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Youth empowerment through the implementation of an IoT-based flood early warning system to strengthen community preparedness

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ABSTRACT

Frequent flooding in Sidomulyo Village causes significant losses both in the residential sector of residents. The lack of disaster management infrastructure and the lack of knowledge of the Sidomulyo Village Youth Organization regarding flood mitigation have implications for low community preparedness for flood disasters. The purpose of this activity is to provide a solution by increasing the knowledge of youth in flood preparedness by implementing Early Warning System (EWS) technology integrated with the Internet of Things (IoT); and the creation of a Flood Safe Zone Map. The implementation method is carried out in stages including socialization, counseling, training, technology application, mentoring, evaluation, and program sustainability planning. The results of the activity show that the Youth of the Sidomulyo Village Youth Organization are very enthusiastic about this program, as evidenced by a positive response in the form of an increase in flood preparedness knowledge by 75%. The availability of IoT-integrated EWS infrastructure for flood disaster mitigation. In addition, the partners also succeeded in compiling a safe zone map. This community empowerment activity is expected to strengthen the role of Karang Taruna youth in reducing the risk of flood disasters that occur.

Keywords: *flood; EWS; IoT; mitigation*

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INTRODUCTION

Lamongan Regency is divided into 27 sub-districts and 476 villages. The regency's landmass is bisected by the Bengawan Solo River, and its terrain can be broadly classified into three types. The southern region consists of relatively fertile lowlands, while the southern and northern parts are characterized by rocky limestone hills with moderate fertility. The north-central area, known as the Bonorowo region, is prone to flooding.

The agricultural sector—particularly food crop production—is influenced by various interrelated factors, including climate change (Ana W et al., 2020), population growth (Aprillya et al., 2019; Bianto & Aprillya, 2023; Dzulkarnain et

al., 2019), agricultural land conversion (Aprillya & Chasanah, 2021), and natural disasters (Aprillya et al., 2022), such as floods (Dzulkarnain et al., 2019).

In 2021, the cumulative area of agricultural land affected by flooding in Sidomulyo Village reached 30 hectares. The flood caused significant losses for farmers, amounting to approximately IDR 150 million, as their farmland was inundated. This led to crop failures, substantial economic losses, and a decline in household income.

Additionally, some residents of Sidomulyo Village live in semi-permanent or non-permanent houses with floors built directly on the ground. Consequently, when floods occur, these houses are often inundated. The situation is further exacerbated by the lack of adequate physical infrastructure for flood management. Moreover, the western part of Sidomulyo Village directly borders Bengawan Njero, as illustrated in Figure 1 below.

Figure 1. Bengawan Njero as wastern part of Sidomulyo village

This community service activity focuses on flood risk mitigation by first enhancing the knowledge of the Sidomulyo Village Youth Organization regarding disaster preparedness in their area, particularly floods.

The flood mitigation model to be implemented must be supported by strengthening physical infrastructure for flood management, such as an Early Warning System (EWS) integrated with the Internet of Things (IoT). The second program involves the implementation of an IoT-based EWS capable of providing real-time flood information to the Sidomulyo Village community.

It is therefore expected that the community, especially the Karang Taruna youth group of Sidomulyo Village, will become the vanguard among young people who are environmentally conscious and knowledgeable about flood disaster mitigation. The impact of this program will not only enhance Sidomulyo Village's preparedness for flooding but also strengthen the role of youth in community-based disaster risk reduction.

METHOD

The implementation method of the Community Partnership Empowerment (PKM) activity is carried out using a participatory approach method where target partners will be fully involved in each activity. The target partners in this

community service activity are the youth of the Sidomulyo Village Youth Organization located in Sidomulyo Village, Deket, Lamongan, East Java, Postal Code 62291. Community service is carried out for eight months, starting from May 2025 to December 2025. In this activity, partners play an active role in every stage of socialization, training, technology implementation, mentoring and evaluation, and program sustainability it can be seen at Fingure 2. This community service is a continuation of the previous program (Aprillya et al., 2024). In 2025, this PKM activity continues the continuity of the program that was offered in the previous year's PkM, namely integration with the application of IoT equipped with several sensors such as water level, rainfall sensors and water flow sensors. The sensors used are connected to a microcontroller. The data collected from the sensors, then sent via IoT for flood mitigation has been prepared by the community service. The educational profile of the Sidomulyo Village youth organization consists of young people aged 13 (thirteen) to 45 (forty-five) years. Currently, the Sidomulyo Village Youth Organization, Deket Lamongan District, has 30 active members, both those who are still domiciled and/or those who are currently studying or working outside the city.

Figure 2. Method community service

Socialization: The purpose of this outreach activity is to provide a platform for community service providers to share the planned Community Service Program (PKM) program, with the hope of gaining input and support for its successful implementation.

