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Community Resilience in Times of Disaster; Technology Utilisation Models and Communication Patterns

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ABSTRACT

This study examines the role of Information and Communication Technology (ICT) in strengthening community preparedness and resilience against natural disasters, specifically in the tsunami-prone regions of Sulawesi Island. ICT can serve as an effective tool for the dissemination of information and communication during disaster situations. The aim of this research is to explore how ICT can be utilized to build disaster mitigation awareness and improve community response during emergencies. The study employs a quantitative approach, gathering data through structured surveys involving 188 respondents from the City of Palu and Donggala Regency. The collected data were analyzed using statistical techniques to identify the relationship between ICT utilization and community resilience. The results indicate that ICT significantly contributes to raising public awareness about the importance of disaster mitigation and strengthens communication and coordination during emergencies. The findings suggest that communities with fast and accurate access to information through ICT are generally better prepared for disasters and can take swift and appropriate action. In conclusion, integrating ICT into disaster mitigation strategies is essential for fostering more resilient communities. The study recommends collaboration among communities, government agencies, and the private sector to fully leverage the potential of ICT in disaster mitigation efforts, along with the need for training programs to enhance technological literacy within the community.

Keywords: Information and Communication Technology (ICT); Community Resilience; Disaster Mitigation; Preparedness.

INTRODUCTION

This study investigates the extent to which authorities, such as local governments and relevant institutions, are involved in facilitating and supporting the use of Information and Communication Technology (ICT) in building community resilience to tsunamis on Sulawesi Island (Paulik et al., 2019). Factors such as policies, regulations, and adequate resource allocation can influence the engagement of authorities and institutions in effectively facilitating the use of ICT (Lin, 2019). The vulnerability of Sulawesi's population to natural disasters, particularly tsunamis, is a critical concern in disaster risk mitigation and management.

Sulawesi's topography makes the island highly susceptible to tsunami-related disasters due to its location along the edge of active tectonic plates and its extensive coastline. These geographical factors make Sulawesi vulnerable to tectonic earthquakes, which can trigger tsunamis with devastating consequences. Additionally, the high population density in coastal areas, coupled with low awareness of tsunami threats, increases the community's vulnerability to such disasters (Pfefferbaum et al., 2017).

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A series of tsunami events have impacted Sulawesi since 2005. In September 2005, a 7.6 magnitude earthquake struck the western coast of Sulawesi, triggering a tsunami. This was followed by a national disaster in September 2018, when a 7.5 magnitude earthquake hit Palu, Central Sulawesi, also resulting in a tsunami (Samad et al., 2020). The tsunami waves devastated coastal areas, causing widespread damage and loss of life. More recently, in January 2021, a 6.2 magnitude earthquake hit Mamuju, West Sulawesi, triggering a tsunami that affected the coastal regions of Mamuju and Majene, leading to infrastructure damage and casualties (Yolsal-Çevikbilen & Taymaz, 2019).

The concept of community resilience in the context of disasters can be explained through several relevant theories and concepts. One widely used concept is Community Resilience, which emphasizes a community's ability to confront, adapt to, and recover from disasters. Community resilience involves the capacity of communities to withstand stressors, such as natural disasters, while maintaining or restoring vital social, economic, and environmental functions (Uddin et al., 2020).

According to Vieweg et al. (2010), "Social media can enhance community communication during disasters and connect individuals to resources needed to cope with emergency situations." Mobile applications allow communities to access real-time information about disasters through geographic information systems, social media, and mobile technology. ICT can help communities access the necessary information, facilitate coordination and communication, and strengthen individual and group capacities to respond to disasters. Pathak (2019) revealed that "The use of ICT in disaster contexts can strengthen community resilience by providing quick and accurate information, enabling effective communication, and facilitating coordination and collaboration among various stakeholders."This issue examines the extent to which communities in Sulawesi Island have sufficient physical and digital access to ICT for building resilience against tsunamis. Factors such as limited or damaged telecommunications infrastructure, poor signal coverage, and restricted internet access can hinder the effective utilization of ICT (Pathak et al., 2019).

