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Implementation of multisensor flood-emergency bags for protecting valuable documents in at-risk communities

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ABSTRACT

Felda Mata Air, Perlis, Malaysia, is one of the communities frequently affected by seasonal flooding, resulting in the loss of valuable documents and delayed emergency response. This community service program aimed to improve community preparedness through the implementation of a multisensor flood-emergency bag equipped with a water level sensor, audible alarm, LED indicator, GPS module, smartphone notification system, and waterproof document compartment. The program was conducted using a participatory approach consisting of community training, hands-on practice, field simulation, and mentoring. The effectiveness of the program was evaluated using pre-test and post-test assessments and analyzed using the normalized gain (N-Gain) method. The results showed that the average participant score increased from 5.49 to 7.78, representing a 41.54% improvement, with an N-Gain value of 0.51, indicating a moderate improvement in disaster preparedness knowledge. Participants also demonstrated the ability to operate the multisensor emergency bag independently during flood simulations. These findings indicate that integrating low-cost multisensor technology with community-based disaster education effectively enhances preparedness and contributes to protecting valuable documents during flood emergencies.

INTRODUCTION

FELDA Springs in Perlis, Malaysia, is a residential area located in low-lying areas and is very vulnerable to seasonal flooding, especially during the monsoon period. Flood events have become increasingly frequent due to climate change and rapid land-use changes, emphasizing the importance of strengthening community preparedness and local resilience through technology-based disaster risk reduction strategies Cutter, 2020). High rainfall, limited drainage conditions, and proximity to watershed areas have caused the region to be repeatedly affected by flooding in recent years. Rainfall in the last three months is shown in Table 1. The period from October to December is a critical phase for the Perlis area, including FELDA Mata Air, because it is a transition period and the peak of the northeastern monsoon. In October and November, rainfall reaches its highest level of 237–210 mm, often triggering seasonal flooding (Nazri et al., 2018; Sabri et al., 2013; Sakke et al., 2017).

Table 1. Rainfall at Felda Springs, Perlis

Moon	Rainfall (mm)	Remarks
October	237 mm	Peak of the rainy season (the northeastern monsoon starts to be active)
November	210 mm	High rainfall and frequent inundation/flooding
December	154 mm	The intensity is still high; it rains almost every day

Table 1 shows that the highest rainfall in Felda Mata Air occurs during October (237 mm), followed by November (210 mm), while rainfall remains relatively high in December (154 mm). These data indicate that the community experiences prolonged exposure to seasonal flooding during the Northeast Monsoon. Similar conditions have been reported in many flood-prone regions worldwide, where community preparedness and early warning systems play a crucial role in reducing disaster impacts (Basher et al., 2006). Consequently, implementing a community-based flood preparedness program supported by multisensor technology is highly relevant to improve early response and reduce disaster-related losses.

The floods that occurred not only disrupted the community's economic activities but also resulted in losses in the form of damage to houses, loss of important documents, and delays in the evacuation process. Until now, people still rely on manual information or warnings from other residents when floods begin to rise, without an easy-to-operate, technology-based early warning system. This condition shows the need for intervention through community empowerment programs that are able to increase preparedness and speed of response to residents in dealing with flood disasters. The people of Perlis themselves are a society with social characteristics that tend to be rural or rural. Most of the people live in traditional villages, agricultural areas, and FELDA settlements, so access to knowledge about technology-based disaster implementation is still very limited. Therefore, the implementation of a multisensor disaster preparedness bag integrated with Internet of Things (IoT)-based monitoring technology is expected to improve flood preparedness and support timely emergency response. Previous studies have shown that IoT-based flood monitoring systems significantly enhance early warning capabilities and community safety (Arshad et al., 2019; Cutter, 2020; Paul et al., n.d.)

Through discussion and identification with FELDA, several priority problems were successfully mapped. First, the community needs early warning devices that are practical, can be used individually, and are able to reduce the impact of flood disasters. Second, many important documents such as birth certificates, land certificates, and identity cards were damaged or lost during floods, as there were no safe and waterproof storage containers. From a scientific perspective, two fields are considered relevant to solving this problem: Instrumentation Physics and Information Systems for the development of early warning technology, as well as Disaster Management and Community Empowerment. The agreement between the proposer and the partner stipulates two main problems that will be solved in this program, namely the aspect of technology implementation (lack of a technology-based early warning system) and the low preparedness capacity of residents in the flood evacuation process (knowledge and skills aspects).

