International Journal of Basic and Applied Sciences, 14 (4) (2025) 24-32

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/xj0yh052
Research paper

Community Residents' Preparedness for Volcanic Eruptions: An Integrated Structural Equation Modelling (SEM) framework

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Received: June 24, 2025, Accepted: July 28, 2025, Published: August 2, 2025

Abstract

This study investigates the determinants of community preparedness for volcanic eruptions in Batangas using an integrated Structural Equation Modelling (SEM) framework. Employing a mixed-methods design, the research combined a structured survey and focus group discussions to assess the roles of hazard knowledge, media reliance, risk perception, subjective norm, attitude, and perceived behavioral control among residents, barangay officials, and disaster risk reduction officers. Stratified sampling ensured representation across high-risk and vulnerable groups. Data were analyzed using descriptive statistics, SEM, and thematic analysis. Results revealed that subjective norm ($\beta = 0.59$), perceived risk proximity ($\beta = 0.63$), and media reliance ($\beta = 0.57$) were the strongest predictors of preparedness, while hazard knowledge alone was insufficient to drive action without supportive community structures and resources. Notably, preparedness levels were higher among residents with strong social networks and frequent engagement with official risk communication channels. However, gaps in resource access and persistent misinformation on social media hindered effective preparedness, particularly among marginalized groups. The study proposes a multi-channel, community-driven disaster risk reduction framework and the development of the "Bantay Bulkan Para sa Mamamayan" toolkit to enhance capacity-building, information verification, and inclusive preparedness strategies.

Keywords: *Disaster Preparedness; Volcanic Hazards; Structural Equation Modelling; Risk Communication; Community Resilience; Disaster Tool Kit.*

1. Introduction

Disaster preparedness is a fundamental concern for communities living in hazard-prone areas, as individuals and households are routinely required to make critical decisions that affect their safety, security, and well-being. Each preparedness decision—whether routine or urgent—directly shapes the community's ability to withstand, respond to, and recover from disasters such as volcanic eruptions. Effective disaster management requires a clear understanding of risk, proactive planning, and the capacity to translate knowledge into action, ensuring that immediate needs are met while safeguarding long-term resilience.

In the province of Batangas, disaster preparedness is a part of daily life. The presence of Taal Volcano, one of the most active volcanoes in the Philippines, places residents in a constant state of alertness. Despite regular exposure to risk communication and preparedness campaigns, many residents continue to face significant challenges in translating awareness into concrete action. The 2020 Taal eruption exposed gaps in household and community readiness, with issues ranging from insufficient emergency supplies and unclear evacuation plans to the spread of misinformation and the marginalization of vulnerable groups. These challenges are compounded by socio-economic constraints, frequent disruptions to livelihoods, and the psychological toll of recurring disasters, all of which can undermine the community's collective resilience.

The unique context of Batangas presents additional complexities. Many residents have deep generational ties to the land, with livelihoods and cultural identity closely linked to the volcano's landscape. This proximity fosters both a strong sense of place and an acute awareness of risk, yet it also creates barriers to relocation and adaptation. Community preparedness is further influenced by the role of local government units (LGUs), barangay officials, and disaster risk reduction and management (DRRM) officers, who serve as both sources of information and facilitators of collective action. However, disparities in resource allocation, communication infrastructure, and social cohesion can hinder the effectiveness of preparedness initiatives, particularly among marginalized populations such as persons with disabilities (PWDs), the elderly, and low-income households.

Previous studies in the Philippine context have highlighted the importance of community-based disaster risk reduction, inclusive planning, and the integration of scientific and local knowledge (Sabo o et al., 2025). However, much of the existing research has focused on isolated aspects of preparedness, such as early warning systems or evacuation practices, often overlooking the complex interplay of knowledge, attitudes, social norms, and behavioral control that shape actual preparedness behaviors. There remains a critical need for a more integrative and comprehensive approach that examines how these factors interact within the high-risk, resource-constrained environment of Batangas.

Globally, disaster preparedness has evolved to emphasize resilience through community engagement, inclusive planning, and the integration of diverse knowledge systems. Studies from countries like Japan, Indonesia, and Chile have demonstrated that preparedness is most effective when scientific forecasting is combined with local risk awareness and culturally grounded practices. In alignment with these global findings, previous studies in the Philippine context have highlighted the importance of community-based disaster risk reduction, inclusive planning, and the integration of scientific and local knowledge (Sabo-o et al., 2025). However, much of the existing research has focused on isolated aspects of preparedness, such as early warning systems or evacuation practices, often overlooking the complex interplay of knowledge, attitudes, social norms, and behavioral control that shape actual preparedness behaviors. There remains a critical need for a more integrative and comprehensive approach, especially within high-risk and resource-constrained areas like Batangas.

Recent literature has underscored the value of disaster literacy as a key component of community resilience, influencing both individual and collective capacity to cope with hazards (Paton, 2019). Studies by Becker et al. (2017) and Kurata et al. (2022) have demonstrated that risk perception, social influence, and access to credible information are pivotal in motivating protective actions. Furthermore, the rapid evolution of digital communication platforms has both enhanced and complicated disaster risk communication, necessitating new strategies for information verification, community engagement, and the management of misinformation (ReliefWeb, 2021; ScienceDirect, 2024).

Given these considerations, this study seeks to investigate the determinants of community preparedness for volcanic eruptions in Batangas using an integrated Structural Equation Modelling (SEM) framework. By examining the roles of hazard knowledge, media reliance, risk perception, subjective norm, attitude, and perceived behavioral control, the research aims to provide a comprehensive understanding of preparedness dynamics and to inform the development of targeted, sustainable disaster risk reduction strategies for high-risk communities.

