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MABAR AND SIKESYA: IOT TECHNOLOGY INNOVATIONS FOR ENHANCING FLOOD PREPAREDNESS IN YEHEMBANG KANGIN VILLAGE

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ABSTRACT

This article explores the implementation of MABAR (Modul Anti Blabar/Banjir) and SIKESYA (Sistem Informasi Kebencanaan Desa Yehembang Kangin), aimed at enhancing flood preparedness in a disaster-prone rural area. The MABAR system, utilizing solar-powered sensors for real-time flood detection, demonstrated high accuracy and reliability even during adverse weather conditions. SIKESYA, a mobile application, integrates real-time weather data and participatory mapping to provide essential disaster information, including hazard maps and evacuation guidance. The active involvement of the local community in system development and training sessions improved their awareness and readiness, significantly enhancing their response capabilities during emergencies. Furthermore, the integration of these technologies had a positive impact on the local tourism sector by increasing visitor safety and boosting economic growth. The success of this integrated model offers a practical and scalable solution for disaster risk reduction in similar rural areas, providing valuable insights for future research and application in flood mitigation strategies.

Keywords: MABAR, SIKESYA, IoT, Disaster Mitigation

1. INTRODUCTION

Yehembang Kangin Village, located in Mendoyo District, Jembrana Regency, Bali, is a region known for its diverse natural tourism potential, including waterfalls, river tubing, hiking trails, and camping grounds (Desa Yehembang Kangin, 2024). However, despite its natural beauty, the village faces significant risks of natural disasters such as flash floods, landslides, extreme weather, and coastal erosion. In recent years, the village experienced severe flash floods in 2021 and 2022, resulting in extensive damage (Denpost, 2022). These incidents led to the destruction of community infrastructure, washed away livestock, inundated homes, and severed vital road and bridge connections, isolating parts of the village. The increasing frequency and intensity of extreme weather events pose a critical threat to both residents and visitors (Badan Nasional Penanggulangan Bencana, 2024).

The core problem faced by Yehembang Kangin Village is the high disaster risk in an area heavily reliant on nature-based tourism. The current lack of an effective early warning system and comprehensive disaster information leaves both the local community and tourists vulnerable. Additionally, there is limited infrastructure in place for disaster mitigation, such as hazard maps, evacuation routes, and temporary evacuation points (TES). These issues highlight the urgent need for an integrated solution to enhance disaster preparedness and ensure the safety of residents and visitors.

Figure 1. Disaster Potential Map in Yehembang Kangin Village

To address these challenges, two innovative technologies have been developed and implemented: MABAR (Modul Anti Blabar/Banjir) and SIKESYA (Disaster Information System for Yehembang Kangin Village).

MABAR (Modul Anti Blabar/Banjir) is an Internet of Things (IoT)-based Early Warning System (EWS) specifically designed to monitor river conditions in real-time. The system utilizes ultrasonic sensors, water level detectors, and rainfall sensors, all powered by solar energy. When water levels reach a dangerous threshold, MABAR sends early warning notifications through an Android application. This technology enables the local disaster response team (Pokdarwis) and the community to initiate timely evacuation measures. The use of solar power also aligns with environmentally friendly practices, making the system suitable for remote and rural areas with limited access to conventional power sources (I. G. D. Y. Partama et al., 2022).

SIKESYA (Sistem Informasi Kebencanaan Desa Yehembang Kangin) is an Android-based application that integrates real-time disaster data, weather updates from BMKG (Indonesian Meteorological Agency), and historical disaster records. It provides comprehensive information about current weather conditions, river water levels, and hazard maps, offering guidance on safe areas and evacuation procedures. SIKESYA aims to enhance public awareness and disaster knowledge, while also serving as a reliable source of safety information for tourists (I. Partama et al., 2024).

The implementation of MABAR and SIKESYA is expected to offer an effective, efficient, and integrated solution for disaster mitigation in Yehembang Kangin Village. This approach supports sustainable tourism development by ensuring a safer environment for both local residents and visitors. Furthermore, these innovations contribute to the achievement of the Sustainable Development Goals (SDGs), particularly Goal 11 (Sustainable Cities and Communities) and Goal 13 (Climate Action), by enhancing community resilience and disaster preparedness (Sudipa, Harto, et al., 2023).

By leveraging IoT technology and fostering active community participation, this project aims to create a responsive and data-driven disaster mitigation ecosystem. The successful implementation of MABAR and SIKESYA in Yehembang Kangin Village can serve as a model for other disaster-prone areas in Indonesia, demonstrating the potential of local innovations in addressing global challenges related to climate resilience and disaster risk reduction.

