessons from the 2011 Great East Japan Earthquake and Tsunami. International Journal of Disaster Risk Science, 11(2), 167–178. doi:10.1007/s13753-020-00268-9.

[67] Nugrahandika, W. H., & Putri, R. N. (2021). Sustainable Community-Based Disaster Management (CBDM) in Wonolelo Village, Bantul Regency, Special Region of Yogyakarta, Indonesia. IOP Conference Series: Earth and Environmental Science, 764(1), 12036. doi:10.1088/1755-1315/764/1/012036.

[68] Saputra, A. V., Ardiati, A. S., & Sofiany, I. R. (2025). Community-Based Disaster Mitigation for Building Flood Resilience in Malaka-Timor, Indonesia. Environmental Communication, 1–5. doi:10.1080/17524032.2025.2461620.

[69] Samad, M. A., Arifin, K., & Abas, A. (2025). A systematic literature review on the challenges of Southeast Asian countries in natural disaster management. Cogent Social Sciences, 11(1). doi:10.1080/23311886.2024.2435590.

[70] Rusmana, A., Damayani, N. A., Rizal, E., Siti Khadijah, U. L., Lusiana, E., Saepudin, E., Sjuchro, D. W., & Anwar, R. K. (2024). Community-Based disaster mitigation and its challenge: A case study in Pangandaran coastal area, Indonesia. Journal of Infrastructure, Policy and Development, 8(6), 4075. doi:10.24294/jipd.v8i6.4075.