2. Research method

This study employed a convergent parallel mixed-methods design to investigate the factors influencing community preparedness for volcanic eruptions in Batangas, integrating Protection Motivation Theory (PMT) and the Theory of Planned Behavior (TPB) with media reliance as an extended latent variable. The research aimed to determine how cognitive factors (hazard knowledge, perceived risk proximity, perceived severity, perceived vulnerability), behavioral factors (perceived behavioral control, subjective norm, attitude), and media influence shape preparedness among community residents. Twenty-three hypotheses were formulated to test the direct and mediated relationships among these variables, focusing on the predictive and explanatory power of the combined PMT-TPB-media model. The study was conducted in April 2025 in the lakeside municipalities and cities most at risk from Taal Volcano—Talisay, Laurel, Agoncillo, San Nicolas, Balete, Cuenca, Lemery, Mataasnakahoy, Tanauan City, and Lipa City— during a period of ongoing volcanic unrest and heightened community vigilance. The quantitative component involved a stratified proportional random sample of 384 residents aged 18 and above, with sample sizes per locality determined using Cochran's formula and proportionate to population size. Eligible respondents were randomly selected from municipal registries, ensuring representativeness across socio-economic backgrounds, educational levels, and years of residency.

A researcher-developed survey questionnaire served as the principal data gathering instrument, covering demographics, all PMT and TPB constructs, media reliance, and preparedness behaviors. The questionnaire was reviewed by disaster management experts, pilot-tested in a non-sample municipality, and refined based on feedback to ensure clarity and validity. Reliability testing yielded a Cronbach's alpha of 0.9, confirming excellent internal consistency. The survey used a 7- point continuous scale for responses and was administered both face-to-face and online, with informed consent and confidentiality strictly observed. The qualitative component consisted of a single focus group discussion (FGD) conducted via Zoom with 10 DRRM officers and key disaster management personnel, each representing one of the 10 target LGUs. FGD participants were purposively selected based on their roles, experience, and direct involvement in preparedness and response. The FGD was guided by structured questions addressing policy implementation, risk communication, media's role, and lessons from past eruptions; the session was audio-recorded, transcribed verbatim, and analyzed thematically.

Data analysis began with descriptive statistics to summarize respondent profiles and preparedness levels. Inferential statistics included correlation and multiple regression analyses to examine relationships among variables, while structural equation modeling (SEM) was employed to test the full theoretical model, capturing both direct and indirect effects. Qualitative data from the FGD were coded and analyzed using thematic analysis to identify recurring patterns and contextual insights, which were then triangulated with quantitative findings for a comprehensive understanding. This rigorous, mixed-methods approach ensured robust, context-sensitive results, informing the development of a prescriptive community preparedness toolkit tailored for Batangas' high-risk communities.

3. Results and discussions

Table 1: Level of Community Residents' Preparedness for Volcanic Eruptions

Community Preparedness	Mean	Interpretation
I maintain a first aid kit with necessary medications as recommended by local health authorities.	6	Very High
My family has an agreed-upon evacuation plan that aligns with the official evacuation routes and procedures designated by the local government.	5.89	High
I have protective equipment (masks, goggles) in case of volcanic ashfall as recommended by public health advisories.	5.94	High
I participate in community disaster drills organized and facilitated by the local government.	5.75	High
I have a battery-powered radio for emergencies to receive updates and instructions from local authorities.	5.02	High
Composite Mean	5.72	High

The overall composite mean for community preparedness among Batangas residents was 5.72, interpreted as High. Maintaining a first aid kit received the highest mean score (6.00, Very High), reflecting strong prioritization of health and readiness for emergencies. High ratings were also observed for having protective equipment (5.94), establishing family evacuation plans (5.89), and participating in community disaster drills (5.75), indicating active engagement with recommended preparedness measures and effective local government initiatives. Possession of a battery-powered radio had the lowest mean (5.02, High), suggesting a relative gap in access to traditional emergency information channels. These results highlight that while Batangas residents demonstrate high preparedness—especially in health and planning—continued efforts are needed to further enhance information access and ensure inclusive, community-wide participation in disaster

readiness activities. Focus group discussions reinforce these findings, with LGU officers describing the intensification of education efforts post-eruption, the use of multimedia and real-life experiences to make hazards tangible, and the need for ongoing outreach to newly settled or 109 marginalized populations.

Table 2: Level of Residents' Perceived Status for Volcanic Eruptions in terms of Hazard Knowledge

Hazard Knowledge	Mean	Interpretation
I am familiar with disaster sirens and warning signals for volcanic eruptions disseminated by the local government.	6.07	Very High
I understand how the local government communicates the different alert levels for Taal Volcano and their meanings.	6.17	Very High
I am aware of the health advisories issued by public health authorities regarding potential health injuries and respiratory effects from volcanic eruptions.	6.28	Very High
I am familiar with the official evacuation routes from my location as designated and communicated by the local government.	5.93	High
I am aware of the proper government authorities and agencies to contact during an eruption as outlined in the local disaster response plans.	6.12	Very High
I know where to find up-to-date information from the local government regarding evacuation procedures for various eruption scenarios.	6.02	Very High
Composite Mean	6.10	Very High

As shown in Table 2, the composite mean for hazard knowledge among Batangas residents is 6.10, interpreted as "Very High." This reflects a strong community understanding of volcanic hazards and preparedness information. Residents scored highest in awareness of health advisories (6.28), understanding local government communication on alert levels (6.17), and knowledge of proper authorities to contact during an eruption (6.12), indicating robust hazard literacy shaped by sustained information campaigns and recent volcanic events. Regular barangay-level IEC activities and the use of both face-to-face and digital platforms by LGUs have contributed to this high awareness. However, familiarity with official evacuation routes was relatively lower (5.93, High), suggesting a need for more practical, location-specific education and regular drills. While theoretical knowledge is strong, translating this into consistent preparedness action remains a challenge. Ongoing experiential learning, targeted outreach to vulnerable groups, and community-led initiatives are recommended to ensure that high-hazard knowledge leads to effective and inclusive disaster preparedness.

