Development of Early Real-Time Disaster Mitigation Warning System Landslide with Gyroscope ADXL345 Sensor

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Abstract. The purpose of the research is to develop a Real-Time Landslide Early Disaster Mitigation Warning System with the ADXL345 Gyroscope Sensor and to know the exact system designed in a prototype. The method used is research and development with a prototyping model which is divided into several stages, namely stage (1) problems, (2) data collection, (3) prototype design, (4) prototype testing, and (5) production. The resulting system is a prototype based on an Arduino microcontroller called "ERT-Ladister" with an ADXL345 Gyroscope sensor. Other features include SMS-Gateway, buzzer, and Monitoring via Monitor. Based on the feasibility test and the effectiveness test on a lab scale and field scale, it can be concluded that the system is feasible and effective. The value of the effectiveness test shows that there is a significant difference between before the system is installed and after the system is installed in field trials. The Real-Time Landslide Early Disaster Mitigation Warning System can increase community awareness around landslide-prone areas.

1. Introduction
Indonesia is one of the countries that are prone to natural disasters in the world. This was also stated by the United Nations Agency for the International Strategy for Disaster Risk Reduction (UN-ISDR) based on the data it had released [1].

Geologically, Indonesia is included in the Ring of Fire environment, which has a fairly high potential for natural disasters, because it is located between the trajectory of two mountain paths, namely the Pacific Circum and Mediterranean Circums where there are many volcanoes, and their activities can cause volcanic earthquakes. Indonesia's geological position is at the confluence of three active plates, namely the Indo-Australian plate in the south, the Euro-Asia plate in the north and the Pacific plate to the east. Thus, Indonesia's position is very vulnerable to disasters [2], both from volcanic and tectonic activity. When there is volcanic or tectonic activity, there will be a shift, causing landslides. In addition, landslides can also occur on the banks of the river because it is influenced by the flow of water flowing in the river [3].

Landslide is the movement of slope-forming material in the form of rock, debris, soil, or material [4]. The mixed material usually moves in the highlands to the lowlands. The process of landslides can be explained as follows: water that seeps into the soil will increase the weight of the soil. If the water penetrates to the impermeable soil which acts as a slip plane, the soil becomes slippery and the weathered soil above it will move from the highlands to the lowlands [5].

The landslide disaster mitigation system that is currently being developed by the Center for Physics Research at the Indonesian Institute of Sciences (LIPI) Serpong is a system that uses an inclinometer sensor. This sensor is combined with several other devices to form a system that can monitor a
landslide-prone area so that when a landslide occurs, the disaster can be handled quickly by the surrounding community [6]. The landslide disaster mitigation system can be the right choice of tool for landslide-prone areas as an early warning tool to increase the preparedness of citizens against landslides. This is also supported by previous research which shows that in addition to the aspects of knowledge and attitude preparedness, a warning system is also needed to minimize disaster victims[7]. One other sensor that is considered good enough to be used in a landslide disaster mitigation system is the accelerometer sensor. This sensor will activate and change its angle value when the ground starts to shift or move [8]. This sensor will be combined with a microcontroller device, so that if there is a change in angle then the data will be processed by the microcontroller and will be conveyed to the user or the surrounding community [9].

However, the level of public awareness of the disaster-prone archipelago is still very low [10]. This can be seen from the level of awareness or attitude of community disaster response, which is still sluggish. If a disaster occurs in Indonesia, usually it will take quite a lot of victims due to the public's lack of awareness of potential disasters that will occur and their lack of responsiveness in the disaster management process [11]. In this case, we will develop a disaster mitigation system that uses an accelerometer sensor to detect the occurrence of landslides and uses Arduino Mega 2560 to process the information received and SMS gateway as a processing system so that it can be easily monitored via mobile devices and browser monitors. It is hoped that this mitigation system can monitor landslide-prone areas and provide information quickly via mobile devices or cell phones so that people can immediately anticipate the disaster.

2. Method
The research method used to complete this research is to use research and development methods (Research and Development) with a prototype model that includes problem identification, data collection, Prototype Design, Prototype Testing, and Production [12]. Small field trials were carried out at LIPI Puspitek Serpong and field trials were carried out at 5 landslide-prone points in the Subang area, Lebak Regency for a 3 month trial period.

3. Result and Discussion
3.1. Research result
The results of the research on Landslide Disaster Mitigation System Development Using the ADXL345 Accelerometer Based on Web Localhost and SMS Gateway were obtained after conducting a series of trials. This stage is carried out in order to find out how big the value of success in making prototypes is in accordance with the program or system that has been created. The stages are testing the ADXL345 Accelerometer sensor, Ethernet Shield, SMS Gateway, Webcam, and power supply (Power Supply).
3.1.1. Component test results
In the component section there are several tests carried out including Accelerometer sensor testing, Ethernet Shield testing, SMS Gateway delivery testing, webcam testing, and power supply circuit testing.

