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A Community-Based Flood Early Warning System and Emergency Simulation in Lampeuot, Banda Aceh

Riswandi Riswandi, Taufiq C. Dawood, Kamal Fachrurrozi*), Wisnu Satria, Ichwan Ichwan, Mirzatul Kadri, Naswatun Zikra, Zia Thahira, Maulidar Agustina, Faizah Amalina

Faculty of Economics and Business, Universitas Syiah Kuala, Banda Aceh, Indonesia

Email Korespondensi: kafazi90@usk.ac.id

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Abstract

Community-based early warning systems are critical in flood-prone areas where formal warning infrastructure often fails to reach the most vulnerable households. Lampeuot Village in Banda Aceh experienced severe flooding in November 2025, revealing gaps in local preparedness, unclear roles, and fragmented emergency communication. This community service program aimed to strengthen flood preparedness in Lampeuot by developing a community-based early warning system and conducting an emergency response simulation using a service-learning approach. Lecturers and students from the Department of Development Economics worked with village officials, disaster volunteers, women and youth representatives, and flood-affected households through participatory education sessions, risk mapping, co-design of early warning procedures, and a village-level simulation. Pre- and post-questionnaires from 52 participants showed substantial improvements in knowledge of flood risks, understanding of early warning elements, clarity of roles, and confidence to respond. The program produced a locally owned early warning protocol and highlighted the value of integrating scientific concepts, local knowledge, and simple communication technologies to support community resilience and achieve disaster-related Sustainable Development Goals.

Keywords: Community-Based Early Warning System, Flood Preparedness, Service Learning, Disaster Risk Reduction, Lampeuot Banda Aceh

INTRODUCTION

Community-based disaster risk reduction has become increasingly important amid the intensification of climate. Floods are occurring more frequently and intensely, affecting livelihoods, infrastructure, food security, and socioeconomic development, particularly in low- and middle-income countries (UN DESA, 2023) . Global initiatives such as the United Nations' Early Warnings for All emphasize that effective early warning systems should reach vulnerable communities and translate hazard information into timely collective action (Aprianti, 2025; Haque et al., 2024). However, substantial gaps remain, particularly at the "last mile," where limited community participation, weak communication mechanisms, and unclear response procedures often prevent warnings from becoming effective preparedness actions.

Indonesia is highly exposed to hydrometeorological hazards, including riverine and coastal floods, with recurrent disasters disrupting livelihoods, infrastructure, education, health services, and local economic activities. Aceh faces particularly complex risks due to the interaction of hydroclimatic and tectonic hazards, while institutional fragmentation, limited fiscal capacity, and uneven community participation continue to constrain disaster risk reduction and climate adaptation. The severe floods and landslides that affected Aceh between 26 and 30 November 2025, affecting hundreds of thousands of people and causing substantial displacement and infrastructure damage, further demonstrated weaknesses in evacuation planning, communication, and local emergency response (Sufri & Lassa, 2024). In Desa Lampeuot, Banda Aceh, these conditions have increased the vulnerability of households, particularly those with limited resources, to recurring flood impacts.

Previous studies indicate that disaster preparedness in Aceh remains uneven, particularly in relation to community knowledge, training, coordination, and the integration of early warning information with actionable response plans (Yolanda et al., 2025; Sari et al., 2024). International evidence similarly shows that early warning systems are more effective when they combine scientific forecasting with local knowledge, community participation, social networks, clear communication pathways, simulations, and agreed response procedures (WMO, 2024). Thus, the challenge is not merely the availability of technological warning infrastructure but also the capacity of communities to understand, disseminate, and act upon warnings collectively (Nisa et al., 2025). This “last mile” gap is particularly relevant to Desa Lampeuot, where residents have experienced recent flooding but require stronger village-level warning protocols, emergency simulations, and clearly defined response roles.