This service program aims to improve the preparedness of the FELDA Mata Air community through the implementation of a multi-sensor disaster preparedness bag that can detect water level rise, provide alarm signals, send notifications to mobile phones, and provide water-repellent compartments for important documents. In addition, this program aims to provide education and training on evacuation measures, the use of equipment, and the formation of flood preparedness cadres who can continue activities after the program is completed. A participatory approach is carried out so that the community is actively involved in the planning, implementation, and evaluation stages. The involvement of local cadres is expected to strengthen the sustainability of the program and ensure that the use of technology is not only temporary. This program also supports the achievement of the Sustainable Development Goals (SDGs), especially Goal 11 on resilient cities and settlements, and goal 13 on climate change action, through increasing community adaptation capacity to hydrometeorological disasters.

Based on the description above, this international service program is expected to be able to have a real impact on the FELDA Mata Air community in dealing with flood disasters, improving preparedness, accelerating evacuation responses, and reducing the risk of physical and administrative losses. The technology implemented and the education provided are expected to be a model of collaboration between technology and community empowerment that can be replicated in other regions with similar risk characteristics.

METHODS

The implementation of the International Community Service program at FELDA Mata Air, Perlis, Malaysia, in this activity is a collaboration of relevant scientific fields, namely Physics (Instrumentation) and Information Systems (Azhari et al., 2024; Bondan Dwi & Imam, 2011). The method of implementing this service program actively involves partners, especially in mapping problems (Salamah et al., n.d., 2022).

The community service program consisted of four sequential stages. The first stage involved an initial survey to identify flood-prone locations, community needs, and evacuation routes in collaboration with FELDA management. The second stage focused on training participants to operate the multisensor flood-emergency bag, including sensor operation, alarm activation, GPS functionality, smartphone notifications, and waterproof document storage. The third stage involved field testing and flood simulation to evaluate participants' ability to use the device during emergencies. Finally, the effectiveness of the program was evaluated using pre-test and post-test instruments, and knowledge improvement was analyzed using the normalized gain (N-Gain) method (Nissen et al., 2018; Teel, 1996).

The first stage is an initial survey and analysis of field conditions, which includes mapping flood-prone points, interviews with residents and FELDA administrators, and identifying the safest evacuation route. At this stage, the proposing team collected information about the characteristics of floods in FELDA Mata Air, residents' habits when facing floods, and the readiness of the community to receive new technology. The survey results were used to adjust the design of the activity, ensure the relevance of the training materials, and determine the location of the evacuation simulation.

The second stage was training on the use of multisensor disaster preparedness bags, which was attended by residents from various groups, including parents, youth, and representatives of FELDA management. The training was conducted by direct demonstration methods, practical use, and question-and-answer sessions. Participants were trained to understand how water height sensors work, how to activate alarms, read LED indicators, check GPS functions, and connect devices with mobile phones. In addition, participants were given guidance on simple device maintenance, such as checking the battery, calibrating the sensors, and cleaning the waterproof bag. In this activity, team members who have expertise in the field of electronics and IoT are fully responsible for providing explanations and technical assistance.

The third stage is assistance in installing, adjusting, and testing sensors in the residents' environment. At this stage, the team, together with residents, tested the device under various conditions to ensure sensor sensitivity and alarm reliability. Trials were conducted in low-water environments, water splashes, and scenarios of gradual increase in water level. This process also involves students helping with documentation, monitoring technical functions, and processing test data results. Citizen participation is very important at this stage because they will use the device independently after the program is completed.

The fourth stage is the evaluation of the program and the sustainability plan. Evaluation is carried out through pre-test and post-test instruments (Shivaraju et al., 2017; Tayyaba Gul Malik & Rabail Alam, 2019). Knowledge improvement is carried out by looking for the average pre-test and post-test, which is then analyzed using the N-Gain method (Coletta, 2023; Gagunashvili, n.d.; Sullivan & Artino, 2014). The N-Gain analysis formula is shown in Equation 1.

$$g=\frac{\text{Post-Pre}}{\text{100-Pre}} \qquad (1)$$

Where g = N-Gain value (improvement in training results), Post = post-test average value, Pre = pre-test average value. The categories of improvement, based on the N-Gain method, are shown in Table 1.

Table 2. Parameters of the N-Gain increase category

Value g	Category
$g < 0.3$	Low
$0.3 \leq g \leq 0.7$	Medium
$g > 0.7$	Height

RESULTS AND DISCUSSION

The community service program involved 33 participants representing residents and local community leaders of Felda Mata Air. The implementation was conducted according to the planned stages, including community education, hands-on training, field simulation, and evaluation. During the practical sessions, participants successfully operated the multisensor flood-emergency bag by activating the water-level sensor, alarm system, LED indicator, GPS module, and smartphone notification feature. Participants also demonstrated the proper use of the waterproof compartment to protect valuable documents during simulated flood conditions (Janhunen et al., 2019; Krishnamoorthi, 2020).