Table 3: Level Of Residents' Perceived Status for Volcanic Eruptions in Terms of Perceived Risk Proximity

Perceived Risk Proximity	Mean	Interpretation
I am aware of which volcanic hazard zone I live in according to official government maps and classifications.	6	Very High
I understand the local government's estimates of how quickly volcanic hazards could reach my location.	5.95	High
I observe the local government's monitoring and communication of changes in Taal Volcano's activity from my location.	5.94	High
I am familiar with the nearest evacuation facility designated by the local government that I can go to if Taal Volcano erupts.	6.14	Very High
I understand how past eruptions of Taal Volcano have informed the local government's disaster preparedness strategies in my area.	6.14	Very High
I believe the local government is adequately prepared to evacuate residents in my area if a major eruption occurs.	6.03	Very High
I understand the local government's plans for managing ashfall in my specific community.	6.02	Very High
Composite Mean	6.03	Very High

As shown in Table 3, the composite mean for perceived risk proximity among Batangas residents is 6.03, interpreted as "Very High." Residents scored highest in familiarity with the nearest evacuation facility (6.14) and understanding how past eruptions have shaped preparedness strategies (6.14), highlighting strong awareness of both personal risk and institutional response. High scores for knowledge of hazard zones, government preparedness, and ashfall management further reflect the effectiveness of local risk communication and public education campaigns. Slightly lower, though still high, means for understanding the speed of hazard arrival (5.95) and observing government monitoring (5.94) suggest areas for improvement in communicating the immediacy of volcanic threats and increasing the visibility of official monitoring activities. These results align with Protection Motivation Theory, reinforcing that heightened risk proximity motivates protective behavior, but also point to the need for ongoing, context-sensitive communication to sustain preparedness and address potential complacency. Insights from focus group discussions reinforce these findings,
with participants describing heightened awareness of risk proximity following recent eruptions and the tangible impact of ashfall even in areas not immediately adjacent to the volcano. This aligns with the survey results and supports the theme that residents actively consider their proximity to volcanic hazards in their preparedness behaviors.

Table 4: Level of Residents' Perceived Status for Volcanic Eruptions in Terms of Perceived Severity

Perceived Severity	Mean	Interpretation
I believe that a Taal Volcano eruption could lead to loss of life despite the best efforts of local authorities.	6.18	Very High
I am aware that a Taal Volcano eruption could significantly impact my livelihood and resources, even with government assistance programs in place.	6.34	Very High
I believe that basic services in our area could be completely disrupted if Taal Volcano erupts despite contingency plans.	6.2	Very High
I think recovery efforts would require substantial financial resources from both the local and national governments.	6.38	Very High
I believe that the psychological impact of a volcanic eruption would persist for years, requiring long-term public mental health support.	6.26	Very High
I think that damage to critical infrastructure (roads, bridges, power lines) could severely hinder the local government's ability to respond to a major eruption.	6.18	Very High
Composite Mean	6.26	Very High

As shown in Table 4, the composite mean for perceived severity among Batangas residents is 6.26, interpreted as "Very High." Respondents rated the financial impact (6.38) and livelihood disruption (6.34) as the most severe consequences, followed by concerns about long-term psychological effects (6.26). All indicators—including loss of life, disruption of basic services, and damage to critical infrastructure—received very high scores, reflecting strong recognition of the wide-ranging and serious impacts of a volcanic eruption. These results indicate that residents have a comprehensive understanding of both immediate and long-term consequences, shaped by effective risk communication and recent eruption experiences. Consistent with Protection Motivation Theory, this high perceived severity provides a strong foundation for motivating preparedness, though the literature and focus group insights emphasize the need to pair severity awareness with self-efficacy and practical resources to ensure that risk perception leads to protective action. Insights from focus group discussions reinforce these findings, with participants describing heightened awareness of health impacts, especially among vulnerable groups such as those with respiratory conditions. One participant noted that increased preparedness is driven by recognizing the health, economic, and psychological dimensions of volcanic hazards, supporting the very high composite mean for perceived severity.

