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RESEARCH ARTICLES

Preparing for Natural Hazards Events in Small Island Communities: The Role of Social Vulnerability

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Small island communities in large archipelagos are often underrepresented in disaster and climate change studies. While they share similar features of Small Island Developing States (SIDS), such as remoteness and economic isolation, they remain distinct from SIDS as they tend to lack political priority and sovereignty in allocating resources to manage risk and social vulnerabilities. This can further compromise their preparedness for climate shocks and disasters. This study proposes a comprehensive framework for assessing community preparedness that can be applied to multiple hazards in a small island community setting through two steps: (1) an individual's capacity within a household to prepare for a disaster, followed by (2) an evaluation of the collective community's preparedness at the village level. The researcher administered a 48-question survey among 782 respondents in a small island of North Moluccas province that aimed to understand how respondents leveraged their resources, knowledge, and social networks in their disaster preparedness, measured by four key parameters, namely knowledge and attitude (KA), emergency response plan (EP), early warning system (WS), and community capacity (CC). The findings suggest that the knowledge, attitude and the warning system at the household level mainly shape individual preparedness. At the community level, the availability of evacuation maps and signs, evacuation drills, and sharing information via social media shape the community's preparedness. This investigation contributes to developing strategies to enhance disaster preparedness and sustainably mitigate disaster risks by engaging all stakeholders

1. Introduction

Small-island communities living in disaster-prone areas are considered vulnerable, facing potential losses, damage, and other adverse impacts—consequences that often disproportionately affect the most vulnerable segments of society, such as the poor, children, the elderly, and people with disabilities (Maharani et al., 2020). These groups are frequently

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the least prepared for emergencies and possess the fewest resources to cope with hazards. Preparedness in small-island communities has become imperative (Anglade et al., 2024; Syamsidik et al., 2020). Disaster preparedness involves actions implemented prior to a disaster to mitigate or eliminate the severity of its impact (Raneses et al., 2018). Preparedness is an integral part of the hazard cycle, which encompasses planning, organizing, training, equipping, implementing, evaluating, and making necessary adjustments to guarantee effective coordination during a disaster response (Baker & Grant Ludwig, 2018). Preparedness involves providing communities or individuals with emergency response and recovery plans, ensuring these plans are communicated swiftly and effectively, and fostering continuous public awareness of potential hazards and risks (Raneses et al., 2018). This involves improving the ability to react to emergencies, mitigating the impacts and disruptions caused by disasters, and participating in post-disaster and early recovery efforts (Fatoni et al., 2022). Preparedness increases resilience and has been linked to improving community education and awareness, risk perception, and government intervention (Anshuka et al., 2021; Ebhuoma et al., 2024; Twerefou et al., 2023). As part of government interventions, early warning systems, for example, have been shown to increase resilience substantially (Ebhuoma et al., 2024).

Therefore, individuals, communities and governments must collaborate to seek and disseminate appropriate information, effectively communicate warnings and engage with local knowledge in dealing with the threat of hazards. However, preparedness is generally low among small island communities because of the lack of early warning systems, low public education, poor information dissemination, poor risk transfer mechanisms, and lack of protective measures, protocols, and procedures (Pelupessy & Silverman, 2024). This paper is concerned with the preparedness of a community on a small island in Indonesia (Ternate Island). We undertook a survey using a semi-structured questionnaire with 782 respondents, with the aim of measuring community preparedness by examining how small island inhabitants leveraged their resources, knowledge, and social networks in their disaster preparation efforts at the household and village levels. To do so, we propose a new comprehensive framework for assessing community preparedness that can be applied to multiple hazards in a small island community setting to examine (1) how individuals in a household prepare for a disaster, and (2) collective community preparedness at the village level in a small island setting. The results will offer valuable methodological insights to help local decision-makers understand the preparedness status of small island communities, allowing local governments to implement targeted program interventions. This study's findings will lay the foundation for sustainable disaster management systems on small islands and emphasize essential programs that strengthen community resilience to future disasters and climate change.

2. Methodology

2.1. Research area

This study was conducted in 60 villages on Ternate Island, located in North Maluku Province, Indonesia (Figure 1, supplementary materials), engaging the village community from five sub-districts. Those villages are grouped into five sub-districts: the North Ternate Sub-district comprises 14 villages; the Central Ternate Sub-district consists of 16 villages; the South Ternate Sub-district encompasses 17 villages; the West Ternate Sub-district contains seven villages; and the Ternate Island Sub-district includes six villages. Ternate Island was selected as a study site due to its classification as a disaster-prone area within Indonesia's territory. Ternate Island faces many threats from natural hazards, including hydrometeorological hazards such as floods, flash floods, landslides, and extreme waves and abrasion, as well as geological hazards such as earthquakes, tsunamis, and volcanic activity (Lessy et al., 2024). Several studies have shown that the Ternate community has been affected by these hazards. A flash flood in 2012, for example, resulted in 1041 displaced people from 272 families and 910 damaged buildings (Masinu et al., 2018). The eruption of Mount Gamalama in 1980 led to the evacuation of 40,000 individuals to nearby islands (Hidayat et al., 2022). Another eruption in 2011 resulted in seven fatalities, 15 injuries, and damage to 577 houses (Hidayat et al., 2022). The strong winds and high waves that hit Ternate Island in January 2021 damaged houses in coastal areas, and many residents evacuated (Sabrina et al., 2021). Between 1600 and 1992, approximately 32 tsunamis occurred in the Maluku Sea, resulting in 7,576 fatalities (Hamzah et al., 2000). One of them was generated by the eruption of Mount Gamalama in 1871, which resulted in the loss of 4,000 lives (Hamzah et al., 2000; Yudhicara & Lukman, 2024). Regrettably, as noted by Lessy et al. (2024), this long history of fatalities and damages hints at poor disaster risk management and preparedness, and even to date, the Ternate government has a limited capacity to comprehend the necessary measures for disaster prevention and management.

