Risk Communication Readiness for Community-Based Flood Mitigation: Evidence from an Environmental Education Program in Urban Indonesia

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Abstract

Urban flooding has become one of the most frequent environmental hazards affecting rapidly growing cities in developing countries. While governments increasingly invest in flood risk communication strategies, relatively little attention has been paid to whether communities are adequately prepared to receive, interpret, and act upon risk information. Existing studies predominantly examine communication channels, message design, and institutional coordination, whereas the concept of risk communication readiness remains underexplored. This study investigates how participation in a community-based environmental education program contributes to risk communication readiness by strengthening environmental literacy, environmental responsibility, and community engagement. A descriptive evaluation design was employed using survey data collected from 31 participants of an environmental education program implemented in Pamulang District, South Tangerang City, Indonesia. The findings indicate that participants demonstrated high levels of environmental literacy, strong perceptions of shared environmental responsibility, positive behavioural intentions, and substantial willingness to participate in future environmental activities. These findings suggest that environmental education may strengthen the social and cognitive conditions required for effective flood risk communication. Building upon these findings, the study proposes the Risk Communication Readiness Model (RCRM), a conceptual framework explaining how environmental education supports environmental literacy, strengthens risk awareness, encourages preparedness, and enhances community readiness for flood risk communication. Rather than replacing existing risk communication models, the RCRM complements them by emphasizing the preparatory conditions necessary before communication strategies can effectively influence community action. The study contributes to disaster risk reduction literature by introducing risk communication readiness as a distinct analytical construct and offers practical guidance for integrating environmental education into community-based flood mitigation programs.

Keywords: *Risk Communication, Community Preparedness, Flood Mitigation, Environmental Literacy, Disaster Risk Reduction.*

A. INTRODUCTION

Climate change, rapid urbanization, and inadequate environmental management have significantly increased the frequency and severity of urban flooding worldwide (IPCC, 2023; UN-Habitat, 2022; World Bank, 2023). Floods now represent one of the most common natural hazards affecting urban communities, particularly in developing countries where expanding populations, land-use changes, and poor waste management place additional pressure on urban drainage

systems. Governments have increasingly adopted risk communication as an essential component of disaster risk reduction (UNDRR, 2015; WHO, 2021). Effective communication enables communities to understand hazards, recognize warning signals, and undertake protective actions before disasters occur. International frameworks such as the Sendai Framework for Disaster Risk Reduction 2015–2030 emphasize that disaster resilience depends not only on infrastructure and emergency response but also on informed, prepared, and engaged communities capable of understanding and acting upon risk information (UNDRR, 2015).

Despite substantial advances in disaster communication research, many flood mitigation initiatives continue to experience limited community response. Early warning messages are frequently ignored, evacuation recommendations are delayed, and community participation remains inconsistent Lindell & Perry, 2012; Reynolds & Seeger, 2005). These observations suggest that communication effectiveness cannot be explained solely by message quality or communication channels (Covello & Sandman, 2001; Fischhoff, 2013). An overlooked factor may be the readiness of communities to receive and utilize risk communication. Communities that lack environmental knowledge, perceive environmental issues as someone else's responsibility, or possess limited experience with collective environmental action may be less capable of translating risk information into protective behaviour.

Accordingly, communication effectiveness should be viewed not only as a function of message delivery but also as a function of community preparedness to interpret, trust, and respond to that information. Traditional risk communication research has primarily focused on designing effective messages, selecting communication channels, and improving institutional coordination during disasters (Ajzen, 1991; Lindell & Perry, 2012). Although these components remain important, communication itself does not automatically produce behavioural change (Covello & Sandman, 2001; Lundgren & McMakin, 2018). The same warning message may generate immediate action in one community while being ignored in another. This variation suggests that communities differ in their capacity to process, interpret, and apply risk information. Consequently, understanding community readiness before communication occurs represents an important but relatively neglected area of disaster risk reduction research.