Table 5: Level of Residents' Perceived Status for Volcanic Eruptions in terms of Perceived Vulnerability

Perceived Vulnerability	Mean	Interpretation
I believe my location makes me highly vulnerable to volcanic hazards despite local government mitigation efforts.	5.03	High
I feel my financial situation limits my ability to prepare, even with access to government assistance programs during volcanic emergencies.	5.28	High
I feel my age increases my vulnerability during an eruption despite targeted support services for vulnerable populations.	4.87	Average
I feel my community connections are insufficient for emergency situations despite local government initiatives to foster community resilience.	4.74	Average
I believe I am less prepared compared to others in my community due to challenges in accessing information provided by the local government.	4.55	Average
I am concerned that the local government's evacuation plans may not adequately address the needs of vulnerable populations in my community (such as the elderly, disabled, or those with limited mobility).	4.88	Average
I fear that the local government's communication systems may fail to reach all residents, particularly those with limited access to technology or those who do not speak the primary language.	5.05	High
Composite Mean	4.92	Average

As shown in Table 5, the composite mean for perceived vulnerability among Batangas residents is 4.92, interpreted as Average. Financial limitations (5.28, High) and concerns about communication system failures (5.05, High) were the most prominent, indicating that socioeconomic constraints and potential information gaps are the main contributors to residents' sense of vulnerability. Location-based vulnerability was also rated high (5.03), while age, community connections, and concerns about evacuation plans for vulnerable groups were rated as average. These findings suggest that while residents recognize the risks associated with living in hazard zones, their sense of vulnerability is shaped more by financial and systemic barriers than by individual factors. Focus group discussions reinforced that low-income families and those with limited access to technology feel especially exposed during disasters. Overall, the results highlight the importance of addressing financial constraints and improving communication infrastructure to ensure that preparedness efforts are inclusive and that vulnerable groups are not left behind.

Table 6: Level of Residents' Perceived Status for Volcanic Eruptions in Terms of Perceived Behavioral Control

Perceived Behavioral Control	Mean	Interpre tation
I can afford to maintain emergency supplies in our house with available government subsidies or assistance programs.	5.18	High
I am confident in my ability to recognize warning signs of an eruption thanks to public education campaigns.	5.98	High
I can prepare adequately for emergencies despite my work schedule because my employer supports participation in local disaster preparedness initiatives.	5.93	High
I have access to local preparedness training programs offered by the local government.	5.61	High
I can influence my family's preparedness behavior because I can share information and resources obtained from public awareness campaigns.	6.03	Very High
I can access transportation to evacuation centers even with limited resources because of available local government assistance programs.	5.7	High
Composite Mean	5.74	High

As shown in Table 6, the composite mean for perceived behavioral control among Batangas residents is 5.74, interpreted as High. The highest score was for influencing family preparedness by sharing information from public awareness campaigns (6.03, Very High), highlighting the importance of knowledge-sharing within the household. Confidence in recognizing warning signs (5.98) and the ability to prepare despite work schedules (5.93) were also rated high, reflecting the effectiveness of public education and supportive environments. Access to training, emergency supplies, and transportation received slightly lower, but still high, ratings, indicating that some resource and logistical barriers persist. Focus group discussions confirm that while most residents feel empowered to prepare, this confidence is conditional and relies on continued government support and accessible resources, especially for marginalized groups. Overall, high perceived behavioral control is evident, but ensuring equitable access to resources remains crucial for enabling all residents to take effective preparedness actions.

Table 7: Level of Residents' Perceived Status for Volcanic Eruptions in Terms of Subjective Norm

Subjective Norm	Mean	Interpre tation
People important to me think I should prepare for volcanic hazards because they trust the information and guidance provided by local authorities.	5.95	High
My family encourages me to maintain emergency supplies as recommended by the local disaster management office.	5.9	High
My neighbors expect me to know about evacuation procedures due to widespread community outreach efforts by the local government.	5.75	High

Community leaders expect me to be prepared for volcanic emergencies to contribute to overall community resilience as emphasized by local preparedness initiatives.	5.84	High
Other families in my area participate in evacuation drills organized and promoted by the local government.	5.43	High
My community respects and values individuals who actively participate in local government-led disaster preparedness activities.	5.94	High
Local government officials encourage community members like me to take personal responsibility for disaster preparedness.	6.01	Very High
Composite Mean	5.83	High

As shown in Table 7, the composite mean for subjective norm among Batangas residents is 5.83, interpreted as High. The highest score was for encouragement to government officials (6.01, Very High), highlighting the strong influence of authorities in shaping community expectations for disaster preparedness. High ratings for family encouragement (5.90), respect for active participants (5.94), and trust in official guidance (5.95) further underscore the importance of both close social circles and community leaders in motivating preparedness behaviors. Focus group discussions confirm that visible, proactive leadership by mayors, barangay captains, and DRRM officers is key to fostering collective responsibility and compliance. These findings align with the Theory of Planned Behavior, which identifies subjective norm as a significant predictor of preparedness intentions, and emphasize the value of leveraging community leadership and social networks to sustain disaster readiness. Focus group discussions in this study reveal that residents frequently cite the proactive role of mayors, barangay captains, and DRRM officers in organizing community meetings, issuing advisories, and leading preparedness campaigns. The visible presence and active engagement of local officials reinforce the importance of preparedness and foster a culture of collective responsibility and compliance. This highlights the effectiveness of government-led initiatives in setting behavioral norms and mobilizing residents toward disaster readiness

Table 8: Level of Residents' Perceived Status for Volcanic Eruptions in Terms of Attitude

Attitude	Mean	Interpre tation
I think preparing for volcanic hazards is a good use of my resources, given the support and resources provided by the local government.	6.18	Very High
Taking preparedness actions gives me peace of mind knowing that I am better able to protect myself and my family with the guidance and resources from local authorities.	6.16	Very High
I feel positively about participating in preparedness activities because they are well-organized and supported by the local government.	6.19	Very High
Maintaining emergency supplies is sensible given the potential for disruptions and the guidance provided by local disaster management plans.	6.08	Very High
Learning evacuation procedures is useful for enabling me to take part in the LGU-initiated emergency response plan.	6.14	Very High
I believe investing in disaster preparedness contributes to a more resilient and self-sufficient community, reducing reliance on government aid.	6.14	Very High
Composite Mean	6.15	Very High