Training and Counseling, the purpose of this activity is to increase the capacity of the Youth Organization to increase independence in flood emergency response. Technology Application, the purpose of the technology implementation activity is to provide direct training to the Youth Organization in the use and maintenance of an IoT-integrated Early Warning System (EWS) as flood mitigation infrastructure.

Mentoring and Evaluation, the purpose of the mentoring and evaluation is to ensure the Youth Organization understands flood disaster education and partners' understanding of the use of an IoT-integrated EWS.The objective of this sustainability program is to encourage the use of IoT-integrated Early Warning Systems (EWS) as part of flood mitigation infrastructure. Program Sustainability Stages: Handover of assets, namely the IoT-integrated Early Warning System (EWS) and the Safe Zone Map. Follow-up training plan: Developing an annual training agenda or follow-up training on flood mitigation.

RESULT AND DISCUSSION

Condition beginning partners. Before program implementation, understanding of the youth of the Sidomulyo Youth Organization about mitigation flood is at a low level. This is look from discussion beginning that part big youth no

know steps emergency when flood come, and not yet Once involved in compilation plan preparedness in the village. In addition, the role of Karang Taruna in issue environment and disasters almost Not yet seen – they Not yet Once initiate reduction activities risk flooding in village. Preparedness structural the village is also minimal: no There is system warning flood, and not available map evacuation or sign track evacuation in the field. Findings This confirm the need intervention in aspects improvement human resource capacity and procurement technology support mitigation.

Figure 3. Discussion together between PKM team with karang taruna partners of Sidomulyo Village

Implementation of the socialization and education program. The socialization activity, held on August 11, 2025, at the Village Hall, was attended by 45 participants (administrators and members of the Youth Organization (Karang Taruna) it can be seen in Figure 4, as well as village officials. The participants' enthusiasm was quite high, as evidenced by the active interaction during the question session. The counseling material regarding the annual flood cycle in their area raised awareness that flooding can be anticipated through pre-disaster measures. Participants were also invited to discuss the potential role of youth in dealing with floods. The results of the pre-test given at the beginning of the event showed an average initial understanding score of only around 60% (categorized as poor). Many participants did not yet know the benefits of an early warning system or the correct evacuation procedures. After the socialization and counseling session was completed, the post-test showed an average knowledge score increased to 77%, which is considered good. There was an increase in understanding of around 17%. This increase indicates that the material presented was well received and relevant to the needs of participants. After the counseling activity, partners better understood the importance of pre-disaster efforts such as forming a standby cadre and procuring emergency response equipment at the community level.

The 60% increase in pre-test scores to 77% in the post-test not only demonstrates the success of the material delivery but also indicates the effectiveness of the participatory approach in the outreach and training activities. Participants showed a more active response when the material was presented in a way that aligned with conditions occurring in Siidomulyo Village, such as the

increase in water discharge volume in the Bengawan Njero River, which is familiar to them. Furthermore, the training method, which combined lectures, discussions, and mini-flood simulations, made it easier for participants to understand the concept of risk and preparedness steps. Direct involvement in identifying flood-prone areas increased their sense of ownership of the activity's outcomes, which contributed significantly to the increase in post-test scores.

Figure 4. Socialization and Extension Activities with the Sidomulyo Village youth organization

Implementation of an IoT-integrated EWS. On August 18, 2025, the team installed an IoT-based flood early warning system at a village river location. The EWS device consists of an ultrasonic sensor installed in the Bengawan Jero River to measure water levels. The sensor is connected to a microcontroller that has been programmed to send water level data periodically via the internet (IoT) to a monitoring dashboard. During training, members of the Karang Taruna (Youth Organization) learned how to read the indicators on the dashboard and the procedures for turning the device on/off, it can be seen in Figure 5. They were also provided with simple maintenance knowledge, such as checking the power supply and sensor cleanliness. The active participation of youth in the EWS installation increased their sense of ownership of the technology. Villagers welcomed the presence of the early warning device. With an IoT-integrated EWS, information on potential flooding can be received more quickly and accurately, so that evacuation and asset rescue times can be optimized. The implementation of this technology is in line with the trend of community-based disaster risk reduction supported by IoT (Sutarti et al., 2022), as reported in other studies (Valentin et al., 2021).

However, the community service team faced several technical challenges, including the village's slightly unstable internet network. To address this, the team adjusted the solar panel power and added a data logger to ensure the system continued recording data even if the connection was temporarily interrupted.

Figure 5. IoT integrated EWS training activities with the Sidomulyo Village youth organization

Participatory mapping of safe zones. The next phase, on August 21, 2025, focused on creating a flood-safe zone map with the community, it can be seen in Figure 5. This process began with a mapping workshop at the village hall, where the community service team introduced the concept of Community Based Mapping. Participants were encouraged to familiarize themselves with the village layout and their local knowledge. Community participation was strong throughout the process, with each participant providing input based on their experiences with flooding in previous years. All this local information was then marked on the working map. Using Geographic Information System (GIS) software, elevation data was used to verify truly safe zones (with higher elevations). The final result was a simple village-scale flood risk map, marking vulnerable areas (red), relatively safe areas (green), as well as evacuation routes and assembly points (the village hall as a temporary shelter). This map was printed in large color and displayed in front of the village office for easy access by residents.