Results of the pre-test and post test as shown in Table 2. The results of the analysis showed that the average pre-test score of participants was 5.49 (scale 10), while the average post-test score increased to 7.78. This shows an increase of 41.54%. Based on the table of pre-test and post-test results, it can be seen that there is a significant change in values after learning interventions are carried out. The pre-test scores that have been converted to a scale of 10 show a fairly wide variation in participants' initial abilities, with a range of scores from 0.67 to 9.33. This indicates that the participants have a heterogeneous knowledge background before participating in the activity.

After the implementation of learning, post-test scores showed a more even increase with the dominance of scores in the medium to high range, which was between 5.33 to 9.33. In general, most participants experienced an increase in grades, which indicates that the material provided can be well understood by the participants.

If analyzed further, there are several important patterns that can be identified. First, participants with low initial scores (e.g., in the range of 0.67–3.33) experienced a significant increase to reach a score above 7 on the post-test. This shows that learning interventions have a strong impact on improving participants' basic understanding. Second, participants with medium to high initial scores tended to experience smaller or relatively stable improvements. In some cases, there is a slight decrease in scores, which can be caused by factors such as fatigue, differences in the difficulty of the questions, or variations in concentration when taking the post-test. Nevertheless, overall, the upward trend remains dominant.

Table 2 demonstrates that most participants achieved higher post-test scores than pre-test scores. Participants with initially low scores experienced the greatest improvement, indicating that the training effectively enhanced fundamental knowledge regarding flood preparedness and the operation of the multisensor emergency bag.

Table 3. Pre-test and Post-test scores of Training Participants

No	Pre-Test	Pre Scale 10	Post-Test	Post Scale 10
1	13	8.67	11	7.33
2	1	0.67	13	8.67
3	6	4.00	14	9.33
4	5	3.33	12	8.00
5	4	2.67	8	5.33
6	8	5.33	12	8.00
7	7	4.67	11	7.33
8	5	3.33	13	8.67
9	3	2.00	14	9.33
10	12	8.00	12	8.00
11	3	2.00	8	5.33
12	12	8.00	12	8.00
13	12	8.00	11	7.33
14	12	8.00	13	8.67
15	12	8.00	14	9.33
16	12	8.00	12	8.00
17	13	8.67	8	5.33
18	11	7.33	12	8.00
19	11	7.33	11	7.33
20	11	7.33	13	8.67
21	4	2.67	14	9.33
22	5	3.33	12	8.00
23	11	7.33	8	5.33
24	4	2.67	12	8.00
25	12	8.00	11	7.33
26	13	8.67	13	8.67
27	10	6.67	14	9.33
28	4	2.67	12	8.00
29	14	9.33	8	5.33
30	3	2.00	12	8.00
31	4	2.67	11	7.33
32	6	4.00	13	8.67
33	9	6.00	14	9.33

In aggregate, the average pre-test score of 5.49 increased to 7.78 on the post-test (scale 10), which shows an increase of 41.54%. In addition, based on the calculation of normalized gain (N-Gain), a value of 0.51 was obtained. Based on Table 1 on the parameters of improvement in training outcomes, the value refers to the improvement in the medium category. This shows that the training conducted is quite effective in improving the knowledge of the participants, although there is still room for further improvement.

The increase in participants' knowledge indicates that integrating multisensor technology with community-based education effectively strengthens disaster preparedness. Practical demonstrations and direct simulations enabled participants to understand not only the theoretical aspects of flood mitigation but also the practical operation of the emergency bag during flood events. Similar findings have been reported in previous studies, where technology-assisted disaster education significantly improved community preparedness and response capacity.

The N-Gain value of 0.51, categorized as moderate, suggests that the training program was sufficiently effective in improving participants' knowledge. Nevertheless, this result also indicates opportunities for further enhancement through periodic refresher training, continuous mentoring, and wider dissemination to neighboring communities. Sustainable implementation is expected to strengthen community resilience against future flood disasters (Paton, 2003).

CONCLUSIONS

The implementation of the multisensor flood-emergency bag successfully improved disaster preparedness among the Felda Mata Air community. Participants demonstrated a better understanding of flood mitigation and emergency response, as reflected by the increase in the average score from 5.49 to 7.78 (41.54%) and an N-Gain value of 0.51 (moderate category). These findings indicate that integrating affordable multisensor technology with community-based disaster education effectively strengthens community resilience and supports the protection of valuable documents during flood emergencies.

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