Jurnal Kejuruteraan SI 4(2) 2021: 135-139
https://doi.org/10.17576/jkukm-2021-si4(2)-20

Implementation of Early Warning System in Kampung Jenagor, Kuala Berang as an Effort to Increase Human Resilience Towards Flood Disaster

(Pelaksanaan Sistem Amaran Awal di Kampung Jenagor, Kuala Berang sebagai Usaha Meningkatkan Daya Ketahanan terhadap Bencana Banjir)

Azrul Ghazali[a*], Sivadass Thiruchelvam[a], Kamal Nasharuddin Mustapha[a], Rahsidi Sabri Muda[b], Nora Dato' Yahya[a], Hasril Hasini[a], Ng Yu Jin[a] & Fatin Faiqa Norkhairi[a]

[a]*Institute of Energy Infrastructure, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, Kajang, Selangor, Malaysia*
[b]*TNB Research Sdn. Bhd., Kawasan Industri Penyelidikan, Kajang, Selangor, Malaysia*

**Corresponding author: azrulg@uniten.edu.my*

Received 20 March 2021, Received in revised form 19 April 2021
Accepted 30 September 2021, Available online 31 October 2021

ABSTRACT

Residents living downstream of Kenyir dam (Stesen Janaelektrik Sultan Mahmud) are at risk of being flooded due to overflow through spillway, or worst, dam breaks. The nearest community to Kenyir dam is Kampung Jenagor (Kampung Jenagor) residents. A disaster preparedness action plan was proposed to equip the residents with essential knowledge on how to respond to such disaster and how to safely evacuate to designated safe havens. This paper presents one key element of the mentioned action plan, which is to develop and install a flood disaster early warning system. The system is aimed to effectively disseminate warning to Kampung Jenagor residents and ensure that there is a constant state of preparedness. The paper discusses the fundamentals of effective warning dissemination and basic design of Kampung Jenagor's early warning system.

Keywords: Disaster preparedness; early warning system

ABSTRAK

Penduduk yang tinggal di hiliran empangan Kenyir (Stesen Janaelektrik Sultan Mahmud) mempunyai risiko banjir yang berpunca dari limpahan air empangan melalui alur limpah, atau yang lebih teruk, apabila berlakunya empangan pecah. Komuniti yang paling hampir dengan empangan Kenyir adalah penduduk Kampung Jenagor (Kampung Jenagor). Satu pelan tindakan kesiapsiagaan menghadapi bencana telah diusulkan untuk melengkapkan penduduk dengan ilmu pengetahuan penting berkaitan dengan cara bertindak balas menghadapi bencana banjir dan seterusnya berpindah ke tempat selamat. Makalah ini membentangkan satu elemen penting dalam pelan tindakan kesiapsiagaan tersebut, iaitu penghasilan dan pemasangan sistem amaran awal bencana banjir. Sistem ini bertujuan untuk menyebarkan amaran banjir kepada penduduk Kampung Jenagor secara efektif dan untuk memastikan tahap kesiapsiagaan bencana yang berterusan. Makalah ini membincangkan perkara asas mengenai penyebaran amaran yang efektif dan reka bentuk sistem amaran awal di Kampung Jenagor.

Kata kunci: Kesiapsiagaan bencana; sistem amaran awal

INTRODUCTION

Officially opened in 1987, Kenyir dam has been a good provider of green electricity. The dam is 150 m in height above foundation, with a crest length of 800 m. It has the capacity to store 13 600 million cubic meters of water with maximum flood level at 153 m. Its large reservoir also served as flood mitigation purposes, which is to decrease or eliminate impacts of flooding to the communities living downstream of the dam.

The nearest community downstream of Kenyir dam is only 3 km in distance, which is the residents of Kampung Jenagor. Kampung Jenagor community does not only consist around 100 families but also includes teachers and students in Akademi Binaan Malaysia (ABM) Wilayah Timur and Sekolah Menengah Kebangsaan (SMK) Jenagor. Figure 1 shows the map location of Kenyir dam and Kampung Jenagor.

Residents in Kampung Jenagor have never experienced any flooding caused by Kenyir dam. Even during the great flood of 2014, water level in Kenyir dam only reached to height level of 148m. Hence, many of its residents felt safe from any flood risks and are not prepared for any flood hazards due to dam disaster.