To address these challenges, the Department of Development Economics, Faculty of Economics and Business, Universitas Syiah Kuala conducted the community service program “Community-Based Early Warning System Development and Emergency Response Simulation for Floods in Lampeuot Village, Banda Aceh” on 9 December 2025. The program combined participatory education on flood risks, co-development of a community-based early warning system, emergency response simulation, and distribution of basic food packages to households affected by the recent floods. The approach emphasized community co-creation by involving residents, local leaders, and disaster volunteers in identifying risk areas, establishing warning thresholds, assigning communication and evacuation roles, and utilizing locally accessible communication tools such as WhatsApp groups, mosque loudspeakers, and manual alarms.

The program aims to strengthen the capacity of residents and local institutions in Desa Lampeuot to anticipate, respond to, and recover from recurring floods. Specifically, it seeks to improve community understanding of flood risks, clarify communication and response roles, test evacuation procedures through simulation, and provide short-term assistance to affected households. This article therefore documents and critically reflects on the design, implementation, and early outcomes of the Lampeuot community-based early warning system and emergency simulation as a model of university–community partnership in disaster risk reduction. Its contribution lies in demonstrating how participatory disaster preparedness, low-cost communication technologies, simulation-based learning, social assistance, and local governance can be integrated to strengthen community resilience and support the achievement of SDGs 1, 3, 11, 13, and 17.

METHOD

The community service activity was implemented in Lampeuot Village, a flood-prone peri-urban area of Banda Aceh that is regularly affected by riverine and local drainage floods. The target community consisted of village officials, neighborhood leaders, disaster preparedness groups, women representatives, youth, and households affected by the November 2025 floods. Approximately 63 residents participated in at least one component of the program. Community members were actively involved as co-designers of the community-based early warning system (CB EWS), participants in emergency simulations, and providers of local knowledge regarding flood patterns, vulnerable groups, and feasible communication channels. The program was implemented through a service-learning approach involving lecturers and undergraduate students from the Department of Development Economics, Universitas Syiah Kuala, together with village authorities, religious leaders, disaster volunteers, and other local actors.



Figure 1. Community Service Documentation

The implementation consisted of several interconnected stages. First, a preparatory stage involved reviewing recent flood information, communicating with village authorities, identifying stakeholders, and conducting a rapid needs assessment concerning early warning, evacuation, and basic needs. Second, the service-learning framework was designed to connect classroom learning, community service, and student reflection. Third, participatory education was conducted on flood risks, early warning, and disaster preparedness, followed by group activities to map flood-prone areas, critical facilities, and evacuation routes. Participants and facilitators then identified warning indicators, defined warning levels, established communication channels, and assigned responsibilities for monitoring, warning dissemination, and evacuation support, resulting in a draft village-level CB EWS protocol.

The next stage involved an emergency response simulation based on the November 2025 flood experience. A mock warning was activated to test communication, household mobilization, and evacuation procedures. Lecturers and students observed response time, clarity of roles, communication effectiveness, and operational challenges, followed by a debriefing session to identify strengths and procedures requiring improvement. The program also included the distribution of basic food packages to flood-affected households identified by village authorities. This component linked disaster preparedness with immediate welfare support, while the final reflection session connected students' field experiences with service-learning, community resilience, and disaster economics.

The science and technology transferred were primarily people-centered and non-hardware innovations. These included simplified knowledge of flood risk and disaster risk reduction; the four components of an early warning system—risk knowledge, monitoring and warning services, dissemination and communication, and response capability; standard operating procedures defining roles and communication chains; and the use of accessible technologies such as mosque loudspeakers, WhatsApp groups, and mobile phones. Participatory risk mapping and simulation were also used as practical tools for community learning and preparedness. Supporting materials included presentations, posters, handouts, paper-based mapping tools, markers, stickers, loudspeakers, bells, attendance lists, and pre- and post-activity questionnaires, complemented by observation checklists and field documentation.

Data collection combined quantitative and qualitative approaches. Quantitative information was obtained from pre- and post-activity questionnaires measuring knowledge, attitudes, and self-reported preparedness, while qualitative information was collected through observations, informal interviews, student reflections, photographs, and village records. Program success was assessed through output indicators, including participant involvement, completion of the CB EWS protocol, and implementation of an emergency simulation, as well as outcome indicators such as changes in knowledge, confidence, clarity of roles, communication, and community feedback. Quantitative data were analyzed using descriptive statistics and simple pre-post comparisons, whereas qualitative data were examined through thematic analysis of observations, interviews, and reflections. Triangulation across these sources was used to strengthen the interpretation of the program outcomes.

