Landslide Early Warning System Using Real-Time Sediment Monitoring By Geophone

by Geophone Solutions Mr.Kenji Tsuruta, Geo-electronics Dr.Saiichi Sakajo, GAIA Consultant Dr.Masayuki Inoue

1. Introduction

In recent years, record-breaking long rains and local torrential rains have increased globally due to climate change, leading to numerous landslide and flood disaster. The Japan Meteorological Agency (JMA) issues landslide disaster warnings using rainfall data (rainfall amount and soil water index) as an indicator and calls for evacuation of residents. However , since landslide occurrences depend on local ground and sediment runoff characteristics , rainfall information alone is insufficient for effective evacuation guidance.

Currently , landslide-related fatalities are rising , and existing forecasting technology cannot reliably predict the timing and location of landslides and debris flows during heavy rainfall . We have developed sediment monitoring technology and created a landslide early warning system based on sediment volume .

By continuously observing sediment runoff, we can detect unusual phenomena in advance and deliver warning evacuation information at an early stage.

2. Geophone System Features For Warning of Landslide

2.1 Sediment Monitoring System

The Geophone system monitors water levels (flow rate) and sediment transport (bedload and suspended sediment) caused by landslides and debris flows over time using a solar power. The system also captures local situation via camera images.

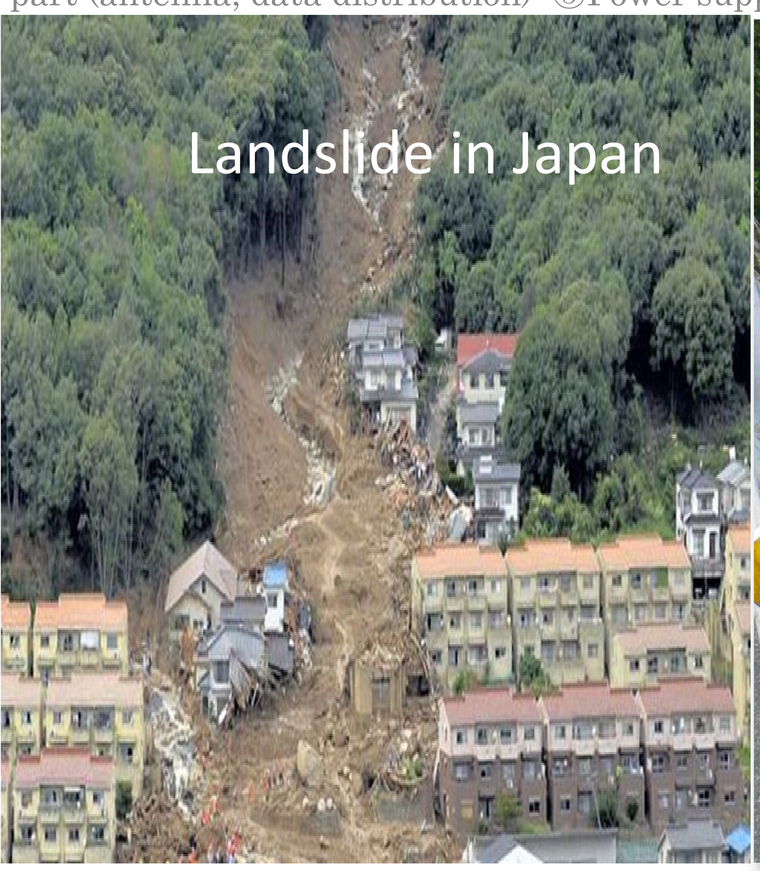
The system uploads data to a cloud server. We can monitor sediment transport phenomena at the catchment area in real time. By monitoring sediment flow, we can detect landslides and debris-flows in advance. In addition, we can provide graduated alerts (caution, warning, evacuation) based on water level (flow rate), sediment volume, to the necessary locations.