Environmental education is generally viewed as a strategy for improving environmental awareness and promoting sustainable behaviour (UNESCO, 2020; UNESCO, 2021). However, environmental education may also contribute to disaster risk reduction. Household waste management, environmental responsibility, recycling behaviour, and community participation all influence the condition of urban drainage systems and consequently affect flood vulnerability (UNEP, 2024; OECD, 2023). Educational programs encouraging sustainable waste management therefore generate benefits extending beyond environmental protection. They may also strengthen community capacity to understand environmental risks and support future disaster communication initiatives.

Existing literature presents four important gaps. First, risk communication research predominantly examines communication strategies, message framing, warning systems, and institutional coordination, while comparatively little attention has been directed toward community readiness before communication occurs. Second, environmental education studies generally evaluate environmental literacy and pro-environmental behaviour but rarely examine their contribution to disaster communication. Third, disaster preparedness research frequently measures emergency response capability without considering how environmental education influences readiness to receive and interpret future risk communication. Finally, empirical evidence from rapidly urbanizing cities in the Global South remains limited despite increasing flood vulnerability and growing investment in community-based environmental education programs (Fischhoff, 2013; Lindell & Perry, 2012; UNDRR, 2022).

This study aims to examine how community-based environmental education contributes to risk communication readiness for flood mitigation by strengthening environmental literacy, environmental responsibility, behavioural intention, and community engagement. Drawing upon evidence from an environmental education program implemented in Pamulang District, South Tangerang City, Indonesia, the study proposes the Risk Communication Readiness Model (RCRM) as a conceptual framework explaining the preparatory conditions that support effective flood risk communication.

B. LITERATURE REVIEW

1. Risk Communication in Disaster Risk Reduction

Risk communication has become an essential component of disaster risk reduction (DRR), enabling authorities, experts, and communities to exchange information regarding hazards, vulnerabilities, and protective actions before, during, and after disasters (Covello & Sandman, 2001; Lundgren & McMakin, 2018). Rather than functioning merely as the dissemination of warnings, contemporary risk communication emphasizes interactive communication processes that facilitate understanding, trust, and collective decision-making among multiple stakeholders. Its primary objective is to communicate risk information clearly to individuals and communities, enabling them to make informed choices about the potential consequences of risks and, ultimately, determine appropriate actions to take (Hidayat, 2023).

The Sendai Framework for Disaster Risk Reduction (2015–2030) recognizes effective risk communication as one of the key priorities for reducing disaster losses. Governments are encouraged not only to improve early warning systems but also to strengthen public understanding of disaster risks and increase community engagement in preparedness activities.

Previous studies have demonstrated that effective risk communication improves public awareness, increases evacuation compliance, reduces misinformation, and strengthens community resilience. However, communication

strategies frequently produce inconsistent outcomes across different communities. Similar warning messages may encourage immediate protective action in one location while generating limited response elsewhere.

This inconsistency suggests that communication effectiveness depends not only on message quality but also on the capacity of communities to receive, understand, trust, and apply risk information. Accordingly, understanding the conditions that shape community readiness before communication occurs represents an important extension of current risk communication research (WHO, 2021; Reynolds & Seeger, 2005).

2. Protective Action Decision Model (PADM)

The Protective Action Decision Model (PADM), developed by Lindell and Perry, explains how individuals decide whether to undertake protective actions after receiving hazard information. According to PADM, protective behaviour develops through several stages (Lindell & Perry, 2012).

Individuals first receive environmental cues or warning messages. They then interpret the information, evaluate potential risks, assess available protective actions, and finally decide whether to respond. Importantly, PADM suggests that effective communication requires more than simply transmitting information. Recipients must possess sufficient knowledge, confidence, and perceived capability to understand and evaluate the message. Without these prerequisites, warning information may fail to generate appropriate behavioural responses.

Although PADM has been widely applied to earthquakes, hurricanes, floods, and other natural hazards, relatively few studies have explored how environmental education contributes to the preparatory conditions supporting protective decision-making before disasters occur. The present study extends PADM by proposing that environmental literacy generated through community education strengthens the cognitive capacity required for future risk communication.