2.2. Measuring community preparedness framework

A number of academics have developed criteria to evaluate the extent of community preparedness. Van Wassenhove (2006) outlined five critical elements of preparedness: human resources, knowledge management, operations and process management, logistics, financial resources, and community awareness. Raneses et al. (2018) evaluated preparedness using six parameters: demographics, understanding of preparedness, disaster awareness, perception of roles and responsibilities, preparedness actions, and access to information. Furthermore, Ostadtaghizadeh et al. (2016) assessed community resilience in Iran by employing indicators that include the ability to pinpoint disaster-risk zones, collaboration and networking among all relevant parties, governmental legal and institutional backing, as well as disaster management strategies. The community preparedness assessment framework provides a

Table 1. An overview of community preparedness assessment measures

Disaster	Location	Methods	Preparedness tools/ indicators	Audience	Sources
Tsunami	Oregon; Washington (US)	Interview with	emergency response preparedness and risk communication	Community	Lindell et al. (2009)
Tsunami	Kedah (Malaysia)	survey questionnaire, interviews, documents analysis and field observations	communicating information on disaster and level of preparedness	Coastal Community	Zahari et al. (2013)
Earthquake and tsunami	Palu; Gorontalo (Indonesia)	Focus Group Discussions and interviews	prevention/mitigation, preparedness, response, recovery, business plan, disaster preparedness, workforce, and relation with government	Hotel manager	Ismiyati and Lestari (2020)
All disaster	South Korea	Online survey	Interpersonal factors (general characteristics, prior disaster experience, anxiety, dispositional optimism, perceived disaster risk, and disaster preparedness knowledge), institutional factor (front-line preparedness), community factor (community resilience), public policy factor (governmental preparedness)	Household	Kim and Kim (2022)
Earthquake	Auckland (New Zealand)	Survey questionnaire	Perception of Roles and Responsibilities; Understanding of Preparedness and Disaster Awareness; Preparedness Actions and Access to Information	Household	Raneses et al. (2018)
Dam Disaster	Cameroon	Survey questionnaire	community awareness, and community preparedness	Community	Muda et al. (2021)

comprehensive overview of a community's capacity to anticipate, respond to, and recover from natural hazards, along with its involvement in post-disaster recovery and early recovery initiatives (Fatoni et al., 2022).

Moreover, the implementation of community preparedness assessments has been conducted by numerous individuals in different areas (Table 1). According to this table, various studies were conducted addressing different disasters, employing diverse methods and tools, and targeting specific audiences. Nonetheless, individuals and households serve a crucial function as the focal point and catalyst of preparedness, which has a direct effect on disaster risk (Hidayati et al., 2011). The community preparedness assessment framework provides a comprehensive overview of the extent to which communities are prepared to anticipate, respond to, and recover from natural hazards, in addition to their involvement in post-disaster recovery and early recovery initiatives (Fatoni et al., 2022).

We recognize that preparedness must begin from the grassroots level, encompassing both individual and family preparedness as well as the surrounding environment at the village level (Lassa et al., 2018). We have therefore developed a framework designed to evaluate community preparedness, which is anticipated to be utilized in various other regions. The parameters and their associated questions evaluate the knowledge and

attitudes of individuals and families regarding disasters, emergency preparedness, and early warning systems while also assessing the community's capacity to confront such events (Table 1, supplementary materials).

This framework presents a total of 48 questions aimed at achieving specific objectives. The parameters related to the knowledge and attitudes (KA) of individuals and families include 18 questions focusing on individual understanding of the causes and effects of disasters and climate change, comprehension of safe living locations in the face of disasters, and insights on self-protection from danger. Additionally, 13 inquiries within the emergency preparedness (EP) criteria highlight the preparedness of individuals and families in the event of a disaster. This includes the accessibility of evacuation maps, first aid supplies, essential emergency items (such as food, beverages, and response gear like tents, blankets, and flashlights), as well as maintaining a list of emergency contact numbers (including local government, police, military, search and rescue, hospitals, and fire services).

The subsequent parameters of the early warning system (WS) within the family, comprising 4 questions, emphasize the accessibility of systems and methods for sharing disaster information among family members. In the meantime, 13 inquiries regarding the community capacity (CC) assessment parameters highlight the presence of a disaster management system at the local level (neighbourhood or village). This includes the existence of evacuation maps, early warning systems, designated evacuation routes and symbols, temporary refugee camps, community-level simulations and training, as well as a transparent information dissemination system within the community.

2.3. Data collection method

This investigation employed an exploratory qualitative methodology, drawing on primary data sources. The sample size of respondents representing households was determined using the Slovin formula:

$$n = \frac{N}{1 + N\,(e^2)}$$

N = Total Population
n = Sample size
e^2= margin of error

With a 95% confidence level and a 10% margin of error, resulting in a minimum required sample size of 782. The breakdown is as follows: North Ternate District (163 respondents), Central Ternate District (166 respondents), South Ternate District (340 participants), and West Ternate District and Ternate Island District (54 and 59 participants, respectively).

The procedure for collecting data for the community preparedness assessment involved utilizing an online survey that employed a snowball sampling method. An online survey was selected for its adaptability, rapid execution, relevance, and straightforward process of gathering a substantial

sample (Evans & Mathur, 2005). The survey link was disseminated through the group's social media channels and then further shared with additional participants. Individuals who accessed the survey link were required to review the information detailing the purpose, procedure, and benefits of participation, along with the contact details and consent form, before proceeding with the survey. Only those participants who voluntarily expressed their written consent by choosing "I agree" were allowed to continue with the online questionnaire. To align with the research objectives, participants for assessing community preparedness were chosen through a snowball sampling method. Participants should be adults (aged 18 and above) residing in Ternate, with everyone representing one household and consenting to fill out the questionnaire.

