



Application of a Web-Based Landslide Mitigation Information System (Sensor-Ku) in Kalongan Village Semarang, Central Java

Zahra Yulia Putri ^a, Salsa Bella Anjani ^a, Alika Pevi ^a,
Dilean Zeva ^a, Sri Hapsari Wahyuningtyas ^a,
Aprelia Dwi Hapsari ^a, Ika Pantiawati ^b,
Hugi Cherlyawati ^c and Slamet Isworo ^{c*}

^a The Student Organizing Capacity Building Program, Environmental Health Student Association, Universitas Dian Nuswantoro, Indonesia.

^b Medical Records and Health Information, Universitas Dian Nuswantoro, Indonesia.

^c Environmental Health Department, Universitas Dian Nuswantoro, Indonesia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Background and Objectives: Kalongan is one of the villages in Ungaran District with a potential landslide risk of 2% of its territory. Landslides occur along roadways and in residential areas, endangering the environment and damaging the infrastructure. A web-based early warning system application is the Landslide Early Warning System (Sensor-Ku) which is applied at the research

*Corresponding author: E-mail: slametisworo512@gmail.com;

location. This study intends to detect and provide real-time information on the likelihood of landslides, specifically to the people of Kalongan Village.

Methods: This research creates a web-based monitoring and early warning system, as well as its implementation on an experimental microservice architecture, to provide landslide risk mitigation information to Kalongan residents.

Results: According to the research, the landslide early warning system (LEWS) provides a solution by integrating many modules, such as recording dynamic variability, handling multi-scale data sets, extracting important trigger information about the onset of potential landslides, and broadcasting multi-level data. warning. This research also combines a real-time landslide early warning system.

Conclusion: The Landslide Early Warning System (LEWS) Program is effective in reducing the risk of landslides. Some of the issues found when running the program include the costs of maintaining the landslide early warning equipment, which must be managed by the Kalongan village community.

Keywords: Disaster mitigation; landslide early warning system (LEWS); potential risk; Kalongan Village.

1. INTRODUCTION

The potential for landslides in Kalongan Village, Semarang district, has resulted in massive losses and has an impact on many aspects of life in the local community [1] According to Law Number 24 of 2007, a disaster is defined as "a series of events that threaten and destroy the life of a community, the causes of which are natural or non-natural factors, as well as human-made factors." This disaster resulted in several losses, including loss of life, environmental harm, property loss, and psychological effects. Another reason for numerous victims is the community's lack of readiness when a calamity strikes [2]. The high level of losses suffered by the community as a result of natural disasters is due to a lack of information gained by the community regarding the possibility of catastrophes occurring around them, resulting in very low public awareness of disaster response, preliminary information and understanding of disaster potential and hazards are required [3].

The absence of public awareness about catastrophe threats in their immediate surrounds increases disaster vulnerability and reduces community capacity to respond to disasters, resulting in a detrimental impact on the community and environment surrounding the disaster location. Minimizing the impact of disasters is the greatest thing to do when confronted with one [4].

Landslides are a sort of mass movement of ground or rock produced by instability disturbances. Disturbances in slope stability are governed by morphological factors (particularly slope slope), the state of the rocks or soil that

make up the slope, and the hydrological conditions or water system on the slope [5]. Semarang Regency in Indonesia is one of the districts in Central Java that is prone to landslides. According to the National Disaster Management Agency, Semarang Regency is ranked 327th out of 497 regencies with a high risk of landslides, based on the Indonesian Disaster Prone Index [6]. Semarang Regency is included in the districts with a high level of disaster risk based on the summary of disaster events from 2013 to 2019 showing this. In Semarang Regency, at least 88 landslides occurred in 17 sub-districts in 2019. Landslides are the most common disaster in Semarang Regency [6]. Kalongan Village is situated in a landslide-prone location. The landslide incident that occurred on January 23, 2023 in Bandungan Hamlet, Kalongan Village, East Ungaran District, Semarang Regency finally closed access to the Ungaran-Demak connecting route, and land movement is increasingly spreading towards settlements, necessitating future landslide disaster mitigation efforts.