2. RESEARCH METODOLOGY

This article outlines a structured methodology designed to address disaster challenges in Yehembang Kangin Village while enhancing community disaster preparedness and tourism safety. The process consists of several key stages, including socialization, technology development, training, evaluation, and stakeholder reporting.

Figure 2. Research Methodology Flowchart

a) Socialization and Needs Assessment The initial stage of the research involves socialization with key stakeholders, including village authorities, community leaders, the tourism awareness group (Pokdarwis), and local farmers. A participatory approach is employed to gather insights about disaster risks and specific needs of the community. Surveys and interviews are conducted to assess the current conditions in disaster-prone areas and to identify optimal locations for installing early warning systems. During this stage, detailed plans for the implementation of MABAR and SIKESYA technologies are presented, highlighting their benefits and anticipated outcomes.
b) Development and Implementation of MABAR Technology The next stage focuses on the technical design and implementation of the MABAR (Modul Anti Blabar/Banjir) early warning system. Hardware development involves using ultrasonic sensors, rainfall detectors, water level sensors, and solar panels to ensure energy efficiency. These sensors are integrated with an Arduino microcontroller, enabling real-time data processing. The software component includes the development of an Android application utilizing Webhook and Google Data Studio for interactive data visualization (Saputro et al., 2024; Setiawan et al., 2024; Sudipa, Sarasvananda, et al., 2023; Wibowo & Kraugusteeliana, 2024). The system is installed at strategic points along the Yeh Sumbul River and undergoes beta testing to evaluate its accuracy and reliability under various weather conditions.

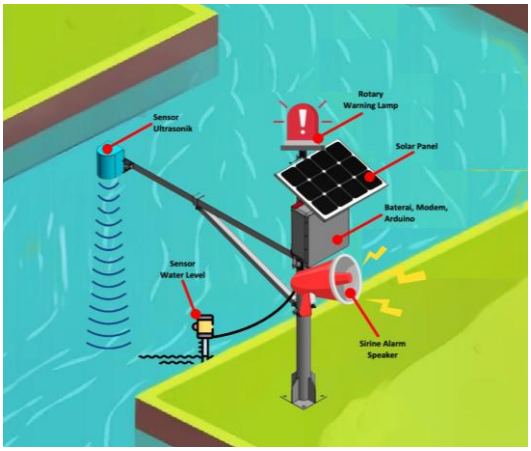

Figure 3. Design of the MABAR (Tool)

c) Development of the SIKESYA Application The SIKESYA app focuses on delivering accessible disaster information to the village community. This Android-based application integrates real-time weather data from BMKG (Meteorological, Climatological, and Geophysical Agency) alongside historical disaster data specific to the area. Key features include weather forecasts, river water level monitoring (linked with the MABAR system), hazard maps, and evacuation guidance. The mapping process is conducted with active community participation, resulting in accurate and locally relevant disaster maps. Comprehensive training sessions are provided to ensure users can effectively utilize the application for disaster response.

Figure 4. Design of the SIKESYA Application

d) Capacity Building and Knowledge Transfer This phase aims to enhance the local community's ability to operate and maintain the technology independently. Disaster response training, conducted in collaboration with the local disaster management agency (BPBD), covers search and rescue techniques, disaster mitigation strategies, and effective use of MABAR and SIKESYA. Additionally, Pokdarwis members receive training in tourism management and digital marketing to enhance visitor safety and the overall tourist experience. Knowledge transfer is facilitated through detailed guides and training materials, empowering the community to sustain the technology without external dependencies.

e) Evaluation and System Sustainability The success of the systems is assessed through comprehensive evaluation, including user feedback and extensive

system testing. Beta tests and surveys measure system performance in terms of detection accuracy, notification response times, and user satisfaction with the SIKESYA app. Focus group discussions are conducted to gather insights on the impact of the technologies on disaster preparedness and tourism safety. Based on the evaluation results, necessary adjustments are made to enhance the systems. A long-term maintenance plan is developed with local stakeholders, ensuring sustainable operation of MABAR and SIKESYA technologies.

f) Reporting to Stakeholders The findings and outcomes of the research are documented in detailed progress reports submitted to stakeholders. These reports outline the achievements, challenges encountered, and recommendations for future improvements. Comprehensive reporting ensures transparency and provides a valuable reference for academics and practitioners seeking to adopt similar disaster mitigation models in other regions facing comparable risks.