3. Risk Perception and Environmental Responsibility

Risk perception represents one of the most influential predictors of disaster preparedness (Slovic, 1987; Breakwell, 2014). Individuals who perceive hazards as personally relevant are generally more likely to seek information, adopt protective behaviours, and participate in disaster preparedness activities. Risk perception extends beyond awareness of hazards. It includes judgments regarding probability, severity, personal vulnerability, and confidence in available protective measures. Environmental responsibility further shapes these perceptions (Bandura, 1986; Rimal & Real, 2003). Individuals who believe environmental protection represents a shared social responsibility are more likely to recognize the consequences of poor waste management and appreciate its contribution to flood risks. Consequently, environmental responsibility may strengthen community willingness to engage with future risk communication initiatives. This study therefore considers environmental responsibility as an important psychological foundation supporting risk

communication readiness.

4. Community Preparedness

Community preparedness refers to the collective capacity of communities to anticipate, respond to, and recover from disasters (Paton, 2003; Becker et al., 2012; Norris et al., 2008). Preparedness encompasses knowledge, skills, planning, organizational capacity, collaboration, and social networks that enable communities to reduce disaster impacts. Previous preparedness research frequently evaluates emergency plans, evacuation procedures, warning systems, and disaster response capacity. However, preparedness should also include communication readiness, as the effectiveness of warnings depends not only on whether information reaches communities but also on how that information is understood and interpreted. Communities do not respond to hazards solely based on raw alerts, they rather respond according to the meanings they assign to those alerts (Hidayat, Assegaf & Rubiyanto, 2026). This highlights the importance of ensuring that risk information is not only accessible, but also meaningful, trusted, and relevant to community contexts.

Communities unable to understand or trust warning information remain vulnerable even when sophisticated communication technologies are available. Preparedness therefore depends not only on emergency resources but also on social learning, environmental knowledge, and collective engagement developed before disasters occur. Community-based educational programs provide opportunities to strengthen these capacities through continuous interaction and shared learning.

5. Environmental Literacy as the Foundation of Risk Communication Readiness

Environmental literacy has traditionally been examined within environmental education and sustainability research (UNESCO, 2020; UNESCO, 2021). However, environmental literacy may also represent an important determinant of disaster preparedness. Individuals possessing stronger environmental knowledge are generally better able to understand relationships between human behaviour and environmental risks. Household waste management provides an important example. Improper waste disposal contributes to blocked drainage systems that increase urban flood vulnerability.

Communities understanding these relationships are more likely to recognize why flood risk communication is relevant to their everyday lives (UNEP, 2024). Consequently, environmental literacy provides more than environmental awareness. It develops the cognitive capacity required for interpreting environmental risk information and understanding recommended protective actions. This perspective suggests that environmental education contributes indirectly to disaster risk reduction by strengthening the knowledge foundation upon which future risk communication depends.

6. Toward a Risk Communication Readiness Model (RCRM)

The preceding literature highlights an important limitation within existing disaster communication research. Risk communication, risk perception, preparedness, and environmental education have generally been investigated independently. Few studies integrate these concepts into a single framework explaining the conditions that enable communities to receive and act upon future risk communication. To address this limitation, this study proposes the Risk Communication Readiness Model (RCRM). Unlike traditional risk communication models emphasizing message delivery or warning systems, the RCRM focuses on the preparatory social and cognitive conditions that precede communication effectiveness. The model suggests that community-based environmental education strengthens environmental literacy, which supports environmental responsibility and risk perception. These conditions enhance community preparedness and create greater readiness to receive, interpret, and respond to future flood risk communication. Accordingly, effective risk communication should be viewed not merely as a communication process but as the outcome of long-term community capacity development.

7. Theoretical Proposition

Because this study employs a descriptive evaluation design, I recommend formulating research propositions rather than causal hypotheses.

P1: Community-based environmental education contributes to environmental literacy that supports disaster-related understanding.