FIGURE 1. Geographical location of Kenyir dam and Kampung Jenagor

Tenaga Nasional Berhad (TNB) as Kenyir dam's owner, have initiated a disaster preparedness action plan which includes involvement of Kampung Jenagor residents. In this plan, TNB plans to install an early warning system (EWS) near the center of Kampung Jenagor. Its main function is to disseminate warnings on the impending disasters such as dam structural failures which can be caused by natural and man-made disasters. With the assistance of early warning system, Kampung Jenagor residents can strive towards being a resilient community to flood risk.

LITERATURE REVIEW

According to Hyogo Framework for Action 2005–2015, early warning is a key component of disaster risk reduction. According to Hyogo Framework for Action 2005–2015, enhancement of risk monitoring and early warning is given the second priority in its framework. Early warning was also listed as a key component in the Sendai Framework for Disaster Risk Reduction 2015–2030.

According to United Nations International Strategy for Disaster Reduction (UNISDR), EWS is defined as a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss. A systematic community-centered early warning system comprises four key elements (Basher, R. 2006; Cools, J. et al. 2012] as shown in Figure 2.

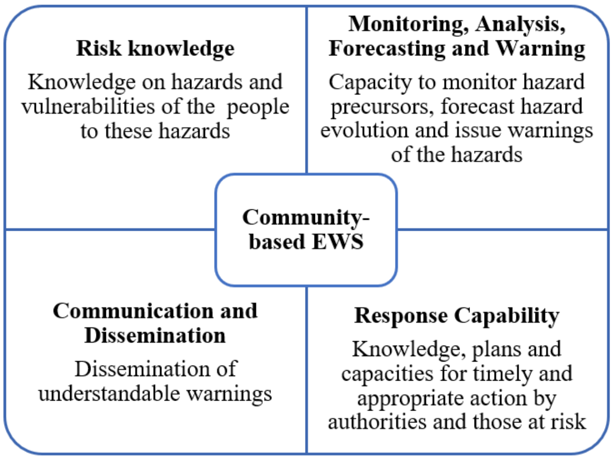

FIGURE 2. Four elements of community-centered EWS

Warning of an imminent disaster is not only about imparting of information on what is about to happen, but the warning message itself must be credible (Nigg 1995) and contains explanation with advice on the necessary action in the real time of its pending or actual occurrence.

Successful implementation of community-based EWS were reported in Bandung (I. Dewa Gede et al. 2017), in Nepal (Smith et al. 2017), and several European countries (Krzhizhanovskaya, V.V. et al. 2011). Technology has become a necessary tool in modern EWS to improve the performance and effectiveness of the system. Basha et al. in 2007 proposed mobile radio communication as a mean of system communication to cover long-range communication links of approximately 25 km range in their EWS project in Honduras.

Hadi et al. (2020) and Satria (2017, 2019) developed a small-scale prototype that detects and monitors water level using ultrasonic sensor and sends data to mobile phone application through IoT. At the larger scale, Kuantama et al. in 2013 reported the design and construction of a standalone EWS which transmit warnings via Short Message Service (SMS) to specific clients' phone numbers. Balaji et al. (2017) and Jayahsree et al. (2017) reported EWS implementation using Zigbee-based wireless sensor network while Z.N.K Wafi et al. (2015) implemented

EWS using Smart Communication Platform System (SCPS), which is a large ad-hoc wireless network organized in the sky on the disaster area. In addition to wireless network, R.J.M. Mercado (2016) and A. Dersingh (2016) utilized microprocessor-based embedded platform to perform various EWS functions while J.K. Roy et al. (2012) utilized Artificial Neural Network to develop flood predictive model by considering six flood-related parameters. In supporting green technology, A. Yusoff et al. (2015) studied and proposed the implementation of green cloud platform for early flood detection and warning system.

Jose Ibarreche et al. (2020) reported their implementation of flash flood early system in Colima, Mexico named Emergency Water Information Network (EWIN). The system integrates early warning system with real-time monitoring of areas with high flood risk. Similar to EWIN, Priya et al. (2017) and Shah et al. (2018) also implemented IoT-based EWS. The difference in the implementation lies in the alert processing and triggering methods and the precision of the sensors used.

Considering the high costs of EWS especially when integrated with decision support system, the proposed EWS in Kampung Jenagor only utilized SMS technology. At this stage, the siren will not be integrated with Kenyir dam water level sensor system. SMS technology is sufficient to manage the desired EWS operations. The siren in Kampung Jenagor can be activated and deactivated via a coded message transmitted using SMS. Only selected people will be given the authority to activate and deactivate the siren.