As shown in Table 8, the composite mean for attitude toward disaster preparedness among Batangas residents is 6.15, interpreted as Very High. All items received "Very High" ratings, with the highest scores for positive feelings about participating in well-organized, government-supported activities (6.19), viewing preparedness as a good use of resources (6.18), and experiencing peace of mind from taking preparedness actions (6.16). These results indicate a strong consensus that preparedness is sensible, beneficial, and contributes to both personal and community resilience. Focus group discussions confirm that proactive local government support and clear communication have fostered these positive attitudes, though some barriers, such as fatalism and skepticism, persist among a minority. Overall, the findings highlight that effective government intervention and resource provision play a critical role in sustaining highly positive attitudes toward disaster preparedness.

Table 9: Overall Assessment on Community Preparedness

Community Preparedness	Mean	Interpre tation
Protection Motivation Theory		
Hazard Knowledge	6.1	Very High
Perceived Risk Proximity	6.03	Very High
Perceived Severity	6.26	Very High
Perceived Vulnerability	4.92	Average
Theory of Planned Behavior		
Perceived Behavioral Control	5.74	High
Subjective Norm	5.83	High
Attitude	6.15	Very High
Overall Mean	5.86	High

As shown in Table 9, the overall community preparedness in Batangas is high, with a composite mean of 5.86. The highest scores were recorded for perceived severity (6.26), attitude (6.15), hazard knowledge (6.10), and perceived risk proximity (6.03), all interpreted as "very high." This indicates that residents are highly aware of volcanic hazards, recognize the seriousness of the threat, and maintain a positive outlook toward preparedness. Subjective norm (5.83) and perceived behavioral control (5.74) were both rated "high," reflecting the strong influence of social expectations and confidence in acting—consistent with the Theory of Planned Behavior. However, perceived vulnerability was only "average" (4.92), suggesting that many residents do not strongly identify as personally at risk, possibly due to normalization or complacency. Focus group discussions confirmed that while community knowledge and engagement are high, the sense of personal vulnerability is less pronounced, especially among those frequently exposed to volcanic hazards. Overall, these findings highlight the strengths of Batangas communities in preparedness but also identify the need to personalize vulnerability and sustain engagement, particularly for at-risk groups.

Table 10: Level of Community Residents' Media Reliance for Disaster Preparedness

Reliance on Types of Media	Mean	Interpretation
Radio	5.14	To a great extent
Television	6.02	To a very great extent
Newspapers	4.22	To a moderate extent
Social Media	6.24	To a very great extent
Mobile Phones	6.38	To a very great extent
Verified Local News Outlets	5.99	To a great extent
Local Authorities and Official government sources/ websites	6.17	To a very great extent
Relief Organizations	5.94	To a great extent
Composite Mean	5.76	To a great extent

As shown in Table 10, Batangas residents rely on media for disaster preparedness to a great extent (composite mean = 5.76). Mobile phones, social media, television, and official government sources are used "to a very great extent," while radio, local news outlets, and relief organizations are also important. Newspapers are used only moderately. LGUs use multiple channels for information, but misinformation on social media remains a challenge, prompting efforts to verify and coordinate messaging. These tools offer real-time updates, accessible formats, and widespread reach, making them indispensable during disaster warnings and preparedness campaigns. This media engagement pattern is consistent with global trends, where digital and mobile technologies increasingly serve as the primary vectors of disaster-related communication (Houston et al., 2012; UNDRR, 2022).

Qualitative findings from LGU officers indicate the use of a mix of social media, Facebook pages, LED walls, group chats, and barangay assemblies for information dissemination. Officers report that misinformation is a major challenge, with instances of unauthorized sharing and alteration of official content. To counter this, LGUs validate information with PHIVOLCS and other official agencies before public release, and have trained local communicators for fact-checking and rapid information dissemination.

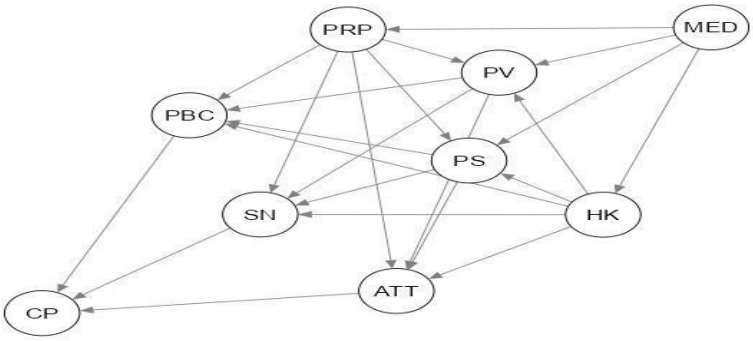

Fig. 1: SEM Path Diagram.