P2: Environmental literacy strengthens environmental responsibility toward flood-related environmental risks.

P3: Environmental responsibility is associated with stronger perceptions of environmental and flood risks.

P4: Risk perception contributes to community preparedness for disaster communication.

P5: Community preparedness supports greater readiness to receive and act upon future flood risk communication

C. METHOD

1. Research Design

This study employed a descriptive program evaluation design to examine the extent to which participation in a community-based environmental education program supports risk communication readiness for flood mitigation. Rather than testing causal relationships, the study evaluated participants' levels of environmental literacy, environmental responsibility, behavioural intention, and community engagement as indicators of the social and cognitive conditions that may facilitate effective risk communication.

A descriptive evaluation approach was considered appropriate because the primary objective was to assess the outcomes of an educational intervention and

interpret these outcomes within the conceptual framework of the Risk Communication Readiness Model (RCRM). This design allows the study to provide practical insights into community capacity building while avoiding unsupported causal claims.

Study Area

The research was conducted in Pamulang District, South Tangerang City, Banten Province, Indonesia. South Tangerang is one of the fastest-growing urban areas within the Jakarta Metropolitan Region. Rapid urban expansion has increased pressure on environmental infrastructure, particularly urban drainage systems and household waste management. Seasonal flooding remains a recurring environmental issue, with clogged drainage channels caused by improper waste disposal contributing to localized flood events.

Recognizing these challenges, a community-based environmental education program was implemented to improve household waste management practices, encourage community participation, and strengthen environmental awareness among local residents.

The program addressed several topics, including:

a. Household waste segregation
b. Principles of Reduce, Reuse, and Recycle (3R)
c. Community waste bank management
d. Environmental responsibility, and
e. Collaborative environmental action.

Although the program was not specifically designed as a disaster preparedness intervention, its educational content provides an appropriate context for examining the conditions that may support future flood risk communication.

2. Participants

Participants consisted of 31 community members who voluntarily attended the environmental education program. A purposive sampling strategy was adopted because the study focused specifically on individuals who had completed the educational activities. The participants represented adult residents living within the program implementation area and varied in age, occupation, and educational background. Most participants were female, reflecting the dominant role of women in household waste management activities and community environmental initiatives. Because the study sought to evaluate a specific educational program rather than estimate population parameters, purposive sampling was considered appropriate.

3. Environmental Education Program

The educational program was designed to increase public awareness of sustainable household waste management while encouraging active community participation. Training activities combined lectures, interactive discussions, practical demonstrations, and collaborative learning exercises. Key learning materials

included:

a. Introduction to household waste management,
b. Waste segregation techniques,
c. Implementation of the 3R principles,
d. Household composting,
e. Waste bank participation,
f. Environmental responsibility,
g. Collective action for maintaining neighbourhood cleanliness.

Participants were encouraged to discuss local environmental problems and identify practical solutions that could be implemented within their communities. Although flood mitigation was not the explicit focus of the training, improved household waste management contributes to cleaner drainage systems and therefore represents an important supporting factor for reducing urban flood risks.

4. Research Instrument

Data were collected using a structured questionnaire administered immediately after completion of the educational program. The questionnaire consisted primarily of closed-ended items designed to measure:

a. Environmental knowledge,
b. Understanding of waste management,
c. Environmental responsibility,
d. Willingness to participate in environmental activities,
e. Behavioural intentions,
f. Participant satisfaction.

Responses were summarized using frequencies and percentages to describe overall participant characteristics and program outcomes. The instrument was developed based on the learning objectives of the educational program and reviewed by facilitators experienced in community environmental education to ensure content relevance.

5. Data Collection

Data collection was conducted immediately following completion of the environmental education sessions. Participants completed the questionnaire voluntarily after receiving an explanation regarding the purpose of the evaluation. Researchers ensured anonymity by removing personal identifiers from the dataset before analysis. Participation in the survey was entirely voluntary, and respondents were informed that their responses would be used solely for research and program evaluation purposes.