RESULTS AND DISCUSSION

Targeted location for EWS installation in Kampung Jenagor are based on several considerations, such as, its location should be near the center of Kampung Jenagor so that the siren sound can reach all residents. An ac power source (electric pole) must be nearby the targeted location. Location area with tall trees or structures must be avoided. This is to prevent the siren sound being absorbed by the immediate obstacles, thus reducing its range and coverage. Figure 3 shows the selected location of EWS, which is at the corner of football field outside SMK Jenagor.

The EWS in Kampung Jenagor consists of a Remote Terminal Unit (RTU) that performs data collection and monitoring of real time data, GSM modem to allow SMS data transmission, 12 V rechargeable battery as backup power supply in the event of power failure, strobe lights to transmit visual warnings, and siren system (siren horn, amplifier, and control) to generate the siren sound. A master system (dedicated PC workstation with GSM modem) is also installed in Kenyir dam's control room to record transmitted data (battery health, siren status, etc.) and to control activation and deactivation of the siren. In addition, master system also performs other controls as required by TNB, such as switching off the siren sound while maintaining the strobe light to always be on, requesting battery health or siren status, and others. Figure 4 shows the basic architecture of the proposed EWS.

Two different patterns of siren sound were proposed. The intermittent or wavering siren sound represents flood alert. Upon hearing this sound, community must make necessary preparations for the possibility of evacuation. The long and high-pitched siren sound indicates danger of flooding. Community must evacuate immediately. Each sound pattern is also associated to a colored strobe light. When alert sound is activated, the amber strobe light will turn on. When danger sound is activated, the red strobe light will turn on. The siren and strobe lights are mounted on a 16 m galvanized pole. The tall pole permits siren sound to propagate to a greater distance. Figure 5 shows the installation of EWS in Kampung Jenagor.

After installation, EWS was then tested. The siren was successfully activated and deactivated via SMS message on a mobile phone as well as from the master station. The recorded siren sound intensity is measured around 80 to 90 dB within 10 m of the pole and dropped to around 65 dB at 1 km away from the pole. In the open, sound spreads in all directions. The intensity decreases as its energy is spread over a larger area.

The two patterns of siren sound are distinguishable by the residents. The warning sound is a wavering siren, swinging back and forth between the low 70 dB and the high 90 dB. The second siren sound is a high pitch danger siren. It is a continuous high pitch 90 dB sound intensity.

FIGURE 3. Location of EWS in Kampung Jenagor

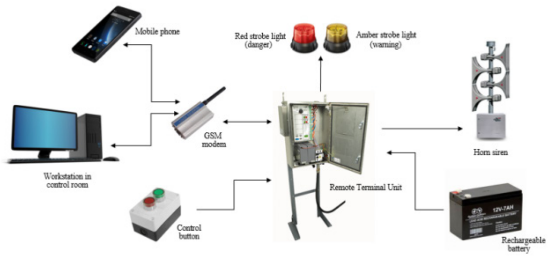

FIGURE 4. Basic architecture of EWS in Kampung Jenagor

FIGURE 5. EWS installation in Kampung Jenagor

CONCLUSION

An early warning system was conceptualized, designed, and installed in Kampung Jenagor, Kuala Berang. The system is essential to disseminate warnings to vulnerable community members on the impending flood from the failure of Kenyir dam. Data transmission between EWS and master system is implemented using SMS technology. Developing EWS in Kampung Jenagor is only the initial step to build a resilient community. Evacuation exercises and awareness campaigns must follow suit to create awareness and equip the residents with enough tools and knowledge to save themselves in the event of a dam disaster.

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to TNB Generation division for funding this project. We are also very thankful to the owner and staff members of Stesen Janaelektrik Sultan Mahmud, research members from TNB Research Sdn. Bhd., local government agencies, community leaders and community members in Kampung Jenagor for their continuous support in completing this project. The views expressed in this paper are solely those of the authors and do not necessarily reflect the views of Tenaga Nasional Berhad and Malaysian Electricity Supply Industry.

DECLARATION OF COMPETING INTEREST

None

REFERENCES

A. Dersingh. 2016. Design and development of a flood warning system via mobile and computer networks. *International Conference on Electronics, Information, and Communications (ICEIC)*

A. Yusoff, I.S. Mustafa, S. Yussof & N.M. Din. 2015. Green cloud platform for flood early detection warning system in smart city. *5th National Symposium on Information Technology: Towards New Smart World (NSITNSW)* 1-6.

Balaji, V., Akshaya, A. Jayashree, N. & Karthika T. 2017. Design of Zigbee-based Wwireless sensor Nnetwork for early flood monitoring and warning system. *IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural Development (TIAR 2017)*, 7-8 April, Chennai, India.