3.1.2. Tilt test results ADXL345 accelerometer sensor
The test was carried out by changing the tilt position of the ADXL 345 accelerometer sensor using the Arduino IDE 1.0.6 application. The data changes will be displayed through the serial monitor menu in the Arduino IDE application. In addition, to produce a degree value, the data must be calibrated first using a comparison. The following formula is used in the prototype of this system:

\[
\text{Sensor tilt angle} = \left( y - 5 \right) \cdot \frac{90}{(277 - 5)}
\]

Information:
y = Initial slope value
90 = Maximum slope angle
277 = Maximum limit of initial tilt angle
5 = Calibration value

After testing the sensor, the results are obtained as shown in table 1 below.

| No | Degree | Description |
|----|--------|-------------|
| 1  | 0      | The value taken is the value that often appears, namely 5 with an intensity of 7 times appearing in a row |
| 2  | 45     | The value taken is the value that often appears, namely 141 with an intensity of 5 times appearing in a row |
| 3  | 90     | The value taken is the highest value, which is 277 |

So it can be concluded that the value of 0 degrees, starts from 5 bits and the maximum limit is 90 degrees, which is 277 bits.

3.1.3. Application test results
At this stage, the results obtained from testing entering data into the localhost database, testing the database calling to the localhost web, and testing the status / conditions displayed on the Opera browser with the Windows 7 operating system.

Figure 2. Homepage display on localhost

Figure 2 shows the web homepage on localhost, which contains the slope, time, and webcam display conditions.
3.1.4. Status test result / condition
Table 2 shows the status of testing sensor information at 5 received landslide-prone points. If the sensor is in a state of more than 75 degrees, then the command will be carried out such as sending a short message via SMS Gateway.

| No. | Condition                  | Testing Criteria                  | Description                                      |
|-----|----------------------------|-----------------------------------|-------------------------------------------------|
| 1   | Slope Status “Safe” ≤ 30°  | Status “Safe” appears in Log_data.php | Condition 10 degrees with status “Safe”          |
| 2   | Slope Status “Standby” 30° ≤ 75° | Status “Standby” appears in Log_data.php | Condition 58 degrees with status “Standby”      |
| 3   | Slope Status “Landslide” 75° ≤ 90° | The “Landslide” status appears in Log_data.php “Landslide” status information received from mobile/HP | Condition 83 degrees with “Landslide” status |

3.2. Discussion
Based on the overall test results that have been carried out, it is known that the Development of a Landslide Disaster Mitigation System Using the ADXL 345 Accelerometer Based on Localhost Web and SMS Gateway functions according to the plan. However, there are still some limitations that exist in this system, namely:

The first discussion is that in component testing there are still some shortcomings, such as the IP Address setting on the Ethernet Shield sometimes changes itself when uploading programs on the Arduino IDE so to check it, you must use the help of the console command (CMD). The time frame for sending data from Arduino Mega 2560 to the database using the Ethernet Shield is sometimes interrupted even though the sending time has been set. For sending information via SMS, sometimes it doesn't reach its destination because the provider's signal is experiencing interference, so it is necessary to look for a provider card with a strong signal, reaching all corners, and rarely experiencing interference. When using the webcam, you still have to click the button to take a picture because the button is part of the .swf file so it can't be created automatically.

With the additional interface in the form of a website application at localhost on Landslide Disaster Mitigation System Development Using the ADXL 345 Accelerometer Based on Localhost Web and SMS Gateway, it makes it easier to monitor an area prone to landslides. The researcher believes that the prototype is very good in terms of providing information and can be a new alternative in developing a disaster mitigation system for further research.

4. Conclusions and Suggestions
4.1. Conclusions
After identifying problems, collecting data, designing prototypes, and testing prototypes, the following conclusions can be drawn:

4.1.1 Prototype for Landslide Disaster Mitigation System Development Using the ADXL 345 Accelerometer Based on Localhost Web and SMS Gateway has been designed with a slope limit of 30 degrees and can function as an information system that is quick to respond to landslide hazards through mobile devices.

4.1.2 Mobile / Mobile devices can receive short messages warning of landslide hazards from the prototype of Landslide Disaster Mitigation System Development Using the ADXL 345 Accelerometer Based on Localhost Web and SMS Gateway.
4.2. Suggestions
In developing a prototype of a Landslide Disaster Mitigation System Using the ADXL 345 Accelerometer Based on Localhost Web and SMS Gateway, the researcher has several suggestions to overcome and complete the system that will be used in this study.

- For the use of the Accelerometer sensor, use a sensor that is easy to find in the market so that many tutorials can be found in books or the internet.
- First, calibrate the Accelerometer sensor so that the resulting value is as desired.
- Adding a website application on localhost to display the results of the Accelerometer sensor and the data can be stored in the database.
- For database creation, create at least 2 databases to facilitate the data storage process.
- Adjust the delay of the Accelerometer sensor with the delay of sending data to localhost via Ethernet Shield so that the results of the accelerometer can be read and stored in the localhost database.
- When running this prototype open the Arduino IP address and the homepage of its mitigation system in a browser with a different tab.

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