Enhancing Landslide Risk Management in the City of Guwahati: Implementing an Automated Early Warning System Utilizing Soil Moisture Sensors

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Abstract: - Landslides pose a significant threat to human lives, infrastructure and environment, necessitating a landslide Early Warning system. A significant change in the soil moisture sensor value is observed as the time for landslip approaches in rainfall induced landslides. This paper represents an early warning system for the city of Guwahati using a basic automated tool, Zapier. By automating the early warning system, messages can be sent to the people residing in the landslide prone areas. This method is a low cost alternative to other landslide monitoring techniques such as use of retaining walls etc.

Key-Words: - : Landslide, Soil Moisture, Automated Tool, Early Warning, Risk Hazard

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1. Introduction

Eli Roth says, "Natural disasters are terrifying, that loss of control, this feeling that something is just going to randomly end your life for absolutely no reason is terrifying. But what scares the most is the human reaction to it and how people behave when the rules of civility and society are obliterated." Thus, there was always a need for early warning system for any kind of natural hazards. One such risk that needs to be prevented if left unchecked is landslides, which can be prevented with an effective and long-lasting warning system.

The doorway to the North East region of India and the land of Maa Kamakhya, Guwahati is surrounded by 18 hills out of which 8 are found to be landslide prone. The reason behind the vulnerability lies in two facts - rapid urbanization and cutting of natural slopes for infrastructure. During monsoon season, highest number of landslide events happens as evident from the Table 1.

Landslide early warning system consists of 3 basic steps as landslide mapping, monitoring and modeling [1]. The first step involves the landslide zonation mapping where the landslide prone areas are mapped with the help of satellite images or using the Digital Elevation Model (DEM) models. In [2], landslide hazard zonation for Guwahati City was performed with the help of Arc GIS where areas prone to Debris Slide or Rock Fall are classified and identified by different colors (Figure 1).

In the second basic step of landslide early warning, various sensors can be placed at the landslide prone areas to collect the data which are directly or indirectly related to the occurrence of landslide. Soil Moisture, temperature, humidity, slope area, range of vegetation, rainfall and displacement are some of the parameters on which occurrences of landslide depends. Soil moisture sensors are placed at various places in the experimental set up and tested with induced rainfall, since the landslides in the concerned area is mainly rainfall induced. In the third or final step of landslide early warning system, with the help of monitored data, an early warning system can be modeled.

Table 1 Details of landslide occurrences during the month of June, 2020 for the city of Guwahati (Assam, India).

Date	Place	Temperature (Min/Max)(Degree Celsius)	Rainfall Intensity(mm)
19/6	Santipur, Fatasil	25/32	8
26/6	Kahilipara	26/33	17.8
27/6	Durgasarowar, North Guwahati	26/33	8.4
28/6	Kharghuli, Nabagrah, Pandu, Dispur, Dhirenpara, Geetanagar	26/33	9.6
11/7	Maligaon	25/32	7.6
12/7	Sonapur, 12th Mile	24/33	9.4