The completion of the survey took approximately 10 to 15 minutes. Participants were directed to respond to every question; a "yes" answer was assigned a score of 1, whereas a "no" answer was assigned a score of 0. Individuals who indicated "Yes" are regarded as "prepared," while those who responded "No" are considered "not prepared." The greater the number of respondents who affirmatively respond, the more equipped they will be, and conversely (Adiyoso & Kanegae, 2018).

2.4. Data analysis

First, we evaluated variations in individual/household preparedness across sub-districts on Ternate Island to comprehend the influencing factors. The items from each response to the preparedness questionnaire were aggregated. Household preparedness can be calculated from the cumulative value for each participant, based on three components that constitute household preparedness: the knowledge and attitude component (KA), the emergency response plan (EP), and the early warning system (WS). However, the community preparedness value is calculated from the total community capacity component (CC).

Subsequently, we employed Welch's test and Games-Howell post-hoc analysis to examine potential differences in household and community preparedness across sub-districts and various sociodemographic variables. Additionally, we applied multinomial logistic regression analysis to explore the relationship model between sociodemographic variables and community preparedness. By employing multinomial logistic regression, we analyse the nominal outcome variable to identify influential factors, enabling us to understand, explain, and predict them effectively. These factors, or independent variables, influence the degree of community preparedness. Therefore, we create the code for all parameters. The community preparedness variable (independent) is classified as almost ready (Y_1) and ready (Y_2). The independent variables involve gender parameters for men (X_{11}) and women (X_{12}). Additionally, the age parameters are defined as follows: under 20 years (X_{21}), between 20 and 40 years (Y_{22}), and over 40 years (Y_{23}). Parameters for education levels include junior school (X_{31}),

senior school (X_{32}), bachelor (X_{33}), master (X_{34}), and doctor (X_{35}). Marital status categories are classified as unmarried (X_{41}) and married (X_{42}). For occupation parameters, students (X_{51}), civil servants/officers (X_{52}), self-employed individuals (X_{53}), housewives (X_{54}), and others (X_{55}). Additionally, the parameters for length of stay in Ternate are as follows: less than 5 years (X_{61}), between 5 and 10 years (X_{62}), between 10 and 20 years (X_{63}), and more than 20 years (X_{64}). All the analyses were conducted using SPSS 29 software.

3. Results

3.1. Respondents' characteristics

A total of 782 island inhabitants participated in our survey. The sample was slightly skewed towards women, with 55% of the respondents being female and 45% male (Table 2). According to the sub-districts, most respondents (43%) were from South Ternate, followed by 21% from Central Ternate, 21% from North Ternate, 7% from West Ternate, and 8% from Pulau Ternate. The majority of respondents (51%) were between 20 and 40, while those older than 40 accounted for 27%, and the rest were 22%. In terms of highest education levels, 73% of respondents completed a college or university degree, while 26% completed high school and 1% attended junior high school. More than half of the respondents (53%) were married, and nearly half (46%) have lived on the island for more than 20 years. A quarter have been living on the island for 10 to 20 years, 10% for 5 to 10 years, and 20% for less than 5 years.

3.2. Households' Preparedness to deal with natural hazards

Household preparedness was assessed based on parameters regarding knowledge and attitudes, emergency preparedness, and warning systems. The mean values and standard deviations of the "Yes" responses provided by participants reflect household preparedness, as presented in Table 3.

The knowledge and attitude parameter assesses an individual's understanding of various disaster types, recognizing residential areas vulnerable to natural hazards, and being aware that their locality is susceptible to hazards. Moreover, they have an understanding of how to protect themselves from natural hazards and recognize the potential for disasters to inflict damage and pose risks to human safety. The results indicate that, for the parameters of knowledge and attitude, respondents from the West Ternate sub-district show the highest mean value of 14.78, followed closely by respondents from the Pulau Ternate sub-district at 14.64. In contrast, the North Ternate sub-district records the lowest mean value at 13.80.

Additionally, regarding the emergency preparedness parameters at the household level, respondents indicated the highest mean value in the Central Ternate sub-district at 7.95, followed by the North Ternate sub-district at 7.26, with the lowest recorded in the West Ternate sub-district at 6.65. This suggests that individuals in this region are adequately equipped to distribute

Table 2. Respondents' characteristics in all sub-districts

Respondents Characteristics	Sub-districts					N	%
	North Ternate	Central Ternate	South Ternate	West Ternate	Pulau Ternate		
Gender							
Male	81	64	156	23	26	350	44.8
Female	82	102	184	31	33	432	55.2
Age (Years)							
< 20	34	42	79	9	9	173	22.1
20 - 40	85	80	166	29	37	397	50.8
> 40	44	44	95	16	13	212	27.1
Education level							
Junior high school or less	1	1	3	4	1	10	1.3
Senior high school	39	60	64	24	18	205	26.2
Bachelor's degree	98	70	186	23	31	408	52.2
Master's degree	20	30	62	2	8	122	15.5
Doctor's degree	5	5	25	1	1	37	4.7
Occupation							
Students	40	47	122	10	26	245	31.3
Civil servant/military	50	55	105	15	3	228	29.2
Self-employed	25	14	23	8	5	75	9.6
Housewives	8	23	24	14	12	81	10.4
Others	40	27	66	7	13	153	19.5
Marital status							
Unmarried	74	76	179	13	25	367	46.9
Married	89	90	161	41	34	415	53.1
Long stay in Ternate (Years)							
<5	22	16	98	3	12	151	19.3
5 - 10	8	20	36	5	6	75	9.6
10 - 20	41	45	80	14	17	197	25.2
> 20	92	85	126	32	24	359	45.9

tasks among family members during rescue efforts in emergencies and have essential emergency items (such as food, beverages, and response gear like tents, blankets, and flashlights). Several family members have engaged in first aid training for accidents, possess communication tools for the family, have emergency response equipment, prepare disaster preparedness bags, and keep contacts that can be reached during an emergency.