The Early Warning System (EWS) is a natural disaster detection system that gives early warning of landslides, floods, and earthquakes. The disaster early warning detection tool developed is the landslide early warning system, which is adapted to the problems that exist in the Kalongan village area. This research aims to identify the potential for landslides and disseminate information regarding the initiation of landslides in real-time, as well as explore in detail the requirements for developing a real-time landslide monitoring, detection, and early warning system [7].

The Landslide Early Warning System is a model of subsurface conditions in landslide areas in Kalongan village based on dynamic soil parameter models derived from data obtained from the microtremor method, namely shear wave velocity (V_s), comparison of compression wave velocity to shear wave velocity (V_p/V_s), modulus shear or rigidity (μ), and Poisson's ratio to identify slip planes in landslide areas, bedrock depth, and potential ground movement [8].

The soil dynamic parameter model data is interpreted in a web application called Sensor-KU, integrated with an Android-based application. This application has several menus such as a map of EWS Extensiometer placement points containing coordinates, administrative location, date and time, sensor graphs of soil deformation that occurs, and the level of danger.

2. METHODS

The research approach uses the action research method, this activity involves the target community group, namely the community in Bandungan Hamlet and Dampu Hamlet, both of which are part of the Kalongan Village area, landslide has just occurred in the village. This activity is separated into two stages: preparation and execution. The preparation stage is carried out by observing areas prone to landslides. After that, obtain permission from the appropriate authorities to carry out outreach operations, specifically the village government, and request assistance in gathering residents from the target community group. The implementation step consists of shipping material, practicing creating a landslide early warning system, and establishing a landslide early warning system at the area [9].

3. RESULTS AND DISCUSSION

The success of the landslide early warning system (LEWS) program in efforts to reduce the risk of landslides in the community in Kalongan Village (Bandungan Hamlet and Dampu Hamlet), is determined by three important stages, namely achieving goals, integration and adaptation [10], as follows.

3.1 Achievement of Objectives

The Student Organization Capacity Strengthening Program is one of the policies implemented by the Indonesian Ministry of Education, Culture, Research and Technology to

prepare students to become transformational leaders in overcoming societal challenges. The Student Organization Capacity Strengthening Program is integrated into community service and empowerment in Kalongan Village by developing sensor tools landslide disaster known as the Landslide Early Warning System (LEWS), as well as developing the Word Electric Browser (WEB) and applications to monitor land movements as a sign of community preparedness. landslide disasters that occurred, as well as revegetation initiatives to reduce landslide victims and restore land through revegetation, as follows:

3.2 Survey of Locations

Conduct surveys at landslide disaster locations, socialize program plans, and determine plans to install a landslide early warning system in Kalongan Village, especially in Bandungan Hamlet and Dampu Hamlet with approval from the Kalongan Village Government through village meetings.

Making a Mitigation Map to Identify Locations Prone to Landslides in Kalongan Village based on secondary data.

A mitigation map was used to identify landslide-prone areas in Kalongan Village. Mapping using ARCGIS identified landslide-prone areas. Kalongan Village contains numerous geological landslide threats that do not cover the entire village. There are five levels of vulnerability: not vulnerable, slightly vulnerable, moderately susceptible, and extremely vulnerable. Dampu, Bandungan, Kalongan, Rejowinangan, Lompo Gunung, Ngaliyan, Glepung, Kalonan, Sipete, and Sigede are among the hamlets that are slightly vulnerable. Meanwhile, the hamlets of Bulu and Mendiro are classified as moderately susceptible. These groups are determined by characteristics such as rainfall, land slope, and soil type. The varying hues in each hamlet represent the variances in land slope in each location [11].

Based on the results of microtremor data processing and analysis in identifying subsurface conditions in the landslide area and its surroundings, the following conclusions can be drawn: a) The slip area near the landslide location is located at a depth of 15 m with a relative direction to the west and north. b) The depth of the bedrock on the west-east side of the road that collapsed is roughly around 40 m,

however on the south side the track varies with a depth of 20 to 80 m. c) Locations prone to fractures and reasonably thick sediments are migrating south-north and southwest-northeast along the axis of landslide locations based on ground shear strain values [12]. The analysis results are used as a consideration for the location of the equipment placement Landslide Early Warning system in Bandungan hamlet, Kalongan Village.