The use of ICT by the people of Sulawesi in responding to tsunami disasters plays a significant role in strengthening community resilience. Information and communication technologies, such as the use of social media, text messaging, and early warning systems, have become crucial tools in providing vital information and facilitating effective communication during emergencies (Paulik et al., 2019). Through the use of ICT, the people of Sulawesi can access the necessary information, communicate with relevant authorities, and take appropriate actions to enhance their resilience to tsunami disasters.In the context of tsunami disaster resilience and the use of ICT in Sulawesi, this research adopts four key concepts: (1) the utilization of ICT, (2) community resilience to tsunamis, (3) technological literacy among communities, and (4) community participation in the use of ICT.

The primary aim of this research is to investigate and understand the model of ICT utilization in building community resilience against tsunamis on Sulawesi Island. The study seeks to gain deeper insights into the role and benefits of ICT in strengthening community resilience and to identify the factors that influence the use of ICT in the context of tsunami disasters in the region (Abunyewah et al., 2020).

METHODOLOGY

This study employs a quantitative approach to explore the effectiveness of community resilience interventions in the context of natural disasters. Data will be collected through surveys and analyzed statistically to identify successful community resilience interventions in disaster contexts and to evaluate their effectiveness (As-syakur et al., 2013). The research aims to enhance awareness of the importance of disaster mitigation, focusing on the most effective interventions for improving disaster preparedness and facilitating recovery processes.

The study will also examine the influence of contextual factors such as socioeconomic status,

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geographic location, institutional frameworks, and cultural dynamics on the relationship between community resilience in disaster contexts and overall community resilience. By doing so, the research aims to provide data-driven recommendations for policymakers and practitioners involved in building more resilient communities in disaster-prone areas (Chen et al., 2019).

Data collect ion and analysis will be conducted numerically to test hypotheses and answer research questions (Danar & Pushpalal, 2014). This quantitative method is well-suited to the research problem, as it allows for the objective and measurable collection and analysis of relevant numerical data. Through this approach, the researchers aim to produce more accurate and reliable results, ultimately providing data-based recommendations to improve community resilience in disaster contexts and foster disaster-resilient communities (Comes et al., 2019).

The study will assess the effectiveness of community resilience interventions in building disaster-resilient communities. This method allows researchers to test hypotheses and answer research questions with a high level of objectivity. Data will be gathered through structured surveys and analyzed statistically to ensure accuracy and consistency in the findings. The research will conduct an in-depth assessment of relevant variables .

Surveys will be distributed in Palu City and Donggala Regency, which were heavily impacted by earthquakes and tsunamis, causing widespread damage to infrastructure and disrupting daily life. In response to these events, effective community resilience, robust disaster preparedness, and appropriate recovery measures are crucial for rapid and comprehensive recovery. Local governments have made efforts to improve emergency communication, expedite aid delivery, and provide disaster preparedness education and training.

A purposive sampling method will be used to select a sample from the population of Palu City and Donggala Regency. The population of this study is drawn from the 372,113 residents in these regions, according to 2020 data from the Central Statistics Agency (BPS) of Palu City and Donggala Regency. The purposive sampling method will allow for the collection of data from 188 respondents, with careful statistical calculations ensuring the desired level of accuracy.

Research Procedures

The data collection instruments, such as questionnaires or surveys, were carefully developed to ensure their validity and reliability. These instruments were pretested with a small group of respondents to identify and address any potential issues (Heeks & Ospina, 2019).

The questionnaire distribution was conducted using online forms, primarily through smartphones and the Google Forms platform. The process began with the creation of a questionnaire aligned with the research objectives. Once the form was finalized, the link was disseminated through various communication channels, allowing respondents to easily access it via their mobile devices. During the distribution phase, the researchers monitored incoming responses in real time. After the data collection period concluded, the responses were analyzed using built-in tools from Google Forms or exported to spreadsheet applications for further analysis. The advantages of using Google Forms and online questionnaires include the ease of creation, broad and rapid distribution, accessibility across multiple devices, and the ability to efficiently gather and analyze data. This approach saves both time and cost compared to traditional methods (Imperiale & Vanclay, 2021).

Distributing questionnaires via WhatsApp proved to be an effective option for reaching respondents in this study. The process involved sending messages to relevant contacts or discussion groups, including brief information about the research objectives and a request for participation. The message contained a link to the questionnaire, allowing respondents easy access. After the data collection period, the responses received through WhatsApp were gathered and analyzed according to the established procedures. Thus, distributing questionnaires via WhatsApp emerged as an efficient and effective method for collecting data from respondents in Palu City.SmartPLS 4 was utilized in this

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study to explore relationships between variables within the model with ease. Additionally, regular updates and support make SmartPLS 4 a reliable and preferred choice for conducting SEM (Structural Equation Modeling) analysis (Koliou et al., 2020).