In terms of the parameters of the warning system at the household level, respondents from the South Ternate sub-district recorded the highest mean value of 2.69. This was closely followed by respondents from the Pulau Ternate sub-district, with a mean value of 2.66. The lowest mean value was observed in the Central Ternate sub-district at 1.78. This indicates that households are equipped with an early warning system, have easy access to disaster information sources, and possess the capability to share disaster information among family members.

3.3. Community capacity to deal with natural hazards

The community capacity assessment parameter emphasizes the capabilities of the disaster management system within local contexts, such as neighbourhoods or villages. This parameter facilitates thorough preparedness,

Table 3. Results of the analysis of the mean and standard deviation of respondents' answers regarding community preparedness

Parameters	Sub-districts	N	Mean	SD
Knowledge and Attitude	North Ternate	163	13.80	2.49
	Central Ternate	166	14.50	1.73
	South Ternate	339	14.51	1.83
	West Ternate	54	14.78	1.94
	Pulau Ternate	59	14.64	1.56
Emergency preparedness	North Ternate	163	7.26	2.81
	Central Ternate	166	7.95	2.99
	South Ternate	339	7.06	3.09
	West Ternate	54	6.65	2.72
	Pulau Ternate	59	7.17	2.86
Warning system	North Ternate	163	2.19	1.09
	Central Ternate	166	1.78	0.99
	South Ternate	339	2.69	1.18
	West Ternate	54	2.44	1.28
	Pulau Ternate	59	2.66	1.10
Community capacity	North Ternate	163	5.98	3.20
	Central Ternate	166	4.84	4.17
	South Ternate	339	5.06	3.36
	West Ternate	54	7.00	2.88
	Pulau Ternate	59	5.85	3.31

encompassing the availability of evacuation maps, early warning systems, designated evacuation routes and symbols, temporary refugee camps, community-level simulations and training, and a disaster information dissemination system within the community.

Community capacity reflects the strength of social capital and local institutions. West Ternate stands out with the highest mean score (7.00; SD = 2.88), indicating that communal ties, the spirit of mutual cooperation (*gotong royong*), and local organizational involvement are robust, thereby supporting regional resilience. Conversely, Central Ternate recorded the lowest mean score (4.84) along with the highest data variability (SD = 4.17). This substantial standard deviation points to extreme disparities in capacity within Central Ternate; some community groups may possess immense capacity, while others remain highly vulnerable or indifferent.

3.4. The correlation between preparedness and the respondents' sociodemographic characteristics

Table 4 illustrates the variation in the average value for household and community preparedness as influenced by the sociodemographic characteristics of the participants. In the analysis of the gender variable, it was observed that men exhibited elevated values across the parameters KA and EP in the North Ternate, West Ternate, and Ternate Island sub-districts. Statistically, there is no significant difference; women demonstrated values for all parameters KA, EP, and WS within the Central Ternate sub-district. Additionally, the age variable revealed elevated values for the cohort under 20

years in the Central Ternate, South Ternate, and West Ternate sub-districts. Conversely, individuals aged 40-60 years exhibited elevated values in the Ternate Island sub-district.

Concerning the marital status variable, the unmarried respondents exhibited elevated values across nearly all parameters in every sub-district, except for the knowledge and attitude parameters, where married respondents demonstrated greater preparedness. The analysis of the occupation variable revealed that self-employed individuals and housewives exhibited elevated values across nearly all parameters. One of our interesting findings is that civil servants' preparedness scores are lower than those of self-employed workers or housewives. This is based on the cumulative results of all parameters: KA, EP, WS, and CC. However, upon closer examination, only the WS parameter contributes to this low score, and other occupations also show low scores on several factors. Subsequently, regarding the variable length of residence in Ternate, respondents who have lived there for over 20 years exhibit elevated preparedness values in Central Ternate District, South Ternate District, and Ternate Island District. In the North Ternate District and West Ternate District, respondents with a 5 to 10-year residency demonstrate a significant level of preparedness.

The results from the multinomial logistic regression analysis (Table 2 in the supplementary materials) demonstrate that the regression model is a good fit for the data, as shown by the significant model fitting information value of <0.001 (<0.05). The value suggests that sociodemographic variables can enhance the accuracy of predicting community preparedness. Additionally, the Goodness of Fit value indicates a significance level greater (0.155) than 0.05, suggesting that the regression model aligns well with the observed data. The findings from the pseudo-R-square analysis indicate that 7% of sociodemographic variables impact community preparedness, although there are additional influences from other variables that were not considered in this study.

After confirming the overall validity of the model, the unique contribution of each demographic characteristic to the model was evaluated using Likelihood Ratio Tests. The results of the partial tests (independent effects) indicate that not all demographic characteristics possess equal strength in influencing or determining respondents' choices regarding the dependent variable. Of the six variables tested, three were found to have a statistically significant influence ($p < 0.05$): First, education (X3): This variable made the strongest contribution to the model, with a Chi-Square value of 15.0126 and a significance value (Sig.) of 0.004. This indicates that differences in the highest level of education attained significantly differentiate respondents' tendencies or decision-making patterns regarding the dependent variable. Second, occupation (X5): The occupation variable yielded a Chi-Square value of 10.686 and a significance value of 0.030. This suggests that the respondents' economic activity or daily profession significantly impacts the model structure. Third, length of residence (X6): The variable representing

Table 4. Mean differences analysis for household and community preparedness by sub-districts and sociodemographic respondents