3.3 Disaster Mitigation Tool LEWS (Landslide Early Warning System)

The target of this program is the creation of a LEWS (Landslide Early Warning System)

Disaster Mitigation tool which has been installed at points prone to landslides. LEWS is connected to the My Sensor application which will be fully monitored by the village government and disaster response organizations. The LEWS sensor will detect ground movement, it will send a signal, issue a siren/sound, and create a graph of ground movement in real time. LEWS landslide detection instruments are positioned at landslide-prone areas and detect even the smallest movement. so that people are aware of the possibility of landslides. Aside from that, planting hard plants (revegetation program) in landslide-prone areas with the belief that the plant roots will stabilize the soil and prevent further landslides [13].

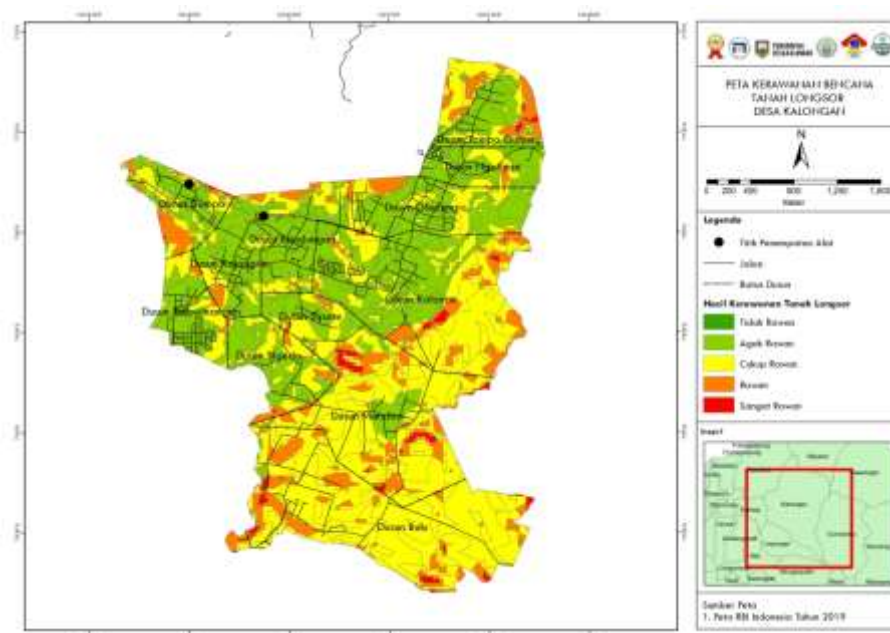


Fig. 1. Mitigation Map to Identify Locations Prone to Landslides in Kalongan Village



Fig. 2. Landslide conditions in Bandungan hamlet, Kalongan Village

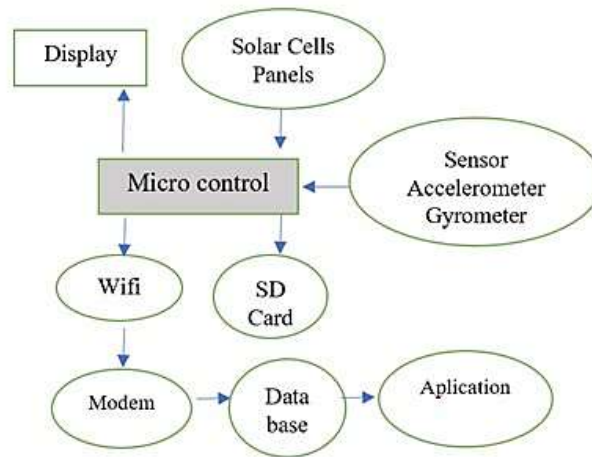


Fig. 3. Landslide Early Warning System Diagram



Fig. 4. Landslide early warning system



Fig. 5. Sensor-Ku landslide early warning system application

3.4 Involvement of the University in the Student Organization Capacity Strengthening Program

The university encourages student organizations to be innovative and creative through the implementation of the Student Organization

Capacity Strengthening Program. To develop results that can be measured, sustainable and responsible. The implementation stage includes coaching, mentoring, monitoring and mentoring [14]. The Student Organization Capacity Strengthening Program is one component of the Independent Campus Program which allows

students to study elsewhere. Dian Nuswantoro University provides student development grant funds for this program as a source of assistance [15].