DISCUSSION

The characteristics of the respondents are presented in Table 1. The majority of respondents were male, with 98 individuals (65%). Most respondents were married, accounting for 95 individuals (63.33%), and the majority were under 30 years old, with 75 respondents (50.01%). Regarding educational background, 97 respondents (64.53%) held a university degree. In terms of residency, 85 respondents (56.66%) had lived in the area for 1 to 10 years. The most represented sub-district had 66 respondents (44.01%), and the majority of respondents belonged to the Kaili ethnic group, with 95 individuals (63.33%).

Table 1. Results of Respondent Characteristics

Respondent information	Frequency (f)	Percent (%)
Gender		
Male	98	65.33
Women	52	34.66
Age		
20 years and below	12	8.01
21-30 years	75	50.01
31-40 years old	14	9,33
41-50 years old	30	20.01
51 years and above	19	12.6
Marital Status		
Not married	46	30.66
Married	95	63.33
Divorce	9	6.01
Religion		
Islam	120	80.01
Hindu	11	7.33
Kristian	19	12.66
Tribe		
Bali	3	2.01
Bugis/Makassar	34	22,66
Jawa	18	12.07
Kaili	95	63.33
Education Level		
Finished primary school	3	2.01
Graduated from junior high school	4	2.66

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Graduated from high school	32	21.16
S1	97	64.53
S2	8	5.33
S3	6	4.01
Location of the neighbourhood where you live		
Ujuna	15	10.01
Baru	8	5.33
Siranindi	10	6.66
Kamonji	11	7.33
Balaroa	66	44.01
Lere	40	26.66

Table 2. Reliability, convergent validity and multicollinearity

Factor & variables	**Estimates**	**α**	**(CR)**	**(AVE)**	**(VIF)**
INFORMATION AND COMMUNICATION TECHNOLOGY (TIK)		0.858	0.725	0.715	
TIK_1	0.727				**1.436**
TIK_2	0.834				**1.249**
TIK_3	0.821				**1.340**
TIK_4	0.745				**1.136**
TIK_5	0.745				**1.154**
TIK_6	0.849				**1.117**
DISASTER MITIGATION AWARENESS(DMA)		0.720	0.717	0.804	
DMA_1	0.827				**1.369**
DMA_2	0.891				**1.373**
DMA_3	0.797				**1.063**
DMA_4	0.879				**1.185**
DMA_5	0.768				**1.242**
DMA_6	0.871				**1.255**
COMMUNITY RESILIENCE(CR)		0.779	0.715	0.862	
CR_1	0.674				**1.066**
CR_2	0.910				**1.050**

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CR_3	0.644	**1.037**
CR_4	0.873	**1.322**
CR_5	0.869	**1.132**
CR_6	0.840	**1.244**
CR_7	0.763	**1.063**

Table 2 This section presents the results of the reliability, convergent validity, and multicollinearity tests. The reliability analysis was conducted to assess the internal consistency of the constructs used in this study, namely Technology, Information and Communication, Disaster Mitigation Awareness, and Community Resilience toward Disaster Mitigation. The results show that all constructs have Cronbach's Alpha values above 0.7, indicating a good level of internal consistency. This means that the items used within each construct consistently measure the intended concept. Convergent validity was tested using the Average Variance Extracted (AVE) values for each construct (Lin, 2019). The AVE values for all constructs exceeded 0.5, indicating that more than 50% of the variance of the indicators is explained by the corresponding constructs. This suggests that the constructs Technology, Information and Communication, Disaster Mitigation Awareness, and Community Resilience toward Disaster Mitigation demonstrate convergent validity, and the indicators effectively measure the intended constructs. Multicollinearity analysis was conducted to ensure that there were no high correlations among the independent variables used in the model. The results show that all variables had Variance Inflation Factor (VIF) values below 10, indicating no significant multicollinearity in the model (Ma et al., 2021). Thus, the independent variables used do not interfere with one another in predicting community resilience toward disaster mitigation.