	North Ternate sub-district					Central Ternate sub-district					South Ternate sub-district					West Ternate sub-district					Pulau Ternate	
	N	KA	EP	WS	CC	N	KA	EP	WS	CC	N	KA	EP	WS	CC	N	KA	EP	WS	CC	N	KA	E
All sample	163	13.80	7.26	2.19	5.98	166	14.50	7.95	1.78	4.84	339	14.51	7.06	2.69	5.06	54	14.78	6.65	2.44	7.00	59	14.64	7.
Female	50.3%	13.72	7.10	2.23	5.78	61.4%	14.57	8.25	1.86	5.45	54.3%	14.47	7.05	2.79	5.15	57.4%	14.52	5.45	2.26	6.65	55.9%	14.52	7.
Male	49.7%	13.89	7.43	2.06	6.17	38.6%	14.39	7.45	1.64	3.88	45.7%	14.57	7.08	2.57	4.95	42.6%	15.13	8.26	2.70	7.48	44.1%	14.81	7.
<20	20.9%	13.56	6.94	2.24	6.97	25.9%	14.77	8.58	2.05	6.30	23.3%	14.38	7.56	2.89	6.11	16.7%	14.33	7.44	2.78	8.11	13.6%	13.88	6.
20 - 40	53.4%	13.95	7.08	2.16	5.97	47.6%	14.35	7.65	1.75	4.44	49.0%	14.57	6.89	2.69	5.16	53.7%	15.10	6.17	2.24	7.34	62.7%	14.68	6.
40 - 60	25.8%	13.69	7.90	2.21	5.19	26.5%	14.50	7.86	1.57	4.14	27.7%	14.53	6.97	2.52	3.99	29.6%	14.44	7.06	2.08	5.75	23.7%	15.00	8.
Junior high school	0.6%	0.00	0.00	0.00	0.00	0.6%	0.00	0.00	0.00	0.00	0.9%	13.33	4.67	1.33	5.33	7.4%	15.75	5.25	2.25	5.75	1.7%	0.00	0.
Senior high school	23.9%	13.18	6.72	2.13	6.36	36.1%	14.57	8.35	1.93	4.97	18.9%	14.48	6.52	2.66	4.75	44.4%	14.63	6.17	2.42	6.46	30.5%	14.56	6.
Bachelor's degree	60.1%	14.13	7.47	2.22	6.13	42.2%	14.53	8.11	1.84	4.87	54.9%	14.47	7.33	2.72	5.72	42.6%	14.70	6.91	2.43	7.70	52.5%	14.68	7.
Master's degree	12.3%	13.35	7.00	2.15	4.65	18.1%	14.47	7.20	1.40	5.03	18.0%	14.67	7.11	2.75	4.08	3.7%	15.00	11.00	3.00	7.00	13.6%	14.75	7.
Doctor's degree	3.1%	14.00	8.40	1.80	5.00	3.0%	13.60	6.00	1.20	2.40	7.4%	14.68	6.68	2.60	3.24	1.9%					1.7%		
Unmarried	45.4%	13.72	7.23	2.34	6.95	45.8%	14.37	7.96	1.89	5.34	52.8%	14.54	6.96	2.78	5.69	24.1%	14.38	7.62	3.00	8.69	42.4%	14.68	6.
Married	54.6%	13.88	7.29	2.07	5.46	54.2%	14.61	7.93	1.68	4.42	47.2%	14.48	7.18	2.59	4.34	75.9%	14.90	6.34	2.27	6.46	57.6%	14.62	7.
Student	24.5%	13.60	6.88	2.20	6.68	28.3%	14.47	8.15	2.00	5.43	36.0%	14.43	6.89	2.79	5.43	18.5%	13.70	7.80	2.80	8.30	44.1%	14.96	7.
Civil servant/ officer	30.7%	13.68	7.34	2.28	4.48	33.1%	14.56	7.33	1.42	4.29	30.7%	14.53	6.91	2.67	3.72	27.8%	14.40	7.27	2.27	5.93	5.1%	14.67	9.
Self-employee	15.3%	14.72	7.16	1.48	6.12	8.4%	14.00	7.50	1.93	6.29	6.8%	14.35	7.78	1.93	4.78	14.8%	14.50	6.38	2.75	7.63	8.5%	14.80	9.
Housewife	4.9%	12.50	5.88	2.50	5.25	13.9%	15.00	9.78	2.13	5.52	7.1%	14.42	6.42	2.29	4.79	25.9%	14.57	4.86	1.93	6.14	20.3%	14.50	6.
Others	24.5%	13.85	7.90	2.45	6.75	16.3%	14.26	7.52	1.74	3.63	19.5%	14.73	7.61	2.76	6.33	13.0%	15.57	7.57	2.47	8.43	22.0%	14.08	6.
<5	13.5%	13.45	7.05	2.27	7.59	9.6%	14.19	7.81	1.75	6.69	28.6%	14.45	6.93	2.75	6.12	5.6%	13.67	7.33	3.33	7.67	20.3%	14.42	7.
5-10	4.9%	12.50	8.13	2.25	8.00	12.0%	14.35	6.20	1.70	4.05	10.6%	14.03	6.94	2.97	5.25	9.3%	13.20	8.20	2.60	9.20	10.2%	14.83	5.
10-20	25.2%	14.00	7.80	2.05	6.49	27.1%	14.53	7.84	1.78	4.47	23.6%	14.59	6.80	2.51	4.34	25.9%	16.07	6.43	2.36	6.71	28.8%	14.76	5.
>20	56.4%	13.91	7.00	2.23	5.18	51.2%	14.58	8.44	1.80	4.88	37.2%	14.65	7.37	2.67	4.63	59.3%	14.56	6.44	2.38	6.72	40.7%	14.63	8.

the duration of residence in the area showed a Chi-Square value of 7.582 and a significance value of 0.045. Spatial experience—or the length of the respondent's interaction with their living environment—was shown to significantly shape the decisions within the model. Conversely, the other three variables—Gender (X1) (p = 0.711), Marital Status (X4) (p = 0.767), and Age (X2) (p = 0.071)—did not exert a significant influence, as their significance values exceeded the 0.05 threshold. Regarding the Age variable (X2) specifically, although it showed a trend approaching the significance threshold (p = 0.071), at a 95% confidence level, it was concluded that this variable did not yet make a strong independent contribution to the model.