Latent Constructs and Abbreviations:
CP – Community Preparedness (outcome variable)
PBC – Perceived Behavioral Control (TPB component)
SN – Subjective Norms (TPB component)
ATT – Attitude (TPB component)
PRP – Preparation (precautionary action tendency)
PV – Perceived Value (importance of protective behavior)
PS – Perceived Support (or Self-efficacy; mediating factor)
HK – Hazard Knowledge (awareness and factual understanding)
MED – Media Reliance (informational variable)
Key Model Pathways:

1) Community Preparedness (CP) acts as a foundational driver, directly influencing:
- Perceived Behavioral Control (PBC)
- Subjective Norms (SN)
- Attitude (ATT)
- Preparation (PRP)

2) Preparation (PRP) then affects:
- Perceived Value (PV)
- Perceived Support (PS)
- Media Reliance (MED)

3) PBC, SN, ATT, and PRP all influence Perceived Support (PS), a key mediator.
4) Perceived Support (PS) has downstream effects on:
- Perceived Value (PV)
- Hazard Knowledge (HK)
- Media Reliance (MED)

5) Attitude (ATT), influenced by CP, also contributes to Perceived Support (PS) and possibly Hazard Knowledge (HK).
6) Finally, HK and PV both have direct effects on Media Reliance (MED), which is treated here as a behavioral or informational outcome reflective of disaster preparedness behavior.

The diagram presents a conceptual framework that illustrates the complex interrelationships among various psychological, behavioral, and contextual constructs that collectively influence a target outcome. In this case, the target outcome is represented by MED, which most likely reflects the level of community preparedness for volcanic eruptions, as outlined in the hypothesized Structural Equation Model or SEM. Each circle or node in the diagram corresponds to a latent variable, an underlying factor that is not directly observed but inferred through measurable indicators. The directional arrows connecting these variables represent hypothesized or empirically tested causal

relationships. This conceptual framework is grounded in an integrated SEM structure that draws upon Protection Motivation Theory (PMT), the Theory of Planned Behavior (TPB), and media influence theory to capture the multidimensional psychological and environmental dynamics that shape individual and collective preparedness for natural hazards. The latent variables identified in the model include Hazard Knowledge (HK), Perceived Severity (PS), Perceived Vulnerability (PV), Perceived Risk Proximity (PRP), Perceived Behavioral Control (PBC), Subjective Norm (SN), Attitude (ATT), Media Reliance (MED), and Community Preparedness (CP).

At the foundation of the model lies Community Preparedness (CP), which is the outcome variable influenced by several direct and indirect pathways. The analysis indicates that CP is significantly shaped by Subjective Norm (SN) with a standardized regression coefficient of $\beta = 0.5947$, $p < .001$, marking it as the strongest predictor. This is followed by Perceived Behavioral Control (PBC) with $\beta = 0.2377$, $p < .001$, and Attitude (ATT) with $\beta = 0.103$, $p = 0.007$. These results underscore the foundational propositions of the Theory of Planned Behavior, which asserts that behavioral intentions and actions are significantly influenced by an individual's perceived control over their behavior, their perception of societal expectations, and their own attitudes. These variables are, in turn, influenced by more distal cognitive and informational factors such as hazard knowledge, perceived vulnerability, and perceived risk proximity. Focus group discussions with DRRM officers corroborate this statistical relationship. For example, officers described using video footage of the 2020 eruption in barangay seminars to illustrate volcanic risks, and noted that residents who engage with LGU Facebook updates are more aware and actively seek further information. Ajzen (1991) emphasizes that behavioral intention is a product of one's perceived social pressure (subjective norms), perceived capacity to act (behavioral control), and personal evaluations (attitude). Similarly, Paton (2013) highlights that disaster preparedness is a socially constructed process, where individuals are motivated to act not only by personal perceptions but also by perceived obligations to family and community.

Media Reliance (MED) is incorporated in the model as a significant external and informational factor. It exerts strong positive effects on Hazard Knowledge ($\beta = 0.5675$, $p < .001$) and Perceived Risk Proximity ($\beta = 0.5691$, $p < .001$). These values reflect that individual who depend more heavily on media sources such as television, radio, or online platforms are substantially more informed about volcanic hazards and more aware of their geographical exposure to risk. Media reliance also has a positive effect on Perceived Severity ($\beta = 0.1764$, $p < .001$), suggesting that frequent exposure to disaster-related content heightens individuals' sense of potential threat. Focus group discussions with DRRM officers reinforce this statistical relationship. Officers noted that increased news coverage and social media updates about volcanic activity make residents more alert, even those outside the official danger zones. Frequent sharing of hazard maps and updates online was cited as making residents more aware of their actual proximity to risk zones. These qualitative insights support the literature showing that effective media communication not only informs but also motivates at-risk populations to recognize their vulnerability and prepare accordingly. Furthermore, UNDRR (2022) underscores the importance of multi-platform risk communication to ensure community-wide access to disaster information.

Within the framework, Perceived Behavioral Control (PBC) acts as a central mediating construct that channels the effects of knowledge and threat perception into preparedness behavior. The SEM analysis confirms that Hazard Knowledge positively influences PBC ($\beta = 0.0992$, $p = 0.015$). This indicates that residents who are more knowledgeable about volcanic hazards feel more confident in their ability to take meaningful preparedness actions. In addition, Perceived Severity ($\beta = 0.3409$, $p < .001$) and Perceived Risk Proximity ($\beta = 0.3254$, $p < .001$) both significantly increase perceived behavioral control. These findings highlight that individuals who perceive volcanic threats as severe and nearby are more likely to believe they are capable of taking protective measures. This reinforces the model's depiction of PBC as a vital bridge between cognitive inputs and behavioral outcomes. In support of this, Tang et al. (2019) in China found that higher disaster knowledge improves self-efficacy and preparedness behavior. Likewise, Lindell and Perry (2012) suggest that knowledge increases the likelihood of recognizing the seriousness of hazards and the need for personal action.