Table 3. Factor loadings of observables-Varimax Rotation

Observable variables	**Factorial Loads**	**Communality**	**Mean**	**Strt Deviation**
INFORMATION AND COMMUNICATION TECHNOLOGY (TIK)				
TIK_1	0.741	0.546	3.960	0.445
TIK_2	0.752	0.685	4.060	0.519
TIK_3	0.691	0.547	4.013	0.589
TIK_4	0.488	0.458	4.060	0.532
TIK_5	0.687	0.489	4.047	0.667
TIK_6	0.752	0.378	4.060	0.685
DISASTER MITIGATION AWARENESS(DMA)				
DMA_1	0.663	0.319	3.887	0.638
DMA_2	0.738	0.654	3.980	0.716
DMA_3	0.403	0.456	4.100	0.651
DMA_4	0.789	0.604	4.000	0.730
DMA_5	0.406	0.597	4.080	0.770
DMA_6	0.752	0.543	3.973	0.541

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COMMUNITY RESILIENCE(CR)				
CR_1	0.748	0.787	3.940	0.676
CR_2	0.438	0.576	4.020	0.648
CR_3	0.644	0.674	4.107	0.613
CR_4	0.819	0.434	3.940	0.479
CR_5	0.750	0.312	4.073	0.590
CR_6	0.611	0.563	4.020	0.627
CR_7	0.729	0.634	4.060	0.580

Table 3 The results of the Factor Loadings of Observables–Varimax Rotation test are presented. This analysis was conducted to evaluate the contribution of each indicator to the latent constructs, which include Technology, Information and Communication, Disaster Mitigation Awareness, and Community Resilience toward Disaster Mitigation (Mikami et al., 2019). The Varimax Rotation technique was employed to clarify the factor structure and maximize the variance of the Factor Loadings on each factor. The results of the Varimax rotation show that each indicator has high Factor Loadings (≥ 0.5) on its corresponding factor and low loadings on other factors, indicating that the indicators consistently measure the intended constructs. The resulting factor structure demonstrates that Technology, Information and Communication, and Disaster Mitigation Awareness are distinct and independent constructs, with clear and separate Factor Loadings. This indicates the validity and reliability of the indicators in measuring the relevant constructs in this study (Pakoksung et al., 2019).

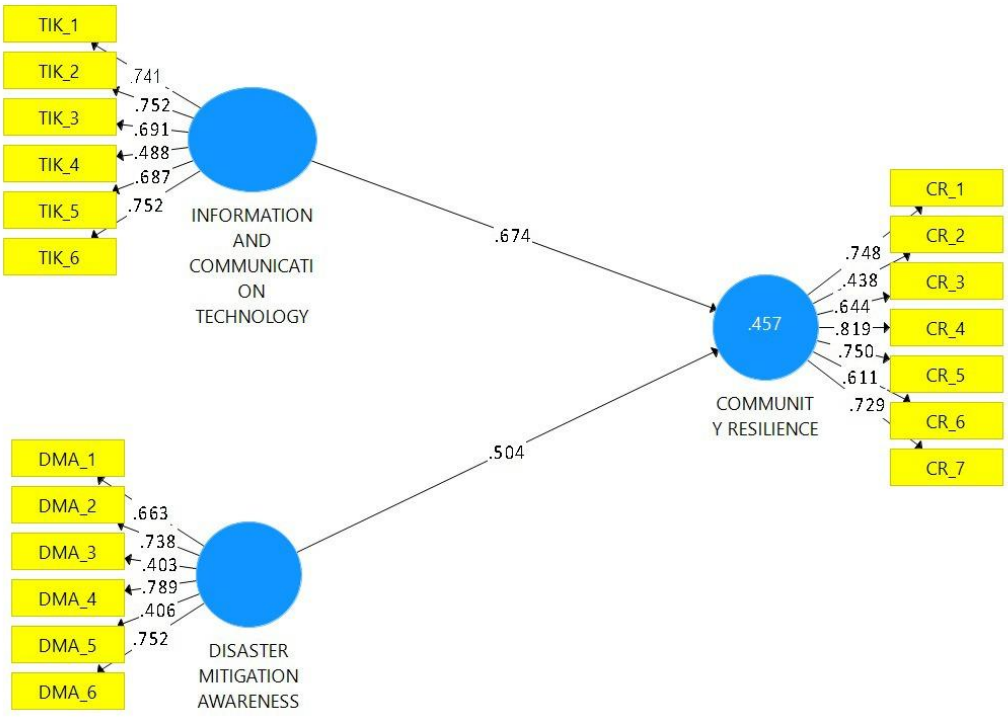

Figure 1. Model of ICT utilisation in building community resilience to disasters

Figure 1 illustrates the results of the Smart PLS analysis, displaying the relationships between Information and Communication Technology (ICT), Disaster Mitigation Awareness, and Community Resilience toward Disaster Mitigation. The diagram shows the influence paths among variables, where

