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FLOOD VULNERABILITY AND ADAPTATION ASSESSMENT IN PADANG TERAP DISTRICT, KEDAH, MALAYSIA

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Abstract

Padang Terap, Kedah in Malaysia experienced frequent floods, incurring financial losses to the flood victims and the government for flood mitigation. For an effective mitigation strategy, there is a need for a reliable database on the vulnerability and adaptation levels of flood victims. Therefore, this study is important to provide the data. The objectives of this paper are to analyse the factors that cause flood vulnerability and to determine and assess the existing adaptation to flood in Padang Terap. The research utilised a quantitative approach, through a household survey of 680 respondents. The data were analysed using descriptive and crosstabulation tests. The findings show that topography, distance between houses and rivers, and flood relief centres affect the vulnerability of the flood victims. The vulnerability to flood is higher than the adaptation level, implying that the Padang Terap flood victims are still not adapting to flood and prone to losses incurred related to flood.

***Keywords**:* Flood, Vulnerability and Adaptation, Padang Terap, Disaster Risk Management

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INTRODUCTION

The world is currently facing a very significant and alarming climate change phenomenon. Climate change has direct and indirect effects, primarily on humans and ecosystems, including changes to the world's climate (Fita & Abate, 2022; Liu et al., 2017; NRE, 2009). Climate change has negative implications that cannot be avoided, such as typhoons, droughts, rising sea levels, and floods. Looking at the effect of this phenomenon, mitigation actions and adaptation measures are necessary to reduce the adverse effects of climate change (Elhazek et al., 2023; Rusnani, 2010).

In Asia, for example, climate change is causing more floods to occur. Countries such as Thailand, India, Bangladesh, Pakistan, and mainland China face severe flood threats (Ghomian & Yousefian, 2017; Bradshaw et al., 2007). The year 2022 saw the worst floods ever hit Pakistan, killing over 1,700 people and affecting over 33 million more. More than 4 million hectares of crops were damaged and flooded, resulting in 14.6 million people facing a food and agricultural crisis. More than 15.4 million people in Pakistan were expected to be below the poverty line due to the floods. The flood had also caused more than US$40 billion worth of damage, as estimated by the World Bank (Haq et al., 2022; World Bank, 2022).

Similarly, Thailand experienced the worst flood disaster from August to October 2011. In that terrible event, 283 people were killed, 8.2 million people from 60 areas were affected, and about 6 million acres of land were submerged, of which 1.17 million hectares were rice fields. Rice was destroyed and could not be harvested (Mushonga & Mishi, 2022; Palamanit et al., 2019; McCombs, 2011). Another damage caused by floods in Thailand was the damage to electronic factories such as Honda Automobile Thailand, Mitsubishi Motors, Nikon and Canon, as well as the destruction of the industrial zone in Saharattananakorn with a loss of more than 30 billion Baht. The total losses from floods in Thailand were estimated to be between US $1.9 billion to US $2.6 billion (Mushonga & Mishi, 2022; Rızaoğlu, 2021; McCombs, 2011).

Malaysia also experienced the same fate. Floods are natural disasters caused by climatological factors such as rainfall, evaporation, wind movement conditions, temperature, and the influence of the natural conditions of the earth's surface (Zain et al., 2020; Muhammad Barzani et al., 2006; Balek, 1983). A total of 29,800 square kilometres in Malaysia is vulnerable to flooding (Kuok et al., 2021; JPS, 2010). The loss and damage caused by the flood is enormous. For example, the total losses due to floods in 2006 and 2007 were as much as RM1.1 billion and RM776 million for all states in Malaysia. This loss only involved government assets. The government had to spend RM 1.79 billion in 2001 and RM 5.81 billion in 2006 to reduce the rate of destruction and risk due to floods by building flood mitigation and RM 100 million to the Jabatan Pengairan dan

Saliran (JPS) in 2009 to maintain the rivers throughout the country (Rosedi & Ishak, 2023; Mohamed Thajudeen, 2009; RMK 9; 2006; RMK 8, 2001).