6. Data Analysis

The study employed descriptive statistical analysis. Participant responses were analyzed using frequencies, percentages, and descriptive summaries. The descriptive findings were then interpreted through the lens of the proposed Risk

Communication Readiness Model (RCRM). Rather than testing statistical causality, the analysis explored how observed levels of environmental literacy, environmental responsibility, behavioural intention, and community participation collectively reflect conditions associated with community readiness for future flood risk communication. This interpretative approach is consistent with descriptive program evaluation and avoids overstating empirical conclusions beyond the available data.

7. Trustworthiness and Quality Assurance

Several procedures were undertaken to improve the quality of the study. First, all participants completed the same educational activities before responding to the questionnaire. Second, standardized questionnaires were administered under similar conditions. Third, responses were checked for completeness prior to analysis. Fourth, interpretation of findings was consistently guided by established theoretical frameworks, including Risk Communication Theory, the Protective Action Decision Model (PADM), Environmental Literacy Theory, and Community Preparedness Theory. These procedures enhance the credibility and transparency of the evaluation despite its descriptive nature.

8. Ethical Considerations

The study adhered to fundamental ethical principles governing research involving human participants. Participation was voluntary, and respondents were informed of the objectives of the study before completing the questionnaire. Personal identities were not collected, ensuring participant anonymity and confidentiality. Survey responses were analyzed only in aggregated form and were used exclusively for academic research and program evaluation. Because the study involved minimal risk and collected anonymous evaluation data following a community education program, no personally identifiable information was retained.

Table 1. Research Design Summary

Component	Description
Research Design	Descriptive Program Evaluation
Research Approach	Quantitative Descriptive
Study Area	Pamulang District, South Tangerang, Indonesia
Participants	31 Community Members
Sampling	Purposive Sampling
Intervention	Community-Based Environmental Education Program
Instrument	Structured Questionnaire
Variables Observed	Environmental Literacy, Environmental Responsibility, Behavioural Intention, Community Participation, Program Satisfaction
Analysis	Frequency and Percentage
Interpretation	Risk Communication Readiness Model (RCRM)

D. RESULTS AND DISCUSSION

1. Participant Characteristics

A total of 31 community members participated in the environmental education program and completed the post-program evaluation questionnaire. Female participants represented the majority of respondents (93.5%), while males accounted for 6.5%. This demographic composition reflects the active involvement of women in household waste management and neighbourhood environmental activities within the study area. Regarding previous experience with community environmental initiatives, 77.4% of participants reported prior involvement in waste bank activities, whereas 22.6% had no previous experience. This indicates that most respondents had already been exposed to community-based environmental programs before attending the educational intervention.

Table 2. Participant Characteristics

Characteristic	Frequency	Percentage (%)
Female	29	93.5
Male	2	6.5
Previous participation in waste bank	24	77.4
No previous participation	7	22.6

2. Environmental Literacy

Participants demonstrated a high level of environmental literacy following completion of the educational program. Almost all respondents indicated that they understood the principles of household waste segregation (93.5%), while 87.1% reported understanding the concept of Reduce, Reuse, and Recycle (3R). Knowledge of waste bank management and the economic value of recyclable waste reached 93.6%, indicating that participants were familiar with both environmental and economic dimensions of household waste management. Similarly, 87.1% reported understanding proper household waste management practices.

Table 3. Environmental Literacy Outcomes

Indicator	Percentage (%)
Understanding waste segregation	93.5
Understanding 3R principles	87.1
Understanding waste bank	93.6
Understanding economic value of waste	93.6
Understanding household waste management	87.1

3. Environmental Responsibility

Participants expressed a strong sense of shared environmental responsibility. All respondents (100%) agreed that environmental protection represents a shared responsibility within the community. Similarly, 100% believed that participation in waste bank activities contributes to increasing environmental awareness. The findings also indicate strong support for environmental education campaigns, with

100% of respondents considering such programs important for improving community environmental awareness.