3.5 Involvement of Semarang Regency Regional Disaster Management Agency (BPBD) Partners in the Student Organization Capacity Strengthening Program

The Regional Disaster Management Agency is a government agency that carries out disaster management tasks in the Semarang Regency area, guided by the policies established by the National Disaster Management Agency (BNPB) [16]. The Semarang Regency Regional Disaster Management Agency is responsible for assisting the Regent in implementing regional autonomy in the field of disaster management, as outlined in Regional Regulation Number 19 of 2016 concerning Disaster Management Implementation and Semarang Regency Regional Regulations [17]. The involvement and participation of the Semarang Regency Regional Disaster Management Agency in the Capacity Strengthening Program of the Environmental Health Student Association, Faculty of Health, Dian Nuswantoro University, Semarang, is by providing data and references regarding Mapping of landslide-prone areas and Landslide Disaster Mitigation, in Kalongan village, Semarang and support for implementation of training activities for community groups and disaster response youth organizations in Kalongan Village [18].

3.6 Environmental Service, Semarang Regency

The Environmental Service is an implementing element of the Regional Government in the field of Environment, overseen by a Service Head. The Head of the Environmental Service is positioned below and reports to the Regent via the Regional Secretary. The duties of the Head of the Environmental Service, as stated in the provisions above, are to assist the Regent in carrying out Government affairs in the environmental sector, as well as Spatial Planning, waste and waste water sub-affairs, and the Forestry sector, which is the authority of the region [19]. The participation of the Environmental Service in the Student Organization Capacity Strengthening Program is to support empowerment and outreach activities

for Kalongan Village community groups, especially knowledge regarding the contours of landslide-prone land and revegetation/reclamation in landslide-prone areas. The environmental service has donated perennial plants to the revegetation program in landslide-prone locations [20].

3.7 Establishment of the Kalongan Village Disaster Response Youth Organization

This Student Organization Capacity Strengthening Program aims, among other things, to form a Disaster Response Youth Organization in Kalongan Village. Disaster Response Youth Organization are an organization that will help the community by providing information regarding equipment operation, maintenance of Landslide Early Warning System equipment, and landslide disaster mitigation training. This group reports directly to the Kalongan village head [21].

The Team coordinated with partners, including the Village Head, Cadres, and Residents of Kalongan Village, Semarang Regency, for their willingness to participate in the Student Organization Capacity Strengthening Program. During the implementation stage, the team creates a schedule and assigns tasks. Coordination was also done with the Kalongan Village Karang Taruna, where the majority of the participants were teens still in high school or equivalent and productive young people, as well as village government officials ranging from the neighborhood Association to the hamlet head. This is done to improve knowledge and talents in catastrophe mitigation. The Student Organization Capacity Strengthening Program team is made up of three academics and 15 students. The program leader is responsible for describing the goals and objectives, as well as executing and assessing community service, while the participants are responsible for implementing and evaluating community service. The team pre-tested landslide disaster mitigation material [22].

3.8 Landslide Knowledge Questionnaire for the Community

Questionnaire was distributed to examine understanding of the variations in using the landslide emergency warning system Sensor-Ku. Based on the results of a survey given to 60

persons about their understanding of landslides and their level of disaster preparedness. The majority of people, 85.7%, were aware that landslides were caused by heavy rainfall, while 14.3% were aware of ground shifts induced by tree felling [23]. The survey results suggest that the majority of people comprehend the impact of landslides caused by rains. They admit that heavy rains might cause landslides, thus it is critical to pay attention and take preventive measures to limit the risk of landslides [24].