Meanwhile, according to the analysis results presented in the parameter estimates table (Table 3 in the supplementary materials), occupations are also correlated with community preparedness, along with education and length of stay in Ternate. Therefore, the multinomial logistic regression model developed in this study relies heavily on the factors of education, occupation, and length of residence. Biological characteristics (gender) and life-cycle factors (age and marital status) are not primary determinants of the respondents' decisions. Thus, the regression models that have been developed are:

$$\ln \ln \left(\frac{y2}{y1}\right) = -0.888 - 0.655X_{33} + 0.606\,X_{52} - 0.464X_{53} + 0.670X_{62} + 0.428X_{63}$$

4. Discussion

This investigation seeks to evaluate the extent of preparedness layered at (1) household and (2) community levels for different natural hazards across five out of seven sub-districts on Ternate Island. As a small island, Ternate faces various disaster threats and has a high vulnerability. According to Chikmawati (2013; Riyas et al., 2020), small islands face significant vulnerability to natural disasters and the impacts of climate change. Land on small islands is at risk of loss due to sea level rise, coastal erosion, and flooding (Ortega et al., 2023). The findings indicate variations in disaster preparedness according to the assessed preparedness parameters. Residents of the West Ternate Island perceive themselves as having greater knowledge and attitudes regarding disasters and community capacity. In contrast, residents of the Central Ternate Sub-district exhibit higher preparedness concerning emergency preparedness parameters, while those in the South Ternate Sub-district demonstrate superior preparedness in terms of warning systems. The findings of the study indicate notable disparities in preparedness influenced by various socio-demographic factors.

4.1. Parameters that influence household preparedness

The parameters of knowledge and attitude play a crucial role in community preparedness. Patrisina et al. (2018) emphasize that understanding individuals residing in disaster-prone regions is the primary focus for stakeholders, ensuring that these individuals are informed and

aware of potential disasters. For instance, as many as 99% of participants indicated that they were aware of the location of their homes that were susceptible to volcanic hazards. Similarly, 99% of participants recognized that in order to protect themselves from a tsunami, they needed to seek higher ground. Previous studies (Muda et al., 2021) indicated that increased public awareness regarding disaster preparedness can facilitate individuals in taking necessary preparatory measures. Tekeli-Yesil et al. (2010) found that the community's solid understanding of the potential consequences of an earthquake in Istanbul enabled them to estimate the damage and prepare for accessibility in the event of such a disaster.

Conversely, the minimum value recorded (30%) emerged from the responses regarding whether participants had ever engaged in simulations related to tsunamis, earthquakes, and volcanoes within their families. This suggests that while the community is aware of how to prevent danger, it is infrequently implemented at the family level. In this context, Yenni et al. (2017) proposed that to preserve local knowledge and enhance community preparedness, it is essential to incorporate emergency training and early warning information to refine emergency plans and facilitate proactive measures. Pascapurnama et al. (2018) emphasized that the knowledge gained about disasters should be integrated into everyday life situations. As noted by Kim and Kim (2022), while relevant knowledge can aid in disaster preparation, developing and implementing an action plan is essential.

Regarding emergency preparedness, community feedback indicates that over 50% recognize the importance of having emergency response equipment readily available, including first aid kits, communication devices, lighting equipment, and disaster preparedness bags. The presence of emergency response equipment significantly aids the community during critical response situations (Maghelal & Arlikatti, 2025; Martins et al., 2019). Moreover, Canavire-Bacarreza et al. (2024) state that when the community in Haiti is equipped with adequate emergency supplies, households are likely to demonstrate sufficient or very good preparedness for disasters. Furthermore, other the response indicating a value exceeding 50% for the emergency preparedness parameter was derived from inquiries regarding the availability of a contact person's number for communication during a disaster, along with the accessibility of essential facilities such as hospitals, fire stations, and police stations. Having these contact numbers will make it easier for people to report disasters and requests for assistance during such events. Kusumastuti et al. (2021) indicate that the government possesses the access and authority to mobilize various resources, including military, police, SAR teams, and volunteers, as well as public facilities, to aid in disaster emergency response. Furthermore, Islam and Walkerden (2015) emphasize that collaboration and coordination with governmental agencies and NGOs can enhance community preparedness, as these organizations possess the necessary resources to offer support during times of disaster.

Moreover, this research indicated that the low value of emergency preparedness parameters can be attributed to the lack of task division among family members during rescue actions in disaster emergencies, the absence of an evacuation plan, and a designated temporary gathering place for the family during a disaster. Additionally, the household has not prepared disaster equipment such as ready-to-eat food, tents, and blankets. Kapucu (2012) similarly discovered in his study of Central Florida households that although 61% of respondents viewed themselves as quite prepared for a hurricane, merely half of the participants had a hurricane evacuation plan, and only 8% possessed disaster supplies, including food, water, and medicine for three days. In contrast, Adiyoso and Kanegae (2018) observed that individuals in Kushimoto exhibited enhanced preparedness at the family level as they engaged in discussions about hazard maps and tsunami evacuation strategies with their family members. Furthermore, developing a route or map for family evacuation is essential, as confusion often arises as a predominant reaction during a disaster. Ultimately, by determining a clear evacuation route, family members can create a safe pathway to the assigned gathering point (Syamsidik et al., 2021).