Basher, R. 2006. Global early warning system for natural hazards: Systematic and people-centered. *Philosophical Transactions of The Royal Society* 364: 2167-2182.

Cools, J., Vanderkimpen, P., El Afandi, G., Abdelkhalek, A., Fockedey, S., El Sammany, M., Abdallah, G., El Bihery, M., Bauwens, W. & Huygens, M. 2012. An early warning system for flash floods in hyper-arid Egypt. *Nat. Hazards Earth Syst. Sci* 12: 443-457.

Basha, E. & Rus, D. 2007. Design of early warning flood detection systems for developing countries. *International Conference on Information and Communication Technologies and Development.*

Kuantama, E., Mardjoko, P. & Saraswati, M.A. 2013. Design and construction of early flood warning system through SMS based on SIM300C GSM modem. 2013 *3rd International Conference on Instrumentation, Communications, Information Technology and Biomedical Engineering (ICICI-BME)*

Hadi, M.I., Yakub, F., Fakhrurradzi, A., Hui, C.X., Najiha, A., Fakharulrazi, N.A., Harun, A.N., Rahim, Z.A. & Azizan, A. 2020. Designing early warning flood detection and monitoring system via IoT. *IOP Conference Series: Earth and Environmental Science*,479(1): 012016.

Junnaedhi, I.D.G.A. et al. 2017. Majalaya flood early warning system: A community based approach. *IOP Conf. Ser.: Earth Environ. Sci.* 7.

Ibarreche, J., Aquino, R., Edwards, R.M., Rangel, V., Pérez, I., Martínez, M., Castellanos, E., Álvarez, E., Jimenez, S., Rentería, R., Edwards, A. & Álvarez, O. 2020. Flash flood early warning system in Colima, Mexico. *Sensor (Switzerland)* 20(18): 1-26.

Roy, J.K., Gupta, D. & Goswami, S. 2012. An improved flood warning system using WSN and artificial neural network. *Annual IEEE India Conference (INDICON)*

Jayashree, S., Sarika, S., Solai, A.L. & Prathibha, S. 2017. A novel approach for early flood warning using android and IoT. *2017 2nd International Conference on Computing and Communications Technologies (ICCCT)*

Nigg, J. 1995. Risk communication and warning systems. *Natural Risk and Civil Protection* 369–382.

Smith, P. J., Brown, S. & Dugar, S. 2017. Community-based early warning systems for flood on in Nepal. *Natural Hazards and Earth System Sciences* 17: 423-437.

Priya, S.J., Akshaya, S., Aruna, E., Julie, J.A.M. & Ranjani, V. 2017. Flood monitornig and alerting system. *Int. J. Comput. Eng. Technology* 8: 1–5.

Mercedo, R.J.M. 2016. Design of wireless sensor networks using embedded Programmable System-on-Chip (PSoC) as applied to community-based flood early warning systems (CBFEWS). *International Conference on Advances in Electrical, Electronic and Systems Engineering (ICAEES)*

Satria, D., Yana, S., Hidayat, T., Syahreza, S., Yusibani, E. & Munadi, R. 2019. Application of GSM communication system on flood alarm systems. *Journal of Physics: Conference Series* 1232(1): 012023.

Satria, D., Yana, S., Munadi, R. & Syahreza, S. 2018. Design of information monitoring system flood based internet of things (IoT). *Malikussaleh International Conference on Multidisciplinary Studies* (MICoMS 2017)

Shah, W.M., Arif, F., Shahrin, A.A. & Hassan, A. 2018. The implementation of an IoT-based flood alert system. *Int.J. Adv. Comput. Sci. Appl*. 9.

United Nations International Strategy for Disaster Reduction. 2009. UNISDR terminology on disaster risk reduction. https://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf (accessed 12 August 2018)

UN: Hyogo Framework for Action. 2005–2015. Building the resilience of nations and communities to disasters. Resolution 2, *World Conference on Disaster Reduction*, in Kobe, Japan, 18–22 January, Kobe, Japan.

UN: Sendai Framework for Disaster Risk Reduction 2015–2030. *Third UN World Conference*. Sendai, Japan.

Krzhizhanovskaya,V.V. & Shirshova, G.S. 2011. Flood early warning system: Design, implementation and computational modules. *International Conference on Computational Science* 4: 106-115.

Wafi, Z.N.K., Abd-Malek, M.F., Alnajjar, S.H. & Ahmad, R.B. 2015. Early warning system for disaster management in rural area. *2015 International Symposium on Technology Management and Emerging Technologies (ISTMET)*