Table 4. Environmental Responsibility

Indicator	Percentage (%)
Environment is a shared responsibility	100
Waste bank increases awareness	100
Environmental campaigns are important	100

4. Behavioural Intention

The survey results indicate strong behavioural intentions toward environmentally responsible practices. A total of 96.8% of respondents expressed willingness to separate household waste. Likewise, 96.8% indicated their intention to reduce plastic consumption in daily activities. Furthermore, 93.6% reported willingness to reuse materials whenever possible. Perhaps the strongest indicator emerged from future participation, where 100% of respondents expressed willingness to participate in future environmental activities.

Table 5. Behavioural Intention

Indicator	Percentage (%)
Intention to separate waste	96.8
Intention to reduce plastic use	96.8
Intention to reuse materials	93.6
Willingness to participate in future programs	100

5. Community Engagement

Participants demonstrated high levels of engagement with community environmental activities. Approximately 90.4% reported previous participation in environmental activities within their communities. This finding indicates that most participants were already engaged in collective environmental initiatives prior to attending the educational program.

Table 6. Community Engagement

Indicator	Percentage (%)
Previous participation in environmental activities	90.4
Willingness to participate in future environmental activities	100

6. Program Evaluation

Overall participant satisfaction with the environmental education program was highly positive. Approximately 80.6% reported the highest level of satisfaction with the program. When asked about suggestions for future improvement, participants most frequently recommended:

a. Additional practical demonstrations,
b. More hands-on waste management activities,
c. Longer discussion sessions,

d. Continued community mentoring.

These suggestions indicate a preference for experiential learning approaches that enable participants to apply environmental knowledge in everyday practice.

Table 7. Summary of Program Evaluation

Indicator	Result
Highest satisfaction level	80.6%
Main recommendation	More practical sessions
Preferred learning method	Hands-on activities
Future expectation	Continued mentoring

7. Indicators of Risk Communication Readiness

Based on the descriptive findings, participants demonstrated consistently high levels across the dimensions considered relevant to the proposed Risk Communication Readiness Model (RCRM). High levels of environmental literacy, strong environmental responsibility, positive behavioural intentions, and active community engagement collectively represent favourable conditions for future risk communication initiatives. Although the study did not directly measure flood preparedness or responses to disaster warning messages, the observed findings suggest that participants possessed social and cognitive characteristics theoretically associated with greater readiness to receive and interpret environmental risk information.

Table 8. Summary of Indicators Supporting Risk Communication Readiness

Dimension	Main Finding
Environmental literacy	High
Environmental responsibility	Very High
Behavioural intention	Very High
Community engagement	High
Program satisfaction	High
Overall indication	Strong conditions supporting risk communication readiness

The descriptive evaluation demonstrates that the environmental education program was associated with high levels of environmental knowledge, shared environmental responsibility, behavioural intention, and community participation among participants. Taken together, these findings indicate favourable conditions for the development of Risk Communication Readiness. While the study does not establish causal relationships between environmental education and disaster preparedness, the results provide empirical support for examining environmental education as an important foundation for strengthening community capacity prior to the implementation of flood risk communication initiatives.

8. Environmental Education as a Foundation for Risk Communication Readiness

The findings indicate that participants demonstrated high levels of environmental literacy following the community-based environmental education program. Most respondents reported understanding household waste segregation, the principles of Reduce, Reuse, and Recycle (3R), waste bank management, and the environmental consequences of improper waste disposal. These findings reinforce previous research suggesting that environmental education strengthens individuals' capacity to understand environmental issues and encourages greater awareness of sustainable environmental practices (UNESCO, 2020; Bandura, 1977). Environmental literacy is widely recognized as a prerequisite for informed environmental decision-making because individuals cannot respond appropriately to environmental risks without first understanding the causes and consequences of those risks (UNESCO, 2021).