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ICT and Disaster Mitigation Awareness serve as independent variables, while Community Resilience is the dependent variable (Panday et al., 2021). The PLS analysis results indicate that both independent variables have positive and significant path coefficients toward community resilience. This implies that the more effectively ICT is utilized and the higher the awareness of disaster mitigation, the stronger the community's resilience in facing disasters. The path is supported by outer loadings and inner model path coefficients, which represent the magnitude of each variable's influence on community resilience. The model also includes the R-Square indicator, reflecting the extent to which the variation in community resilience can be explained by these two variables. With these significant findings, the figure illustrates the strong relationship between technology and awareness in enhancing community resilience against disaster risks.

Table 4. Hypothesis testing

	Assosiation	**Coefficient (β)**	**t-value**	**p-value**	**Decision**	**R^2**	**F^2**
H1	INFORMATION AND COMMUNICATION TECHNOLOGY -> COMMUNITY RESILIENCE	0.674	4.140	0.001	Accepted	COMMUNITY RESILIENCE =0.457	0.276
H2	DISASTER MITIGATION AWARENESS -> COMMUNITY RESILIENCE	0.504	3.856	0.000	Accepted		0.317

Table 4 presents the hypothesis testing results, indicating that Information and Communication Technology (ICT) and Disaster Mitigation Awareness have a significant influence on Community Resilience in facing disasters (Pathak et al., 2019). The coefficient for the ICT variable is 0.674, with a t-value of 4.140 and a p-value of 0.001, suggesting that ICT plays a positive and significant role in enhancing community resilience toward disaster mitigation. This finding shows that the more effectively ICT is used in disseminating information and educating the public about disaster mitigation, the more resilient communities become in facing disaster risks. Additionally, Disaster Mitigation Awareness has an even stronger impact on Community Resilience, with a coefficient of 0.504, a t-value of 3.856, and a p-value of 0.000. These values demonstrate that higher community awareness of the importance of disaster mitigation results in stronger community resilience when confronting disasters. Disaster Mitigation Awareness encompasses the community's understanding of disaster risks, preventive measures, and preparedness, which are proven to play a crucial role in fostering quicker and more efficient responses when disasters occur. Overall, both ICT and Disaster Mitigation Awareness significantly contribute to strengthening community resilience against disasters. The collaboration between appropriate technology use and increased mitigation awareness is expected to further bolster community resilience, reduce risks, and accelerate post-disaster recovery.

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Table 5. Heterotrait-monotrait ratio (HTMT)

	TIK	DSA	CR
TIK			
DSA	0.777		
CR	0.770	0.787	

Table 5 presents the results of the HTMT (Heterotrait-Monotrait Ratio) test, conducted to assess the discriminant validity between the constructs of Information and Communication Technology (ICT), Disaster Mitigation Awareness, and Community Resilience in the context of disaster mitigation. HTMT is a method used to measure the extent to which different constructs are truly distinct from each other, with lower HTMT values indicating stronger discriminant validity. The results show that each construct, including ICT, Disaster Mitigation Awareness, and Community Resilience, demonstrates adequate discriminant validity (Paulik et al., 2019). In other words, these constructs are sufficiently distinct from one another and do not significantly overlap in terms of measurement. This supports the reliability of the study's findings in assessing the individual effects of each construct on community resilience toward disaster mitigation.

Discussion

The results of this study indicate that the utilization of Information and Communication Technology (ICT) models has a significant relationship in enhancing community resilience to disasters. In this context, ICT plays a crucial role as a tool that accelerates information dissemination, facilitates communication, and supports efficient resource management during emergencies. With ICT, communities can quickly receive early warnings, understand the risks they face, and access the resources necessary to confront disasters. This directly enhances the community's ability to endure and recover swiftly after a disaster, thereby contributing to their overall resilience (Pfefferbaum et al., 2017).