One of the states in Malaysia that often experiences frequent flooding is Kedah, which causes very extreme destruction and losses. The total losses experienced from 2000 to 2010 due to the increasingly frequent floods in Kedah were as much as RM 50,920,207.00. Total losses due to floods in Kedah increased from 2000 to 2010, with the highest total losses in 2010 amounting to RM 17,816,000.00 (Tobi et al., 2023; Zahari et al., 2022; JPS, 2000; 2005; 2006; 2007; 2008; 2009; 2010).

Therefore, identifying an area or community vulnerable to flooding is very important in order to examine the characteristics or conditions of an area prone to flooding. In a more detailed context, the states or factors of a flood-prone community can be determined mainly from the aspect of why they are vulnerable to floods and what adaptations are made to face floods (Abdul Rasam et al., 2023; Omar & Kamarudin, 2023; Noordin et al., 2007). Such research is fundamental and helps to assess the extent of vulnerability experienced by a community and flood-prone areas. It also helps to significantly evaluate whether the adaptation is helpful or not from the risk received due to flooding. Furthermore, it could also help to get an assessment of the vulnerability and adaptation to floods faced by a large area. With that, the weaknesses identified, especially in terms of adaptation to cope with floods, will be able to be improved and, at the same time, will help reduce the vulnerability to floods experienced. Residents, local authorities, and the government must understand the problems related to floods, ways to overcome floods and adapt to floods to be better prepared to face floods, reduce the rate of destruction due to floods, make early preparations for floods, and reduce the level of vulnerability to floods (Omar & Kamarudin, 2023; Sulaiman et al., 2019). If not, when global warming continues and flood disasters become more frequent, severe, and unpredictable, then the magnitude of the floods will increase, making more people and areas to be more vulnerable to the dangers of floods. Destruction and losses experienced by the people will be higher and the financial implications will be worse. This situation will cause the development and economic process of an area and country to be retarded, and the government will have to bear a high financial burden for the repair process.

Therefore, Padang Terap District was chosen for this study because this district is an area that has experienced floods since 1937 until now. Flood incidents in the Padang Terap district have become more frequent from 2000 to 2010. The total losses experienced from 2000 to 2010 for the Padang Terap district were RM 16,615,439.00. The highest total loss in Padang Terap district in 2010 was RM 5,695,000.00 (JPS, 2010).

The losses experienced increase every time there is a flood. Therefore, the amount of aid given to flood victims also increase. For example, monetary assistance of RM 500.00 was given to each family involved in floods throughout

Malaysia in 2010, amounting to RM 45,076,000.00, of which RM20,405,000.00 was for the state of Kedah (MKN, 2011). This figure shows the high financial implications for the government in dealing with flood disasters. This increase in cost reflects the weak flood adaptation strategy in this area. The people facing the floods are the ones who suffer the most because they are weak and unprepared. Therefore, a flood risk management strategy must change the defenceless flood-prone population to 'stronger' and from less prepared to 'more prepared' to face frequent flood disasters. Therefore, a reasonable approach should focus on adaptation efforts and not just dealing with problems "ad hoc".

Map 1: Padang Terap District
Source: Google Maps (2024)

Photo 1: Flood in Padang Terap District
Source: Authors; FBA Explorer Enterprise (2010)

Adaptation is the recovery measures taken as a step to adapt to the dangerous effects caused by floods and further reduce the effects of the destruction experienced (Omar & Kamarudin, 2023; Sulaiman et al., 2019; Koshy, 2011; Noordin et al., 2007). As one of the countries heading towards a developed country, Malaysia must have a high and robust adaptation strategy in the face of climate change and global warming that impact flood disasters. Floods are becoming more frequent and have negative financial and physical implications. In addition, knowledge and information about flood-prone areas and residents in an area are also lacking in detail.