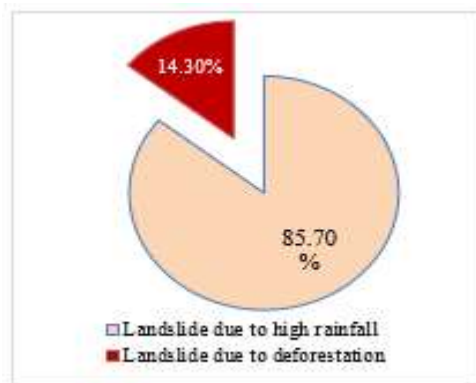


Fig. 6. Results of questionnaire on causes of landslides

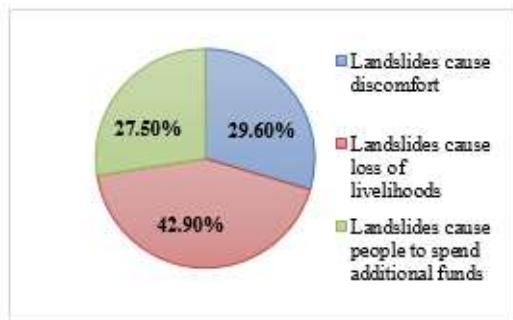


Fig. 7. Impact of landslide disaster on economic conditions

Fig. 6 depicts the impact of the landslide tragedy on the economic situation of the surrounding community. The community 28.6% responded that the landslide disaster made them feel unsafe living in the neighborhood. This is related to concerns about security, uncertainty, and feelings of insecurity as a result of the possibility of future landslides. 42.9% of respondents stated that the landslide tragedy resulted in a loss of livelihood. Landslides can cause damage to infrastructure, farmland, and workplaces, disrupting people's lives. This lack of income may have an impact on their overall economic

situation. Some people 28.6% said the landslide tragedy forced them to spend additional money on house modifications. Landslide damage necessitates more investment to restore or renovate homes, consequently hurting household financial status.

Fig. 7 shows community mitigation actions before a landslide occurs. Emphasis on awareness and response to warnings and landslide mitigation instructions is essential in efforts to minimize the risk and impact of this disaster on society [25]. Aside from that, additional education is required to raise the community's understanding and preparedness to deal with the potential threat of landslides. Some respondents, 34.32%, stated that they were alert to high rainfall as a mitigation measure before landslides occurred. This reflects their awareness of weather factors that can trigger landslides. As many as 10.9% of respondents stated that they were relaxed when there was a threat of landslides. This attitude may reflect a lack of understanding of the risks and dangers associated with landslides or a lack of preparedness in dealing with these potential hazards. Most respondents 45.13% indicated that they would take action in accordance with landslide warning instructions. This shows that people tend to respond to warnings and mitigation guidelines provided by relevant authorities or experts, to reduce the risk of landslides [26].

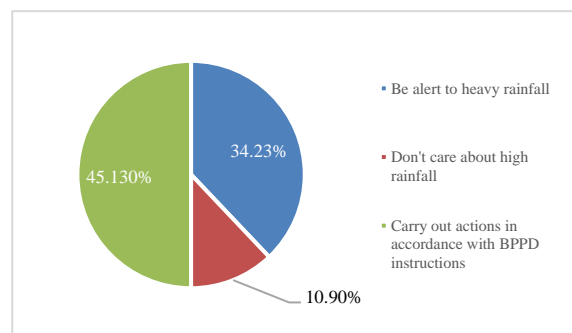


Fig. 8. Landslide mitigation measures

3.9 Integration

The Landslide Early Warning System (LEWS) program in Kalongan village, the Student Organization Capacity Strengthening Program Team, in collaboration with the Semarang Regency Regional Disaster Management Agency, Semarang Environmental Service, TNI-POLRI, Kalongan Village Government, and the

Local Village Community, demonstrates that all stakeholders have effectively coordinated and collaborated so that the program can be carried out effectively and mitigate landslide disasters [27].

3.10 Adaptation

Improvements to landslide disaster mitigation facilities and infrastructure provided by stakeholders, in this case the Semarang Regency regional disaster control agency, have been implemented effectively and efficiently despite a limited budget; therefore, academic support in the form of more appropriate mitigation technology is required; and a capacity building program for environmental health student organizations has been developed through community service [28].

4. CONCLUSION

The effectiveness of the Landslide Early Warning System (LEWS) Program in Efforts to Reduce the Risk of Landslide Disasters in Kalongan Village, Ungaran Regency is as follows, based on the research findings. The Landslide Early Warning System (LEWS) Program is considered effective in Efforts to Reduce the Risk of Landslides in Semarang Regency.

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DATA AVAILABILITY

All relevant data has been built with supporting file information. This research will assist researchers in identifying critical areas related to Web-Based Landslide Disaster Mitigation Information System (Sensor-Ku) Kalongan Village, Semarang, Central Java.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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