The influence of Subjective Norm (SN) is also shaped by multiple cognitive and perceptual inputs. Specifically, Hazard Knowledge ($\beta = 0.0804$, $p = 0.028$), Perceived Risk Proximity ($\beta = 0.6344$, $p < .001$), and Perceived Vulnerability ($\beta = 0.0855$, $p = 0.019$) all contribute to a heightened sense of social pressure or community expectation to act. These statistically significant values suggest that individuals who are better informed and who perceive themselves at greater risk are also more attuned to what others in the community expect them to do in terms of preparedness. The strength of SN as the most influential predictor of community preparedness affirms the crucial role of social norms, peer influence, and communal values in disaster behavior. Globally, Bird et al. (2010) in Indonesia and Donovan and Oppenheimer (2014) in Iceland both found that physical proximity to volcanic hazards strongly influences perception of risk and motivation to engage in protective actions. These findings are consistent with PMT's core assertion that both threat appraisal (severity and vulnerability) and coping appraisal (response efficacy and self-efficacy) drive protective behavior (Rogers, 1975; Maddux & Rogers, 1983).

Attitude (ATT) toward preparedness is likewise significantly shaped by three main inputs. The data show that Hazard Knowledge influences ATT ($\beta = 0.3066$, $p < .001$), Perceived Risk Proximity has a positive effect ($\beta = 0.3588$, $p < .001$), and Perceived Severity also contributes ($\beta = 0.2984$, $p < .001$). These results illustrate that individuals who are informed, who feel near to volcanic hazards, and who perceive the danger as serious are more likely to hold favorable attitudes toward preparing for such disasters. In the diagram, these connections are visually confirmed by directional arrows linking these cognitive constructs to ATT, and in turn, from ATT to CP. This pathway supports the notion that risk communication and public education initiatives should not only inform but also positively shape residents' attitudes to promote action.

Taken together, the diagram and the SEM results provide a comprehensive understanding of how a network of cognitive, social, emotional, and informational variables interacts to shape community preparedness for volcanic hazards. The findings emphasize that preparedness is not solely the result of individual knowledge or motivation but arises from a dynamic system that includes perceived threats, proximity to danger, self-confidence, social expectations, and media exposure. The inclusion of statistically validated pathways adds empirical strength to this conceptual model, reinforcing the need for disaster risk reduction strategies that integrate multiple dimensions. Programs should aim to enhance public knowledge, build self-efficacy, leverage the power of social norms, and strategically utilize media to reach and empower at-risk communities. The model is especially relevant for high-risk areas such as Batangas, where community engagement, communication networks, and localized interventions are essential to reducing vulnerability and enhancing resilience. The hypothesized Structural Equation Model (SEM) integrates Protection Motivation Theory (PMT), Theory of Planned Behavior (TPB), and media influence to predict community preparedness for volcanic eruptions. Latent variables include Hazard Knowledge, Perceived Severity, Perceived Vulnerability, Perceived Risk Proximity, Perceived Behavioral Control, Subjective Norm, Attitude, Media Reliance, and Community Preparedness. This SEM structure reflects the complex interplay of cognitive, behavioral, and contextual factors that shape preparedness, as supported by recent disaster risk reduction literature. Overall, the integrated SEM framework offers a robust basis for understanding how knowledge, risk perception, social influences, and media use collectively foster community preparedness in high-risk volcanic settings.

These findings informed the development of a culturally tailored, evidence-based toolkit designed to empower families and communities to mitigate risks and enhance resilience. The toolkit's design is grounded in empirical SEM results and insights from focus group discussions with Batangas disaster management officers. While residents showed high hazard knowledge (mean = 6.1), their perceived

vulnerability remains only moderate, reflecting a normalization of volcanic risks that can undermine proactive preparedness. This gap led to the inclusion of localized tools such as barangay-specific hazard maps and evacuation plans. The SEM also underscored the critical role of subjective norms in driving preparedness, justifying community-driven strategies like pledge walls and bayanihan challenges to leverage social influence. Moderate perceived behavioral control and recovery knowledge highlighted the need for skill-building modules, while significant media reliance without verification mechanisms prompted the addition of media literacy guides to combat misinformation. By integrating Protection Motivation Theory (threat appraisal) and Theory of Planned Behavior (social norms, attitudes), the toolkit translates knowledge into action and addresses both cognitive and behavioral barriers.

Recognizing the growing role of digital innovation in disaster risk reduction, the toolkit also explores how emerging technologies can augment community preparedness. AI-powered early warning systems—capable of analyzing seismic activity, weather changes, and historical hazard data—can deliver faster and more accurate alerts, while mobile applications offer platforms for personalized risk assessments, evacuation tracking, and two-way communication during crises. These digital tools not only enhance the timeliness and precision of information dissemination but also support behavioral nudges and feedback loops that reinforce preparedness habits. By embedding such innovations into the toolkit, it becomes more adaptive, responsive, and aligned with global DRR trends.

To ensure inclusivity, the toolkit embeds targeted supports for vulnerable groups, particularly persons with disabilities (PWDs), the elderly, and children. For example, evacuation planning modules include customizable checklists for mobility-impaired individuals, with designated "assisted evacuation" roles integrated into family plans and barangay drills. Visual hazard maps are produced in high-contrast and large-print versions, while audio briefings and braille-ready templates are available for visually impaired users. Emergency communication cards use color-coded symbols to help non-verbal or cognitively impaired individuals signal needs during evacuations. For the elderly, the toolkit recommends neighborhood buddy systems and includes medication storage guides and stress reduction tips tailored to age-related concerns. Child-focused adaptations include illustrated preparedness storybooks and interactive classroom activities designed to teach hazard awareness through play. These tailored interventions ensure that no one is left behind in planning or response efforts, reinforcing equity as a core principle of the toolkit's design.