VULNERABILITY AND ADAPTATION ANALYSIS AND FLOOD RISK ASSESSMENT

This study was conducted in Padang Terap district, Kedah. Eleven sub-districts or *mukim* in the flood-affected communities were selected for this study. The list of these mukims are Belimbing Kanan, Belimbing Kiri, Padang Terap Kanan, Padang Terap Kiri, Kurung Hitam, Padang Temak, Tekai Kanan, Tekai Kiri, Batang Tunggang Kanan and Batang Tunggang Kiri as well as Pedu.

The approach of this study is a quantitative method using household surveys of flood victims in the Padang Terap district, which involves collecting primary data in the field using a set of structured questionnaires. For this, purposive sampling is used to select a sample from a population based on the purpose of the study more accurately and representative of the characteristics of the actual people being studied, namely flood victims, while reducing errors in the selection of respondents (Zikmund, 2000; Sabitha, 2005).

From 2011 to 2023, the Padang Terap District has experienced persistent flood disaster. These floods primarily affect several sub-districts, including Pedu, Padang Temak, Batang Tunggang Kanan, and Belimbing Kanan. Table 1 provides an overview of the total number of flood victims recorded across the entire Padang Terap District during these years. Notably, the number of flood victims significantly decreased after the 2010 flood. Analyzing data from that year is critical for understanding vulnerability and adaptation to flood disasters in the Padang Terap District, making it a valuable model for further flood-related studies.

Table 1: Registered Flood Victims for Padang Terap District, 2011-2023

Year	Total Registered Flood Victims
2011	0
2012	19
2013	0
2014	16
2015	0
2016	0
2017	19
2018	0
2019	0
2020	13
2021	7
2022	23
2023	11

Source: Jabatan Pengairan dan Saliran (2011); Pejabat Daerah Padang Terap (2012); Pejabat Daerah Padang Terap (2013); Pejabat Daerah Padang Terap (2014); Jabatan Pengairan dan Saliran (2015); Jabatan Pengairan dan Saliran (2016); Pejabat Daerah Padang Terap (2017); Jabatan Pengairan dan Saliran (2018); Jabatan Pengairan dan Saliran (2019); Jabatan Pengairan dan Saliran (2020); Jabatan Pengairan dan Saliran (2021); Jabatan Pengairan dan Saliran (2022); Pejabat Daerah Padang Terap (2024)

The population for this study is a list of names of flood victims obtained from the JKM of Padang Terap district. Table 2 below shows the sampling for this study. Based on the list, the number of victims registered in the 2010 flood was 1,427 families. The total sample obtained from the study is 680 people: 47.7 per cent of the entire population.

Table 2: Registered Flood Victims and Number of Respondents

Mukim (Sub-District)	**Total Registered Flood Victims**	**Total No. of Flood Victims from the Survey**
Batang Tunggang Kanan	14	7
Batang Tunggang Kiri	43	19
Belimbing Kanan	514	164
Belimbing Kiri	196	187
Kurung Hitam	201	67
Padang Temak	193	83
Padang Terap Kanan	113	83
Padang Terap Kiri	63	30
Pedu	43	12
Tekai Kiri	24	14
Tekai Kanan	23	14
Total	**1427**	**680**

Source: Jabatan Kebajikan Masyarakat (2010)

For the analysis of vulnerability and adaptation, the aspect that is emphasised is related to the flood disaster. Disasters that strike bring risks to individuals, communities, and countries (Negera et al., 2022; Ismail et al., 2019; UNDP, 2004). The levels of risk are identified based on natural threats and threats of danger received, as well as the level of vulnerability to a disaster that will strike an area. An example is the level of risk assessed in terms of economics or that involves every element of the economy, such as agriculture and industry, that is destroyed due to a disaster. The relationship between risk, threat, and vulnerability can be written as an equation as follows:

RISK = Threat (Danger) + Vulnerability
Source: UNDP (2004); NBSE (2013)

In addition, disaster vulnerability assessment is also determined through the analysis of accepted threats. Next, the assessment is done on vulnerability problems such as physical, social, economic, and environmental elements. Threats and vulnerabilities determine whether an accepted risk is small or large. Adaptation factors or coping capacity also determine how small or large risk is accepted due to a disaster (Ekawati et al., 2022; Rondhi et al., 2019; UNISDR, 2009). Conventionally, risk is expressed by the following equation:

RISK = Threat (Danger) x Vulnerability/ Adaptation (Coping Capacity)
Source: UNDP (2004); CGSS (2013

Therefore, vulnerability and adaptation for this study are analysed from two assessments. The first is vulnerability assessment, and the second is adaptation assessment. The diagram below shows the assessment of vulnerability and adaptation and the criteria involved for each assessment.

Vulnerability assessment is related to the criteria of magnitude, intensity, and probability of flooding. The assessment of adaptation involves the criterion of capacity to withstand floods. For magnitude, the evaluation aspect includes the flood level that hit. For intensity, the assessment aspect includes damage to houses and property, theft and accidents, illness and trauma, destruction of crops and livestock, and difficulties experienced before, during, and after the flood, which is divided into intensity and severity.

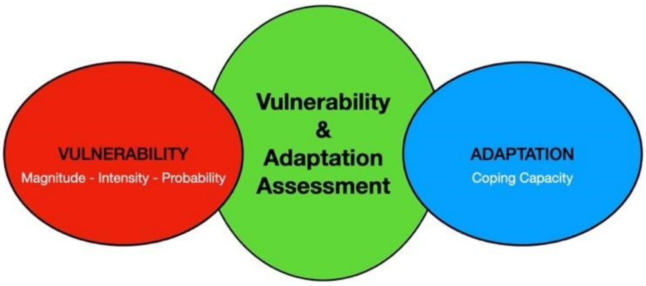

Figure 1: Vulnerability & Adaptation Assessment
Source: Author's

Next, for the probability criteria, the evaluation aspect includes the time and the occurrence of floods. The last criterion is survival capacity. The assessment aspect of this criterion includes preparations before, during, and after the flood by individuals and their crops and livestock.

RESULT AND DISCUSSION

Vulnerability to flooding for this study includes an assessment of the magnitude, intensity, and probability of flooding. The first criterion of vulnerability assessment is magnitude. For this criterion, the measurement refers to the flood level that hit the Padang Terap district. Based on the respondent's body, there are two vulnerability values for the flood level height: 2.00 and 1.00. Therefore, the level of vulnerability for this measure also varies according to the mukim that experiences it and each mukim is classified according to the level of vulnerability.

Based on Table 3, vulnerability assessment for flood level measurements based on the magnitude criterion is 1.55 for the average of the 11 mukims involved. The flood level measurement is assessed from the knee until passing the head of the respondent.

Table 3: Magnitude Assessment

VA/ S-D	BKi	BKa	KH	PT	BTKi	BTKa	PTKi	PTKa	TKi	TKa	P
Flood level measurement based on the respondent's body	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0

VA = Vulnerability Assessment; S-D = Sub District; BKi = Belimbing Kiri; BKa = Belimbing Kanan; KH = Kurung Hitam; PT = Padang Temak; BTKi = Batang Tunggang Kiri; BTKa = Batang Tunggang Kanan; PTKi = Padang Terap Kiri; PTKa = Padang Terap Kanan; TKi = Tekai Kiri; TKa = Tekai Kanan; P = Pedu