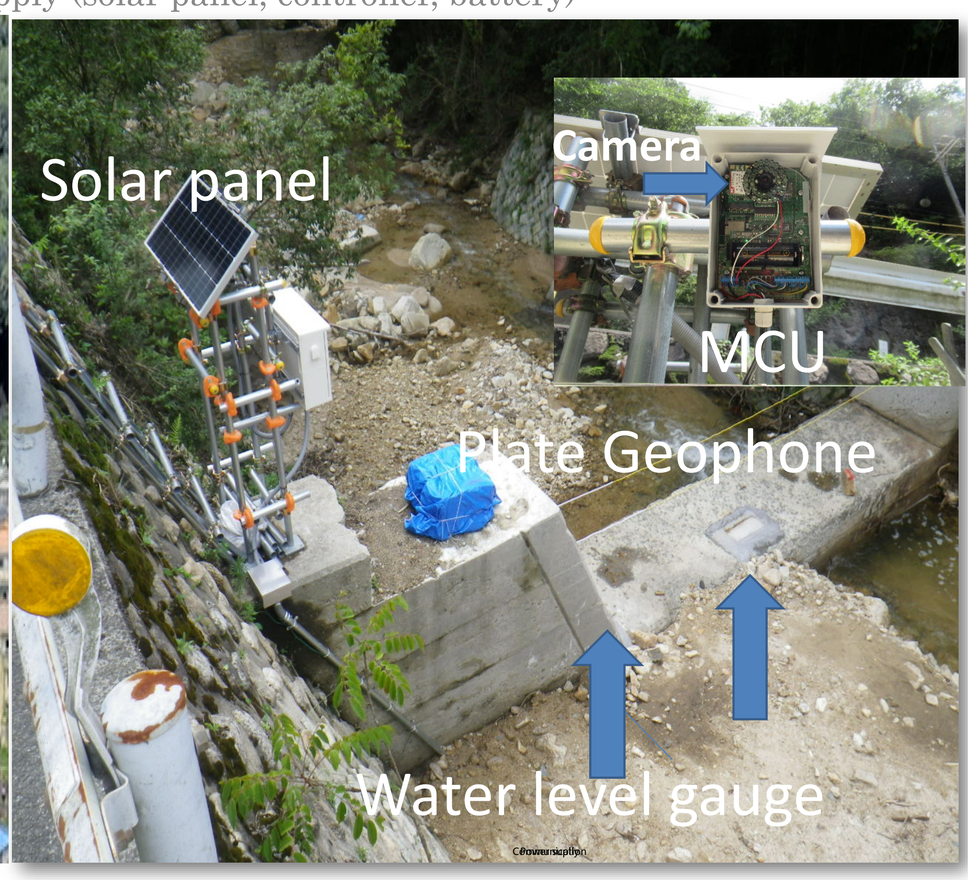
2.2 Conversion Technology to Moving Sediment Volume

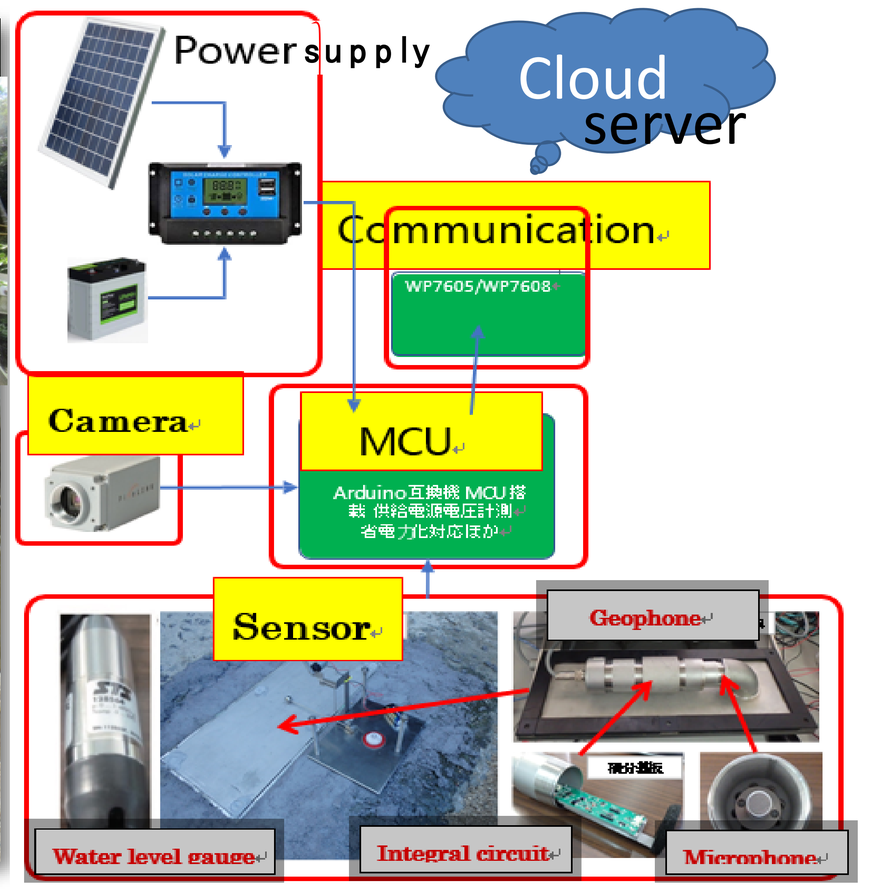
The Geophone uses a microphone to detect the sound of sediment impacting the sensor, and the sound pressure energy (voltage) is integrated and converted into the volume of sediment moved.