From the perspective of disaster risk reduction, the present findings suggest that environmental literacy extends beyond environmental conservation. It also provides the cognitive foundation necessary for interpreting disaster-related information. Communities with stronger environmental understanding are more likely to recognize the relationship between household waste management, drainage conditions, and urban flooding, thereby making future flood risk communication more meaningful and personally relevant.

Rather than viewing environmental education solely as an environmental intervention, the present study supports the argument that environmental education may function as an important preparatory strategy for strengthening community readiness prior to disaster communication initiatives.

9. Environmental Responsibility and Risk Perception

An important finding of this study is the exceptionally strong sense of shared environmental responsibility among participants. Every respondent agreed that environmental protection represents a collective responsibility, while all participants also believed that waste bank activities contribute to increasing environmental awareness. These findings are consistent with studies emphasizing that perceived collective responsibility influences environmental behaviour and community engagement (Bandura, 1986; Slovic, 2000). Individuals who recognize environmental management as a shared obligation are generally more willing to support collaborative environmental initiatives and participate in collective action.

Within the context of risk communication, environmental responsibility also contributes to risk perception. Communities that recognize the consequences of poor environmental management are more likely to appreciate why disaster prevention messages are necessary. Consequently, environmental responsibility should not be viewed merely as an ethical value but also as a psychological condition supporting future communication about environmental hazards. The findings therefore suggest that strengthening environmental responsibility may indirectly enhance public

receptiveness to flood risk communication.

10. Behavioural Intention and Community Engagement

The study found consistently positive behavioural intentions across multiple environmental indicators. Nearly all participants expressed willingness to separate household waste, reduce plastic consumption, reuse recyclable materials, and participate in future environmental programs. These findings align with the Theory of Planned Behavior, which proposes that behavioural intention represents one of the strongest predictors of future behaviour (Ajzen, 1991; Armitage & Conner, 2001). Although this study did not examine actual long-term behavioural change, the consistently positive intentions observed among participants indicate favourable conditions for continued environmental participation.

Similarly, community engagement was already relatively high, with most respondents reporting previous participation in environmental activities. Existing involvement in community programs may facilitate future disaster communication because social participation strengthens interpersonal trust, social learning, and information exchange. The findings therefore suggest that environmental education may contribute not only to individual learning but also to strengthening collective community engagement that supports future communication regarding environmental risks.

11. Interpreting the Findings through the Protective Action Decision Model (PADM)

The findings can also be interpreted using the Protective Action Decision Model (PADM). According to PADM, individuals must first recognize environmental cues, understand available information, evaluate potential risks, and determine appropriate protective actions before behavioural responses occur (Lindell & Perry, 2012). Although the present study did not directly evaluate responses to disaster warnings, the observed levels of environmental literacy, environmental responsibility, and behavioural intention indicate that participants possess several cognitive and motivational characteristics emphasized within PADM.

Participants who understand environmental processes and recognize shared responsibility are theoretically better positioned to interpret future flood risk messages and evaluate recommended protective actions. Consequently, environmental education may strengthen the pre-decisional capacities described within PADM even before disasters occur. The present findings therefore extend PADM by highlighting environmental education as an upstream intervention that supports later protective decision-making.

12. The Risk Communication Readiness Model (RCRM)

The principal theoretical contribution of this study is the proposed Risk Communication Readiness Model (RCRM). Existing risk communication literature

primarily focuses on message design, communication channels, early warning systems, and institutional coordination. While these components remain essential, relatively little attention has been directed toward the conditions that enable communities to effectively receive and utilize risk communication.

The RCRM proposed in this study addresses this gap by conceptualizing risk communication readiness as a combination of cognitive, psychological, and social capacities that develop before communication occurs. Within this framework:

a. environmental education strengthens environmental literacy;
b. environmental literacy reinforces environmental responsibility;
c. environmental responsibility supports stronger awareness of environmental risks;
d. these conditions contribute to community preparedness;
e. preparedness increases readiness to receive, understand, and act upon future flood risk communication.

Rather than replacing existing disaster communication theories, the RCRM complements them by emphasizing community capacity building as a prerequisite for communication effectiveness.