Source: Author's Calculation

The second flood assessment of flood vulnerability focuses on the intensity criteria. Vulnerability assessment for these criteria includes damage to homes and property, economic resources and income, disasters and accidents, trauma and disease, hardship, and food. Based on Table 3, the vulnerability value for this criterion is 1.43. Each province that experiences it has a different intensity of vulnerability. Based on Table 4, a total of seven mukims, namely Belimbing Kiri, Belimbing Kanan, Padang Temak, Padang Terap Kanan, Kurung Hitam, Padang Terap Kiri and Batang Tunggang Kanan have a moderate intensity vulnerability level, which is 1.46. Within these mukims, the measure of house and property damage, income affected by floods, trauma due to floods and food difficulties during floods have a high vulnerability value of 2.00. Meanwhile, the measure of crops and livestock destroyed due to floods, disasters, accidents, and diseases has a low vulnerability value of 1.00. Four other mukims, namely Tekai Kiri, Tekai Kanan, Batang Tunggang Kiri and Pedu have a lower level of intensity vulnerability than the other with a value of 1.38. For these mukims, only the measure of house and property damage, income affected due to flood and trauma due to flood has a high vulnerability value, 2.00. The rest, encompassing the measure of crops and livestock destroyed due to floods, calamities, and accidents due to floods, diseases, and food, have a low vulnerability value of 1.00.

Table 4: Intensity Assessment

VA/ S-D	BKi	BKa	KH	PT	BTKi	BTKa	PTKi	PTKa	TKi	TKa	P
House damaged	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Estimated damage to homes and property	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Affected daily income	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Crops destroyed	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Livestock destroyed	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Case of theft	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fatal accident	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Injuries and venomous animal bites	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Trauma	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Floods cause disease	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Existing disease worsen	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Difficulties	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Food difficulties	2.0	2.0	2.0	2.0	1.0	2.0	2.0	2.0	1.0	1.0	1.0
Average	1.46	1.46	1.46	1.46	1.38	1.46	1.46	1.46	1.38	1.38	1.38

VA = Vulnerability Assessment; S-D = Sub District; BKi = Belimbing Kiri; BKa = Belimbing Kanan; KH = Kurung Hitam; PT = Padang Temak; BTKi = Batang Tunggang Kiri; BTKa = Batang Tunggang Kanan; PTKi = Padang Terap Kiri; PTKa = Padang Terap Kanan; TKi = Tekai Kiri; TKa = Tekai Kanan; P = Pedu

Source: Author's Calculation

The last vulnerability assessment involves the criteria of the probability of flooding. Vulnerability assessment for this criterion includes measures of flood victims' experiences and the nature of floods in the Padang Terap district. Based on Table 5, the vulnerability value for this criterion is 1.58, where each mukim has a different measurement value.

Table 5: Probability Assessment

VA/ S-D	BKi	BKa	KH	PT	BTKi	BTKa	PTKi	PTKa	TKi	TKa	P
Been a victim of a flood	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Frequency of floods every five years	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Number of days of flooding	2.0	2.0	2.0	2.0	1.0	1.0	2.0	1.0	2.0	2.0	2.0
Average	1.67	1.67	1.67	1.67	1.33	1.33	1.67	1.33	1.67	1.67	1.67

VA = Vulnerability Assessment; S-D = Sub District; BKi = Belimbing Kiri; BKa = Belimbing Kanan; KH = Kurung Hitam; PT = Padang Temak; BTKi = Batang Tunggang Kiri; BTKa = Batang Tunggang Kanan; PTKi = Padang Terap Kiri; PTKa = Padang Terap Kanan; TKi = Tekai Kiri; TKa = Tekai Kanan; P = Pedu

Source: Author's Calculation

Based on Table 5, a total of eight mukims, namely Belimbing Kiri, Belimbing Kanan, Kurung Hitam, Padang Temak, Padang Terap Kiri, Tekai Kiri, Tekai Kanan and Pedu, have a probability vulnerability level of 1.67. For these mukims, the measure has been a victim of floods, and the number of days of flood events has a high vulnerability value of 2.00. Meanwhile, the measure of flood frequency every five years has a low vulnerability value of 1.00. The remaining three mukims are Batang Tunggang Kiri, Batang Tunggang Kanan and Padang Terap Kanan. For these mukims, the measure of being a flood victim has a high vulnerability value of 2.00. The rest, the measure of the frequency of floods every five years and the number of days of flood events have a low vulnerability value of 1.00.