This study also demonstrates that the integration of ICT across various aspects of disaster preparedness, such as emergency response planning and inter-agency coordination, further strengthens community resilience. Reliable communication systems and real-time information access allow communities to be more resilient in dealing with the impacts of disasters. In emergency situations, timely and accurate information is critical for enabling communities to take the necessary actions to mitigate the effects of disasters (Rampengan et al., 2014). Therefore, ICT utilization becomes a key element in building sustainable resilience by improving the community's adaptation and response to disaster threats.

Further analysis also revealed that disaster mitigation awareness has a significant relationship with community resilience. ICT plays a vital role in raising public awareness about the importance of disaster mitigation through the dissemination of educational information, online training, and virtual simulations. With a better understanding of mitigation measures, communities can be more prepared to anticipate risks and take necessary precautions before a disaster occurs (Rifat & Liu, 2020). This increased awareness makes communities more proactive in planning preventive actions and making informed decisions when disasters strike (Samad et al., 2020).

The use of ICT in delivering accurate and timely information plays a significant role in minimizing the impact of disasters through improved preparedness. Communities with access to disaster mitigation information via ICT tend to be better equipped to handle emergency situations. Rapid and effective information dissemination through digital communication channels, such as mobile applications, social media, and websites, can reach a wide range of society. This not only broadens the scope of educational outreach but also fosters more widespread and equitable disaster mitigation awareness across all societal levels (Spialek & Houston, 2019).

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ICT-based early warning systems are an especially effective approach to raising disaster mitigation awareness. Through these systems, communities can receive real-time information about potential disasters, allowing them to take immediate actions to protect themselves and their families. Additionally, online platforms providing educational content, such as tutorial videos, infographics, and interactive mitigation guides, have proven effective in enhancing public understanding of the necessary actions to take. The visual and interactive delivery of information via these technologies facilitates easier comprehension of disaster mitigation measures (Uddin et al., 2020).

The use of ICT in disaster simulations also makes a significant contribution to raising public awareness of disaster mitigation. Through virtual and augmented reality technologies, communities can participate in realistic disaster simulations without being in actual disaster situations. These simulations help people understand what actions to take, such as how to evacuate, utilize escape routes, and use emergency equipment. This technology not only provides theoretical knowledge but also helps develop practical skills that enhance community preparedness in crisis situations (Vieweg et al., 2010).

Furthermore, ICT plays an important role in connecting individuals and groups at the community level through digital platforms. Disaster community applications enable people to share information, report potential risks, and coordinate disaster mitigation efforts. With these integrated communication channels, every community member can actively contribute to information dissemination and the execution of preventive measures. The use of ICT in facilitating collaboration among community members strengthens solidarity and coordination, making the entire community more resilient to disaster threats (Yolsal-Çevikbilen & Taymaz, 2019).

The success of ICT utilization in fostering disaster mitigation awareness depends heavily on cooperation among communities, governments, and the private sector. Reliable technological infrastructure, supportive policies, and active public participation are key elements in implementing this model. Through strong collaboration and optimal use of ICT, disaster mitigation awareness can be significantly improved. Ultimately, this will strengthen community resilience in the face of various disaster threats in the future:

CONCLUSION

1. This study demonstrates that the utilization of Information and Communication Technology (ICT) plays a significant role in enhancing community resilience to disasters, particularly tsunami events on the island of Sulawesi. The analysis reveals that disaster mitigation awareness and the use of ICT are positively correlated with community resilience. Communities with access to accurate and timely information through ICT are generally better prepared for emergencies, enabling them to anticipate risks and take appropriate preventive measures. The study also highlights the importance of technological literacy and community participation in leveraging ICT to strengthen communal resilience. Through online training, virtual simulations, and the dissemination of educational information, communities can improve their understanding of disaster mitigation strategies. Therefore, increasing public awareness and preparedness through ICT is critical to building more resilient communities in disaster-prone areas.
2. Future research is recommended to conduct longitudinal studies to observe changes in community resilience in relation to the ongoing use of ICT. Comparative analyses between areas with robust ICT access and those with limited access are also essential for assessing its effectiveness. Additionally, developing ICT-based training models and exploring recent innovations in ICT, such as mobile applications, can enhance disaster literacy and mitigation awareness. Stakeholder involvement and a focus on community participation in ICT utilization should also be further explored. These steps will enable future research to more effectively contribute to building community resilience to disasters.

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