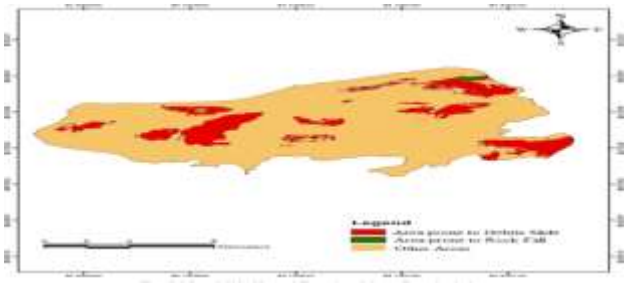

Figure 1 Landslide hazard zonation mapping for the city of Guwahati

2. Methodologies

2.1 Materials Used

In the literature, several methods were found for landslide early warning process. Use of artificial neural networks, GIS (Geographic Information System), IoT (Internet of Things) are many such alternatives that can be used to predict the occurrence of landslide and the same can be transmitted/relayed to the people residing in the landslide prone areas for timely response in emergency situations.
An increase in the soil moisture value is one of the major concerns for landslide prone areas where landslides are driven by rainfall [3]. Literature survey proved the fact that with the help of only soil moisture sensor landslide can be predicted [4][5][6]. The r square value for soil moisture is the highest during sensitivity analysis [7]. Further in [8], soil moisture sensors are placed at the tip and toe of the slope area to investigate the change in the soil moisture value with induced artificial rainfall. YL-38 soil moisture sensor is used for the experimental set up. The soil moisture sensors were placed at different places along the slope areas (with dimension 170cm*100cm*80cm). A solar powered water pump is incorporated with a sprinkler system so that the rainfall can be induced artificially.

There are several alternatives to Zapier that offers similar automation and integration capabilities such as Integroma, IFTTT and Automate.io. These alternatives vary in terms of features, pricing and target audience. After a detailed study on the available automated tools, Zapier is chosen because of the following advantages:

- Ease of Use
- Wide Range of Integrations
- Flexibility.
- Customization
- Automation Scheduling.
- Reliability

2.2 Method

The soil moisture sensors are placed at different points of the experimental set up (Figure 2) and results were obtained for the induced rainfall. The soil moisture sensor data can be sent to the cloud with the help of NodeMCU and ThingSpeakIoT. That sensor data is tabulated in a Google sheet linked to a particular mail ID. Zapier is used to provide the warning whenever the value of the soil moisture sensor changes or the Google sheet gets updated. By giving a trigger (an event that starts the Zapier) and its consequent action (the event Zapier performs after it starts), the warning can be sent to the people residing on landslide prone area. In the trigger tab, the Google sheet is linked with the event given as whenever a new row is added to the bottom of the Google Sheet. In the action tab of Zapier, send mail option has been selected and a number of mail IDs are added where the mail need to be sent. The body of the mail is user defined. Here, "The new soil moisture value is_____" line has been chosen. In the blank space, the updated soil moisture value is automatically displayed in the sent mail. The soil moisture sensor data as received during the condition are sent as mail to different mail IDs (Figure 3 and Figure 4 respectively).

Figure 2 Experimental set up with the sprinkler system

Figure 3 Experimental set up when soil moisture value goes to 88 percent of the maximum value

Figure 4 Experimental set up when soil moisture value goes to 90 percent of the maximum value

3. Experimental Results

Whenever the induced rainfall increases, there is a change in the soil moisture value and this soil moisture value gets updated in the Google Sheet. Each time the google sheet has been updated with a new row, the same is sent as a mail to the designated mail IDs (Figure 5). The same trigger has been repeated and action follows (Figure 6).

4. Discussions

As can be seen from the above results, any change in the soil moisture value gets reflected in the mail that is being sent. The mail Ids of the people residing in the landslide prone area can be collected and bulk mail can be sent to everyone for streamlined emergency response. Although the proposed automated tool does not have the provision of sending bulk messages directly, but Zapier can be used in conjunction with the messaging services that supports sending bulk messages to people residing in the landslide prone areas.

Despite a few disadvantages of Zapier (such as limited complex logic, delay in processing, dependency in third party services), it remains a popular choice for automating simple to moderately complex workflows

Figure 5 The updated or new value of soil moisture is sent through mail

Figure 6 The updated or new value of soil moisture is sent through mail

5. Conclusions

The use of Zapier does not require any coding. The creation of trigger and action has various options. The most suitable one can be chosen from the broad range of options. Hence, the method provides the low cost and simple process for landslide early warning for the people residing in landslide prone areas. Farther, Time response of YL-38 soil moisture sensor is the lowest response time reported for a resistive based soil sensor which makes the proposed system more time efficient.

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Conflict of Interest
The authors have no conflicts of interest to declare that are relevant to the content of this article.

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