Regarding the parameters of the disaster warning system, over 60%-83% of participants indicated that they found it easy to access information sources related to disasters and to share this information with all family members. The low value of this parameter (24%) suggests a lack of an early warning system within the family. The availability of affordable internet, radio, and television options in every village on Ternate Island facilitates the accessibility of this information. Syamsidik et al. (2020) highlight that the insufficient frequency of information dissemination regarding the nature and impact of tsunamis hinders individuals' ability to prepare personally, as well as the preparedness of their communities in response to a potential tsunami event. The findings from Ebhuoma et al. (2024) in Durban, South Africa, indicate that information technology, including radio, television, and social media platforms, is essential for enhancing effective flood preparation information. This technology enables individuals to safeguard their important assets and allows sufficient time for making informed decisions regarding temporary relocation.

4.2. Indicators that influence community preparedness

In terms of community preparation, over 50% of respondents indicated that their area had a volcanic evacuation map, and that the community was aware of the evacuation signs. Additionally, disaster information was effectively disseminated within the community through available information media. In contrast, fewer than 50% of respondents indicated that their residential area lacked an emergency response plan, which includes an evacuation map for tsunamis and floods. Additionally, they had not identified a temporary evacuation site and an unavailable disaster information board or early warning system at the community (village) level. Canavire-Bacarreza et al. (2024) demonstrated similar findings, indicating that the majority of

households in Haiti reside in communities characterized by inadequate levels of communal preparedness, lacking both evacuation routes and emergency shelters. According to Afrida and Manawanui (2018), the emergency response plan is designed to facilitate swift and efficient action by incorporating and taking into account the disaster management system in the region while also tailoring it to local circumstances. Kusumastuti et al. (2021) emphasized the importance of a disaster management plan, which is essential for guiding actions throughout the pre-disaster, emergency response, and post-disaster phases.

It is also important to note the feedback regarding the lack of regular evacuation drills conducted at the community level. Chen et al. (2022) state that evacuation drills serve as a training tool for at-risk communities, utilizing planned scenarios that replicate actual hazardous situations. The objective is to guarantee that the community is capable of implementing evacuation instructions obtained from brochures, lectures, videos, various media, or past experiences.

4.3. Differences in household preparedness by sociodemographic variables

The findings of this study reveal that men demonstrate greater preparedness than women across various sub-districts within the study area, indicating inequality of access to information shaped by gender. ISDR (2009) indicates that in certain situations, women in rural households encounter greater difficulties in managing disasters due to their responsibilities as caregivers, restricted access to resources, discrimination in the labour market, and specific cultural limitations that present challenges for them. This assertion is corroborated by Bali (2022), indicating that women face heightened vulnerability during emergencies due to limited access to resources, diminished decision-making authority within the family, and reduced awareness stemming from low literacy levels. Nonetheless, these findings challenge earlier research that suggests gender plays a role in risk perception, as it has been indicated that women tend to perceive a higher risk from potential disaster threats than men, leading to increased preparedness (Kohn et al., 2012).

The study results indicate no variation in preparedness levels according to the respondents' age. This finding is consistent with Inal et al. (2019), suggesting that age does not significantly correlate with disaster preparedness in Turkey. The survey findings revealed that the younger demographic exhibited a notable level of preparedness across different sub-districts on Ternate Island. This is possible because of easy internet access at the study location, so that information about disasters is easy to access, and the level of education of respondents, who generally have attended school. This finding contrasts with many previous studies. This finding diverges from several previous studies. For instance, Cisternas et al. (2024) indicated that among different age groups, both the older and younger demographics reported

the lowest levels of preparedness. Kim and Kim (2022) discovered that participants aged 60–69 years demonstrated significantly elevated levels of household disaster preparedness. Cornell et al. (2012) indicate that older adults exhibit heightened vulnerability to disasters, attributable to health conditions, diminished mobility, impaired sensory awareness, and social and economic constraints. Therefore, Howard et al. (2015) assert that the inclusion of older individuals in emergency response planning and preparedness strategies is crucial, as their experience greatly improves community preparedness. Personal experiences enhance preparedness and safety during disasters, as individuals acquire knowledge from their parents and the community (Martins et al., 2019; Onuma et al., 2017; Yenni et al., 2017).

The analysis result demonstrates that educational attainment does not influence community preparedness at the study location. This finding contrasts with Kohn et al. (2012), which suggests that individuals with heightened awareness of disaster threats, typically those with higher education, are better prepared to manage such events. Similarly, Canavire-Bacarreza et al. (2024) found that 61% of households in Haiti with limited education experience considerable vulnerability to disasters. Within the research site, despite limited educational attainment, the presence of the internet and other informational resources allows the community to maintain an up-to-date understanding of disasters. The respondent conveyed that access to the internet, radio, television, and social media facilitated the acquisition of disaster information. Canavire-Bacarreza et al. (2024) explain that community access to the internet can enhance preparedness for natural hazards by 14 percentage points. Pelupessy and Silverman (2024) support this, indicating that the actions taken by all respondents in this study were shaped by indirect learning from the experiences of others across various islands in Indonesia, facilitated through social media. Moreover, concerning marital status, the analysis indicated that it did not affect preparedness; however, marital status was identified as a significant factor in the formulation of a family preparedness plan. The findings indicated that individuals who were unmarried demonstrated a higher level of preparedness compared to their married counterparts. This finding contradicts the assertion by Kohn et al. (2012) that married individuals exhibit a greater propensity for planning to address hazards compared to their unmarried counterparts. The presence of children as a burden in the household influences the development of family emergency plans.