RESULT AND DISCUSSION

The service learning program in Lampeuot involved 63 community members (see Table 1), exceeding the initial target of 50, including village officials, disaster volunteers, women, youth, and flood-affected households. Community members actively contributed to risk mapping, early warning roles, and emergency response simulations. This participatory approach aligns with the literature emphasizing that community-based early warning systems are most effective when residents act as co-designers rather than passive recipients (Haque et al., 2024; Chinguwo & Deus, 2022; Canwat, 2025). The service learning approach further strengthened collaboration between students, lecturers, and the community.

Table 1 shows that the activity engaged diverse community groups, including women, youth, and flood-affected households, ensuring that local needs informed the program. This supports SDG 1 (reducing vulnerability) and SDG 11 (strengthening community resilience).

Through group discussions, participants developed a community-based early warning system tailored to Lampeuot, comprising (1) a flood risk map identifying vulnerable areas and critical infrastructure; (2) locally defined warning indicators based on river levels, rainfall, and upstream information; (3) four color-coded warning levels; (4) a communication chain involving village officials, mosque loudspeakers, neighborhood leaders, and households through direct messaging and WhatsApp; and (5) standard operating procedures for each warning level, covering information dissemination, assistance to vulnerable groups, protection of valuables, and evacuation to designated safe locations.

Community members reported that this was the first time the village had formally documented warning procedures and responsibilities. Previously, responses relied largely on spontaneous and

informal communication, reflecting preparedness challenges reported in Aceh (Sari et al., 2024; Yolanda et al., 2025). The Lampeuot CB EWS therefore addresses the "last mile" gap by clarifying responsibilities and communication pathways needed for timely action (Samansiri et al., 2023; Aprianti et al., 2025).

Table 1. Profile of participants and involvement in activities

Category	Number	Percentage
Total participants	63	100%
Female participants	32	50.8%
Male participants	31	49.2%
Village officials and staff	8	12.7%
Disaster volunteers / village guards	10	15.9%
Community leaders / religious leaders	7	11.1%
Women representatives	14	22.2%
Youth representatives	13	20.6%
Flood affected households	45	71.4%

Source: Data processing.

The co-design process integrated scientific knowledge with local experience of the November 2025 floods. This approach reflects evidence that effective early warning systems should incorporate local knowledge, social networks, and impact-based procedures rather than relying solely on centralized infrastructure (Haque et al., 2024; Canwat, 2025). As a result, the system was both technically informed and locally acceptable.

Table 2. Summary of pre and post activity knowledge and preparedness scores (n = 52)

Indicator	Pre activity mean	Post activity mean
Knowledge of local flood hazards (0–100 scale)	58	84
Knowledge of early warning elements	54	86
Clarity about own role in CB EWS	41	82
Confidence to respond to flood warnings	49	83

Source: Data processing.

As shown in Table 2, average knowledge and perceived preparedness scores increased by more than 25 points on a 0–100 scale across all indicators, with the largest improvement in clarity of individual roles in the CB EWS. Participants reported better understanding of "who should call whom" and "what to do first" when water levels rise. These findings are consistent with evidence that participatory approaches and drills improve disaster knowledge, risk perception, and readiness (Chinguwo & Deus, 2022; Haque et al., 2024). The improved role clarity is particularly relevant given previous findings that unclear responsibilities remain a weakness in disaster preparedness and response in Aceh and other Indonesian provinces (Aprianti et al., 2025; Yolanda et al., 2025).

The emergency response simulation showed that most designated role holders could perform their tasks within the expected time, including activating mosque loudspeakers, sending WhatsApp messages, and checking on elderly households. However, several bottlenecks emerged, including delayed communication with households at the village edges, uncertainty about alternative evacuation points, and limited household preparedness of essential items. In response, participants agreed to update neighborhood contact lists, mark alternative evacuation routes, and promote simple family emergency kits. This iterative process supports the view of early warning systems as "learning systems" that evolve through practice and feedback (Samansiri et al., 2023).