3. RELATED RESEARCH

Research on the application of Internet of Things (IoT) technology has shown that it improves early warning systems for disaster mitigation. A portable, energy-efficient early warning system for natural disasters like floods is being developed in this study (Akbar et al., 2023). The suggested system uses IoT-connected water level and weather sensors. Real-time data transmission to a central server and mobile app access enable rapid detection and improvement (Akbar et al., 2023). This study shows that IoT-based solutions can outperform human techniques in catastrophe detection and response. An IoT-based solution is ideal for MABAR, which uses water level sensors and solar power modules to notify rural communities of early warnings. Disaster mitigation research for flood-prone areas focuses on Android-based disaster information mobile apps. The paper describes the development of an app that gives real-time weather, water level, and evacuation advice for high-risk communities. Extreme Programming provides iterative development and user feedback in the app. The study shows that mobile apps can boost public knowledge and preparation (Ardhana, 2022). These discoveries are crucial to the creation of SIKESYA, an Android app that provides real-time disaster data and evacuation information. SIKESYA helps communities make faster, more informed emergency decisions by integrating historical and real-time data.

4. RESULTS AND DISCUSSION

The MABAR (Modul Anti Blabar/Banjir) system has been successfully implemented at two strategic locations along the Yeh Sumbul River, an area known for its susceptibility to flooding. Testing results demonstrated that the water level sensors and rainfall detectors used in the system were able to detect changes in water conditions in real-time with a high degree of accuracy. Early warning notifications were sent via an Android application and a Telegram group, enabling the community to respond quickly when water levels exceeded the designated safety threshold. Additionally, the use of solar panels as the primary energy source for the MABAR system proved efficient and stable, even during overcast or rainy weather. This indicates the system's reliability under various weather conditions, making it a sustainable and environmentally friendly technological solution.

Figure 5. Implementation of the MABAR Tool

The development of the SIKESYA application (Disaster Information System for Yehembang Kangin Village) focused on delivering accurate and easily accessible disaster information to the local community. The application integrates real-time weather data from BMKG (Meteorological, Climatological, and Geophysical Agency) and water level data obtained from the MABAR system. One of the standout features of the app is the interactive map, which highlights disaster-prone areas and evacuation routes, created using participatory mapping methods involving the local community. The evacuation guidance and real-time notifications offered by the ap p have been instrumental in helping residents plan effective mitigation measures during flood events. Evaluation results show that over 80% of users found the app's features to be effective in providing the necessary information during emergency situations.

Figure 6. Implementation of the SIKESYA Application

The implementation of these technologies has resulted in a significant improvement in the community's preparedness for flood disasters. Post-training surveys revealed that 85% of respondents reported increased knowledge on how to respond to early warnings and execute safe evacuations. Active involvement of the community in the participatory mapping process and intensive training sessions has enhanced their sense of ownership of the developed system. Villagers, especially members of the Pokdarwis (tourism awareness group), were trained in using the SIKESYA app and interpreting the displayed data, enabling them to make more informed decisions during emergencies. This active participation not only enhanced the community's technical skills but also strengthened their overall readiness in facing disaster risks.

Another positive outcome of the technology implementation is seen in the tourism sector. The presence of the SIKESYA app, which provides safety information and

evacuation guidance, has increased the sense of security for tourists visiting Yehembang Kangin Village, especially during the rainy season. This has contributed to a rise in tourist visits and brought positive economic impacts to the local area. Additionally, members of the Pokdarwis who received training in tourism management and digital marketing were able to offer improved services, enhancing visitor satisfaction and reinforcing the village's image as a safe and welcoming tourist destination.

5. CONCLUSION

The implementation of the MABAR system and SIKESYA application has helped in disaster preparedness and community resilience in Yehembang Kangin Village.The solar-powered MABAR system provided accurate real-time flood detection and early warning notifications, showcasing efficiency and sustainability in mitigating flood risks, even under challenging weather conditions. The SIKESYA app delivered reliable and interactive disaster information, including hazard maps and evacuation guidance, which were well-received by users, leading to improved community response during emergencies. Active participation from the local community in the system's development and training further strengthened their readiness and sense of ownership. Moreover, the integration of these technologies positively impacted the local tourism sector by increasing visitor safety and boosting the economic growth of the village. The success of this integrated disaster mitigation model offers a practical and scalable solution that can be adapted to other disaster-prone areas, providing valuable insights for future research and applications in disaster risk reduction.

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