Next is the assessment of adaptation. The assessment of flood adaptation in the Padang Terap district is evaluated through the criteria of flood resistance capacity. Adaptation assessment for flood resilience criteria includes measures of financial adaptation, crop adaptation, livestock adaptation and general adaptation, such as adaptation before, during and after the flood.

Table 6 is an assessment of the Padang Terap flood adaptation. Overall, the adaptation value obtained is low, which is 1.25. Based on the table, eight evaluations also have a low adaptation value. The assessment covers finances, crops, livestock, and activities to overcome the flood problem. Meanwhile, the assessment of adaptation aspects has a high adaptation value. In addition, there are also among the flood victims who make other preparations to face the flood. However, the other practices also did not help the flood victims reduce the destruction they faced. For example, preparing food, moving goods, buying equipment during floods, and preparing for personal safety.

Table 6: Adaptation Assessment

AA/ S-D	BKi	BKa	KH	PT	BTKi	BTKa	PTKi	PTKa	TKi	TKa	P
Financial preparation	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Crops preparation before	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Crops preparation during	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Crops preparation after	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Livestock Preparation before	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Livestock Preparation during	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Livestock Preparation after	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Adaptation before	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Adaptation during	2.0	2.0	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0
Adaptation after	2.0	2.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0
Activities to overcome the flood problem	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average	1.27	1.27	1.27	1.18	1.18	1.18	1.27	1.27	1.27	1.27	1.27

AA = Adaptation Assessment; S-D = Sub District; BKi = Belimbing Kiri; BKa = Belimbing Kanan; KH = Kurung Hitam; PT = Padang Temak; BTKi = Batang Tunggang Kiri; BTKa = Batang Tunggang Kanan; PTKi = Padang Terap Kiri; PTKa = Padang Terap Kanan; TKi = Tekai Kiri; TKa = Tekai Kanan; P = Pedu

Source: Author's Calculation

Overall, from the Magnitude (1.55), Intensity (1.43) and Probability (1.58) criteria evaluation, the overall vulnerability value is 1.52. Meanwhile, the overall adaptation value is 1.25. The difference in the value of vulnerability and adaptation shows that the Padang Terap district is at risk of flooding since the vulnerability experienced is higher than the adaptation.

CONCLUSION

In conclusion, Padang Terap district urgently requires the establishment of a sustainable disaster risk management system. This system should incorporate an effective early warning mechanism to alert flood victims to relocate to a safer place. Additionally, the government must also improve infrastructure and public facilities including roads, bridges, community halls, flood evacuation centres, clinics, schools, and banks involved in flood-related matters. Sustainable disaster risk management should encompass actions taken before, during and after a disaster. Before a disaster, the things that need to be done are risk research, risk mitigation, and ensuring preparedness for both risk and disaster. Whereas, when a disaster occurs, a swift and prioritised response such as emergency assistance and search-and-rescue operations for disaster victims is essential. Subsequently, the recovery and reconstruction process after a disaster, such as repairing infrastructure, especially houses and public buildings, and fostering innovation in constructing disaster-resistant homes and facilities for reconstruction projects. Low-impact development that can reduce vulnerability in the future should also be prioritised and implemented.

Therefore, a more sustainable disaster risk management system must be standardised and applied in all places where disasters occur. Through this comprehensive sustainable disaster risk management, the involvement of responsible agencies and commitment from the community will help reduce vulnerability to disasters and further reduce the impact of any disaster that occurs in the future.

CONFLICT OF INTEREST

The author agrees that the conducted research is not related to any personal gain, commercialization, or any form of financial benefit and states that the research also has no conflicting interests with the funder.

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