The simulation also demonstrated the service learning cycle by connecting students' theoretical knowledge of disaster risk reduction and development economics with practical challenges such as time pressure, communication delays, and social constraints. At the same time, community members were able to test and refine the procedures in a low-risk setting before facing future flood events. This reciprocal learning process strengthened both the practical relevance of the CB EWS and the learning experience of participating students.

From an SDG perspective, the Lampeuot program contributes to Target 11.5 by reducing disaster impacts, Target 13.1 by strengthening resilience to climate-related hazards, and Target 1.5 by supporting vulnerable and flood-affected households through preparedness activities and basic food assistance. The program also reflects SDG 17 through collaboration among the university, local government, and community. By translating global and national frameworks, including the "Early Warnings for All" initiative and Indonesian disaster management policies, into local action, the program demonstrates how early warning can be linked with social protection and community resilience (UNDRR, 2022).

The Lampeuot initiative also shows potential as a transferable community-based practice. Its main strengths are the integration of disaster education, co-design of the CB EWS, simulation, social assistance, and locally available communication technologies within a short intervention. The active involvement of diverse community groups further supports its adaptability to other flood-prone villages, although implementation should remain sensitive to local culture, institutional structures, and available resources.

Despite these achievements, several limitations should be acknowledged. The one-day field activity limited the depth of engagement, particularly among residents working outside the village, while the recent November 2025 disaster may have affected participation among households still experiencing physical, emotional, and economic pressures. Sustained engagement is important for embedding disaster preparedness practices, while post-disaster stress and uncertainty can influence community participation (Sufri & Lassa, 2024; Nisa et al., 2025).

The CB EWS also remains partly dependent on electricity, loudspeakers, and mobile networks, which may be disrupted during severe floods. Although manual alternatives such as megaphones and door-to-door communication were included, these still depend on human availability and mobility (Aprianti et al., 2025; Haque et al., 2024). In addition, the assessment relied on a relatively small number of respondents and immediate pre- and post-activity measurements, without follow-up data to determine whether knowledge and preparedness improvements were sustained.

Overall, these limitations reflect broader structural and contextual challenges, including limited resources, vulnerable communication infrastructure, and the slow institutionalisation of disaster preparedness (Sufri & Lassa, 2024; Yolanda et al., 2025). The Lampeuot experience indicates that

service learning can strengthen community-based early warning and preparedness, but longer-term partnerships, follow-up activities, and institutional support are needed to sustain these gains and address the broader drivers of disaster risk in Aceh and similar regions.

CLOSING

The community based early warning system development and emergency response simulation in Lampeuot Village successfully met the objectives set out in this community service program. Through a service learning approach, the activity engaged 63 residents from diverse backgrounds and facilitated the co design of a simple but concrete CB EWS that clarified roles, communication channels, and standard operating procedures. Pre and post questionnaires showed substantial increases in participants' knowledge of flood risks, understanding of early warning elements, clarity of individual roles, and confidence to respond, indicating that the combination of education, co creation, and simulation was effective in strengthening local preparedness.

These results confirm that a short, well structured university community partnership can help address the "last mile" gap in early warning systems identified in previous studies. The Lampeuot experience demonstrates that integrating scientific concepts, local knowledge, and low cost communication technologies can produce a people centered early warning mechanism that is understood and owned by the community. The inclusion of basic food assistance for flood affected households also linked preparedness efforts with immediate welfare support, which is important in a context where recurring floods threaten livelihoods and deepen vulnerabilities.

The implications of this program are significant for both practice and policy. At the community level, the CB EWS and simulation provide a practical foundation for reducing disaster related losses in future flood events and contribute directly to the achievement of SDG 1, SDG 11, and SDG 13. At the institutional level, the activity shows how service learning can be used as a vehicle for universities to operationalise their role in disaster risk reduction and sustainable development. The Lampeuot model can be adapted and scaled to other flood prone villages in Aceh and beyond, provided that it is embedded in longer term partnerships and supported by local government policies and resources that sustain and periodically update the system.

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