The findings have several implications for disaster risk reduction policy and practice. First, environmental education programs should be recognized not only as sustainability initiatives but also as strategic investments in disaster preparedness (UNDRR, 2015; UNESCO, 2020; WHO, 2021). Integrating environmental education into local disaster risk reduction policies may strengthen communities' ability to understand and respond to future risk communication. Second, local governments should incorporate household waste management education into community flood mitigation programs. By linking everyday environmental practices with flood prevention, communication efforts can become more relevant and actionable for residents. Third, disaster management agencies should collaborate with environmental organizations, schools, and community groups to promote continuous environmental learning rather than relying solely on communication campaigns during emergencies. Finally, community-based educational initiatives can strengthen trust, participation, and shared responsibility, creating a stronger social foundation for effective disaster communication.

This study contributes to disaster risk reduction literature in three ways. First, it introduces Risk Communication Readiness as a distinct analytical construct that complements existing research on disaster communication. Rather than focusing on message dissemination, the study emphasizes the capacities that communities need before communication can be effective. Second, the study integrates theories that are often examined separately Risk Communication Theory, the Protective Action Decision Model (PADM), Environmental Literacy Theory, and Community Preparedness Theory into a single conceptual framework, the Risk Communication Readiness Model (RCRM). Third, the study broadens the role of environmental education within disaster risk reduction by demonstrating that educational programs may contribute not only to environmental awareness but also to the social

and cognitive conditions that support future disaster communication.

Several limitations should be acknowledged. First, the study involved a relatively small number of participants from a single community, which limits the generalizability of the findings to other settings. Second, the evaluation relied on post-program self-reported survey responses and did not include pre-intervention measurements or longitudinal follow-up. As a result, changes over time could not be assessed. Third, the proposed Risk Communication Readiness Model was developed conceptually and interpreted through descriptive findings rather than statistically tested. Future research should employ larger samples and inferential methods, such as structural equation modeling or path analysis, to examine the relationships among the proposed constructs. Finally, future studies should directly measure flood risk perception, preparedness behaviors, and responses to actual warning messages to further validate and refine the RCRM across diverse hazard contexts.

E. CONCLUSION

Urban flood mitigation requires more than effective warning systems and well-designed communication messages (UNDRR, 2015; WHO, 2021). It also depends on whether communities possess the knowledge, environmental responsibility, and social capacity necessary to receive, interpret, and act upon risk information. Despite the growing recognition of risk communication within disaster risk reduction, the preparatory conditions that enable effective communication have received comparatively limited scholarly attention. This study examined the outcomes of a community-based environmental education program in Pamulang District, South Tangerang City, Indonesia, to explore the conditions supporting risk communication readiness. The descriptive findings demonstrated consistently high levels of environmental literacy, shared environmental responsibility, behavioural intention, and community engagement among participants. Although the study did not directly assess responses to disaster warnings or flood preparedness behaviors, these findings indicate favourable social and cognitive conditions that may support future flood risk communication initiatives.

The principal contribution of this research is the introduction of the Risk Communication Readiness Model (RCRM). Unlike conventional disaster communication frameworks that primarily emphasize message delivery, communication channels, or early warning systems, the proposed model highlights the importance of community readiness before communication occurs. The model suggests that environmental education strengthens environmental literacy, reinforces environmental responsibility, supports risk perception, enhances community preparedness, and ultimately contributes to greater readiness for risk communication. The findings also broaden the role of environmental education within disaster risk reduction. Rather than viewing environmental education solely as a sustainability initiative, this study argues that it can function as an important capacity-building strategy that prepares communities for future disaster communication (UNESCO, 2020; Lindell & Perry, 2012).

Although the study is based on a relatively small sample and descriptive analysis, it offers an initial conceptual foundation for integrating environmental education into community-based flood risk communication strategies. Future studies involving larger and more diverse populations are needed to statistically validate the proposed Risk Communication Readiness Model across different environmental and disaster contexts.

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