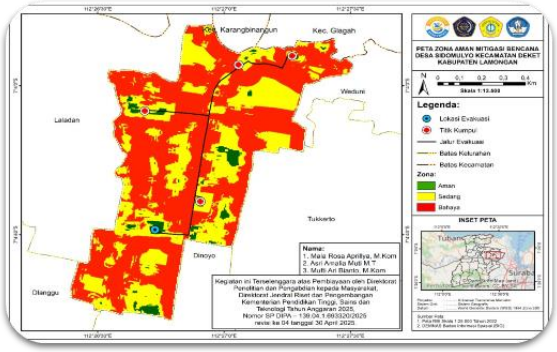

Figure 6. Sidomulyo Village safe zone

The benefits of creating these safety zone maps were greatly felt by residents. First, the maps provided a clear guide when flooding occurred – residents knew where to evacuate, which routes to take, and which areas to avoid. Second, the participatory process trained the community to use local knowledge for risk management. After the training, there was an increase in community

technical skills in using simple technologies (maps, EWS sensors) and a collective awareness of the importance of community-based mitigation was formed. This is consistent with a study (Nauli et al., 2025) and colleagues, where community participation in creating risk maps and early warning systems was shown to strengthen the village's adaptive capacity and resilience in the face of disasters. By having their own evacuation maps, residents felt more confident and independent because they were no longer entirely dependent on external assistance during floods (Hasan & Budyastomo, 2018).

Figure 7. Handover of the IoT integrated EWS set and solar panels for the karang taruna partners of Sidomulyo Village

Evaluation of program outcomes. Overall, the program's output targets were achieved successfully. Partners' knowledge of flood mitigation increased by >75% (exceeding the initial target of 75%). The IoT EWS system has been installed and is functioning, marking an increase in the village's structural capacity for early flood detection. A locally relevant safety zone map has been developed. The immediate impact of this program is that Sidomulyo Village now has an early warning mechanism and evacuation plan, which previously lacked one. The expected long-term impact is increased community resilience to annual flooding. The presence of a cadre of disaster-resilient youth ensures sustainability, as they will maintain the EWS equipment and continue to disseminate evacuation maps to all residents.

To ensure the sustainability of the Early Warning System (EWS) implementation and safe zone mapping program in Sidomulyo Village, several strategies are being implemented in a planned and ongoing manner. The first effort is to increase human resource capacity through advanced training for the Youth Organization (Karang Taruna) and the community on the use and maintenance of the EWS system. Refresher training is planned at the beginning of each rainy season to ensure residents remain prepared for potential disasters. Furthermore, the village government will involve resource persons from the Lamongan Regency Regional Disaster Management Agency (BPBD) and universities to update the community's knowledge regarding technology-based disaster mitigation. This approach is expected to not only maintain the functionality of the devices but also raise collective community awareness of the importance of disaster preparedness.

In terms of technology and funding, the sustainability strategy focuses on optimizing the use of IoT and strengthening local financial support. The EWS system will be integrated with the safe zone map in the Village Information System so that all residents can easily access information via a mobile app or SMS broadcast. This technology will also be developed more broadly to monitor agricultural land prone to flooding, so its benefits extend beyond flood mitigation. Meanwhile, funding sources are being developed by allocating village funds for equipment maintenance and map updates, collaborating with the private sector or CSR institutions, and encouraging voluntary community contributions through mutual cooperation activities. Monitoring and evaluation activities are conducted with the village government and the community service team to ensure the program remains relevant, effective, and sustainable year after year.

Overall, the program's results reinforce the understanding that local community empowerment combined with appropriate technological innovation can produce disaster mitigation solutions. The flood mitigation program in Sidomulyo can serve as a model for other flood-prone villages.

CONCLUSION

The empowerment activities of the Sidomulyo Village Youth Organization through the implementation of EWS integrated IoT technology and safe zone mapping as flood disaster mitigation efforts, which have been carried out in several activities, have achieved results in accordance with targets. Furthermore, EWS integrated IoT has been installed in Sidomulyo Village to provide rapid information on real-time flood warning signs, and a safe zone map has been created for locations that are safe and vulnerable during a disaster.

This map helps residents identify evacuation assembly points, safe routes to evacuation sites, and areas to avoid due to the high risk of flooding during a flood. This participatory training on creating safe zone maps is one of the activities to increase the capacity of Karang Taruna cadres in non-structural disaster mitigation carried out during the pre-disaster phase, while also enhancing their soft skills so they can strengthen their role in flood disaster response. Support from Sidomulyo Village residents, the Village Government, and various parties is essential to making Sidomulyo Village resilient and independent in the face of flood disasters.

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