Targeting ten lakeside municipalities and cities in Batangas—including high-risk areas like Talisay, Agoncillo, and Laurel—the toolkit prioritizes families, with adaptations for vulnerable groups such as persons with disabilities, the elderly, and children. Its six core components are: (1) personalized risk assessment and evacuation planning; (2) media literacy and real-time information guides; (3) disaster skills training modules; (4) community-driven motivation tools; (5) mental health and inclusivity supports; and (6) post-eruption recovery guidance. Implementation strategies include integration into local DRRM plans, barangay-level workshops, digital and print dissemination, partnerships with media and NGOs, and feedback mechanisms to ensure ongoing relevance. Schools are also engaged as partners for education and outreach, with toolkit activities incorporated into classroom and school-based drills.

Each toolkit component is directly aligned with SEM findings and theoretical models. For example, barangay-specific hazard maps and evacuation planning address gaps in risk proximity and help residents translate knowledge into action. Media literacy guides counter misinformation and promote reliance on trusted sources, while disaster skills training modules boost self-efficacy and confidence. Community-driven motivation tools, like pledge walls and bayanihan challenges, leverage strong subjective norms to foster accountability and collective action. Mental health and inclusivity add-ons ensure that trauma and accessibility needs are met, while post-eruption recovery guidance supports safe rebuilding and livelihood protection.

While the toolkit was developed within the specific context of volcanic hazards in Batangas, its structure is inherently scalable and adaptable. The theoretical foundations—particularly Protection Motivation Theory and the Theory of Planned Behavior—are applicable across a range of hazard types, including earthquakes, floods, typhoons, and landslides. For instance, the personalized risk assessment and evacuation planning component can be adapted to flood-prone zones by integrating inundation maps and water-level warning systems, or to earthquake-prone areas by emphasizing structural safety audits and drop-cover-hold drills. Similarly, media literacy modules can be tailored to include hazard-specific misinformation examples, such as false flood alerts or earthquake conspiracy narratives, ensuring communities are equipped to critically engage with all types of risk-related content.

Moreover, the toolkit's focus on community norms, family-centered preparedness, and barangay-level engagement makes it highly relevant to other countries with similar socio-cultural dynamics. In Southeast Asia, for example, nations like Indonesia, the Philippines, and Vietnam share communal decision-making values, high social cohesion, and frequent exposure to a variety of natural hazards. In such settings, strategies like pledge walls and collective action campaigns rooted in community norms can be equally powerful in motivating preparedness. Likewise, the integration of faith-based organizations, schools, and neighborhood associations as communication channels can be replicated across culturally similar regions in South Asia, Latin America, or the Pacific Islands.

To ensure sustainability, the toolkit is designed for annual updates based on PHIVOLCS advisories and community feedback, with monitoring through surveys and barangay logbooks. Its culturally relevant activities and flexible structure ensure it meets the diverse needs of Batangas communities, directly addressing the specific gaps and strengths identified in this study. To amplify its global relevance, the toolkit offers a scalable and adaptable model that can be customized for use in other disaster-prone regions worldwide. By aligning with international frameworks such as the Sendai Framework for Disaster Risk Reduction, it demonstrates how localized, culturally informed preparedness strategies can contribute meaningfully to global resilience-building efforts. The integration of real-time scientific advisories, community-driven feedback loops, and sustainable monitoring practices positions the toolkit as a replicable best practice for enhancing disaster preparedness and response across a wide range of socio-cultural and geographic contexts.

4. Conclusions

Based on the findings of the study, the following conclusions were drawn:

1) The community residents of Batangas exhibit a high level of preparedness for volcanic eruptions, with notable strengths in maintaining health-related emergency supplies but gaps in access to reliable communication tools during disasters.

Residents and officials demonstrate very high cognitive preparedness (hazard knowledge, risk proximity, severity awareness) and strong behavioral readiness (perceived control, social norms, positive attitudes), though socioeconomic barriers moderate vulnerability perceptions, and structural challenges hinder marginalized groups despite institutional support.

2) Reliance on media for disaster information is high, dominated by digital platforms, but traditional tools like radios are underutilized.
3) The Structural Equation Model confirms that subjective norms and media reliance are the strongest predictors of preparedness, while perceived vulnerability has minimal direct influence.
4) The proposed prescriptive toolkit addresses gaps by prioritizing inclusive communication, livelihood-sensitive protocols, and equitable resource distribution.

5. Recommendations

1) Governments and humanitarian agencies worldwide should invest in affordable, multilingual, and culturally appropriate emergency communication systems, especially in underserved areas, to ensure inclusivity in hazard preparedness.
2) Policymakers and global aid organizations should incorporate equity-focused measures into disaster resilience planning to ensure that vulnerable populations are not disproportionately affected.
3) Global preparedness strategies should promote the use of both digital and traditional information systems to address disparities in access to technology, especially in rural or older populations.
4) International agencies and local governments should harness the power of social influence, such as community leaders and influencers, and invest in reliable media to encourage proactive disaster behavior.
5) The toolkit can be adapted to fit disaster-prone communities around the world. Its integration into local and national strategies can help align community-based efforts with international disaster risk reduction frameworks such as the Sendai Framework.

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