The examination of the occupation variable indicated no influence on household and community disaster preparedness in the study area. The findings diverge from the research conducted by Inal et al. (2019) which suggested that individuals with higher monthly incomes, improved employment status, and emergency/disaster education demonstrated enhanced disaster preparedness. Numerous studies suggest that income positively influences individuals' preparedness activities by equipping

communities with essential resources for actions such as food storage, water security, first aid supply acquisition, and disaster insurance procurement (Cisternas et al., 2024; Martins et al., 2019; Onuma et al., 2017).

The analysis results demonstrate that the length of stay on Ternate Island significantly influences community preparedness at the study site. The data revealed that 56% of respondents had lived in Ternate for more than 20 years. This finding is consistent with the report by Pamungkas et al. (2023), which indicates that respondents' length of stay in the Cisarua area, primarily exceeding 10-20 years, significantly influences disaster preparedness. Their experience in managing occasional disasters provides a valuable lesson, allowing for anticipation and vigilance regarding future events.

4.4. The relationship between preparedness and social vulnerability variables

Vulnerability and preparedness share a dynamic, inverse relationship, wherein higher levels of preparedness can reduce vulnerability; however, existing structural and social vulnerabilities often hinder communities from achieving adequate levels of preparedness (Rao et al., 2022). According to the general consensus within the social vulnerability research community, several key factors influence social vulnerability. Widely recognized factors include age, gender, race, and socioeconomic status (Maharani, 2020). Variables or indicators are typically employed to assess vulnerability, highlighting the susceptibility of communities and systems to specific risks. Due to limitations in this study—such as data availability, time constraints, and resource limitations—the analysis of social vulnerability utilizes a total of six variables that collectively represent the local context of the case study area.

Based on regression analysis, three social vulnerability variables contributing to community preparedness are education level, occupation, and length of residence. Research conducted by Hoffmann and Muttarak (2017) in the Philippines and Thailand found that education levels enhance disaster preparedness through abstract reasoning and anticipatory capabilities; consequently, individuals with higher levels of education can take preventive measures without first having to experience—and subsequently learn from—a hazardous event.

Occupation also contributes to preparedness. According to Descatha et al. (2017), the relationship between occupation and preparedness demonstrates that an individual's type of work determines the level of emergency training, safety resources, and institutional planning available to them. The majority of respondents in this study were students and civil servants—groups that typically hold at least a bachelor's degree—suggesting they possess a solid understanding of disaster-related issues.

5. Conclusion and Future Work

This study analyses the preparedness levels of individuals, households, and communities in five sub-districts of Ternate Island concerning multi-hazard threats. This study employs knowledge and attitude, emergency preparedness,

and warning systems to assess individual and household preparedness, alongside community capacity to evaluate overall community preparedness. The study's findings identified several gaps that necessitate attention from decision-makers and planners to improve community preparedness for regional resilience. Enhancing community understanding and perspectives is an area that necessitates attention. The study's results indicate that this parameter significantly enhances preparedness; however, it is essential to continue strengthening disaster knowledge to ensure a uniform understanding of disasters among all individuals. The government should improve disaster knowledge by incorporating it into educational curricula across all levels, from elementary to higher education. The second gap relates to the preparedness of individuals and households in the face of a disaster, as many lack essential items, including first aid kits, family communication tools, emergency response equipment, disaster preparedness bags, and reliable emergency contacts. To achieve this, it is essential for the government and all stakeholders to implement regular socialization and dissemination initiatives that engage all communities.

A significant gap identified is the absence of an early warning system at the family and community (village) levels. Currently, families and villages do not possess an adequate early warning system. The final gap identified is the inadequate capacity within the community concerning the availability of evacuation maps and signage for diverse disaster scenarios. Furthermore, regular exercises and simulations must be conducted in all sub-districts.

The study's findings suggest that preparedness begins at the individual and family level and subsequently extends to the community, thereby contributing to the development of a resilient community. The interaction between individuals and communities during the disaster preparedness process significantly affects household disaster preparedness. Disasters are managed through a systematic framework encompassing prevention, preparation, response, and recovery. This process requires collaboration among governmental entities, local communities, and informal participants (Cisternas et al., 2024; Kim & Kim, 2022). Residents of the community are central to disaster management efforts and actively participate in shaping the effectiveness of these initiatives by interacting with governmental administration and policies within the changing context of disaster management (Ebhuoma et al., 2024). In summary, the effectiveness of preparation and response measures implemented by the government, organizations, and communities will improve household and community disaster preparedness. Recognizing that small islands have a number of limitations and because of political distance, strengthening community capacity, by utilizing social media or other means, can become an internal strength. Therefore, it is recommended that further assessments of the government's preparedness and the involvement of all parties in disaster

management be conducted in future efforts. This aims to collect information on initiatives and strategies from governmental and relevant stakeholders that have been executed or are currently in the planning phase.

CRediT authorship contribution statement

Conceptualization: Mohamamd Ridwan Lessy (Lead). Investigation: Mohamamd Ridwan Lessy (Lead). Data curation: Mohamamd Ridwan Lessy (Equal). Methodology: Mohamamd Ridwan Lessy (Equal). Software: Mohamamd Ridwan Lessy (Lead). Writing – original draft: Mohamamd Ridwan Lessy (Equal). Project administration: Jonatan Lassa (Lead). Resources: Jonatan Lassa (Supporting), Kerstin Zander (Supporting). Supervision: Jonatan Lassa (Equal), Kerstin Zander (Equal). Validation: Jonatan Lassa (Lead), Kerstin Zander (Equal). Writing – review & editing: Jonatan Lassa (Lead), Kerstin Zander (Equal).

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Statement

The study was conducted in accordance with the Declaration of Human Research Ethics Committee, Research Integrity and Ethics, Research and Innovation, Charles Darwin University (Protocol code H23043/June 29, 2023) and a research recommendation letter from the Ternate City government No 070/470/BKBP/2023.

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Supplementary Materials

Supplementary Materials

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