2.3 Basic Components

①Sensor (microphone, integrating board) ②Camera ③MCU (data processing, data storage, control (alarm judgment, trigger switch) ④Communication part (antenna, data distribution) ⑤Power supply (solar panel, controller, battery)







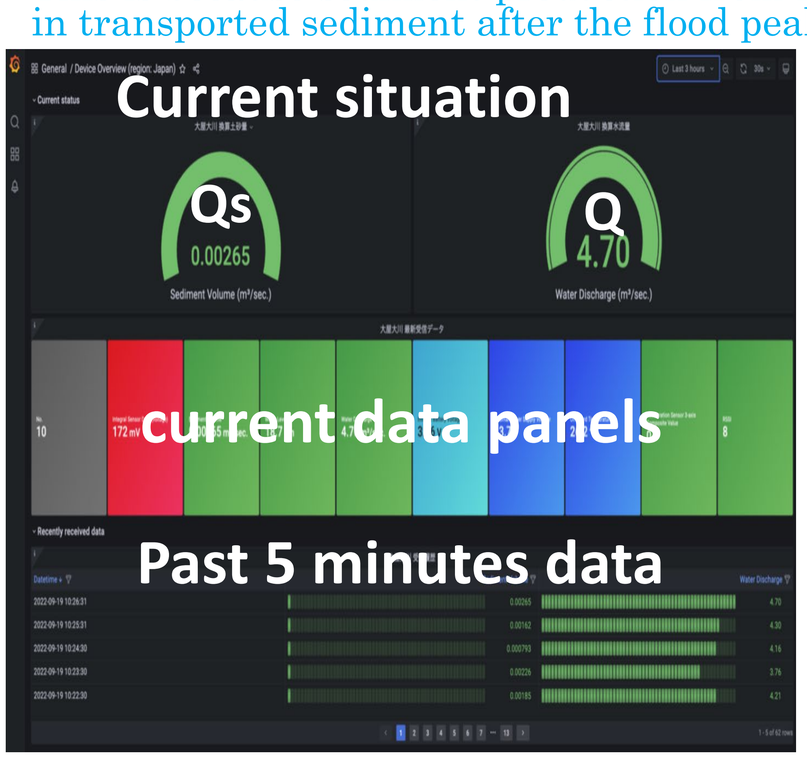
2.4 Real-Time Situation Monitoring and Data Analysis with Disaster Prevention IOT Devices

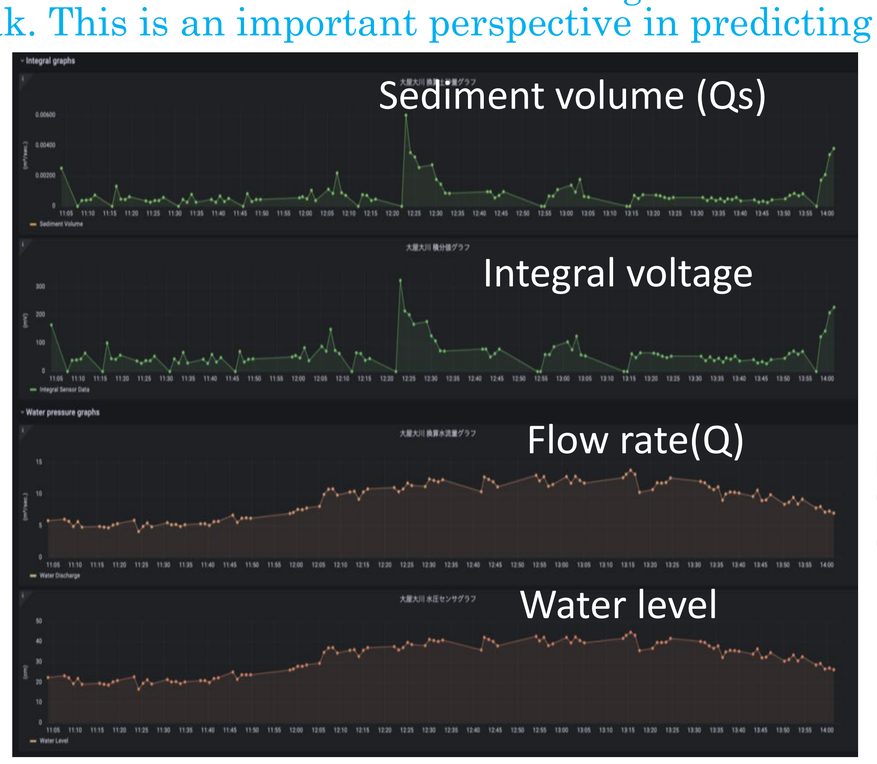
Geophone systems equipped with IOT devices enable real-time monitoring based on multidimensional observation data. The system converts sound pressure integral values into bedload volume, and water level into flow rate, charting these in time series on the cloud server.

Additionally , the system tracks data such as circuit board temperature, battery voltage, and signal strength of the communication environment.

The system also enables sediment discharge analysis visualization of observation data from CSV files on the cloud server.

Figure1 shows that the amount of sediment(Qs) increases after the peak of the tractive force (relating with water level). In the absence of sediment production, sediment volume increases as water rises. However, the observed Qs does not correlate directly with tractive force. This is because sediment production from landslides tends to occur after the groundwater level on the hillside rises, leading to an increase in transported sediment after the flood peak. This is an important perspective in predicting landslides and debris flow damage.





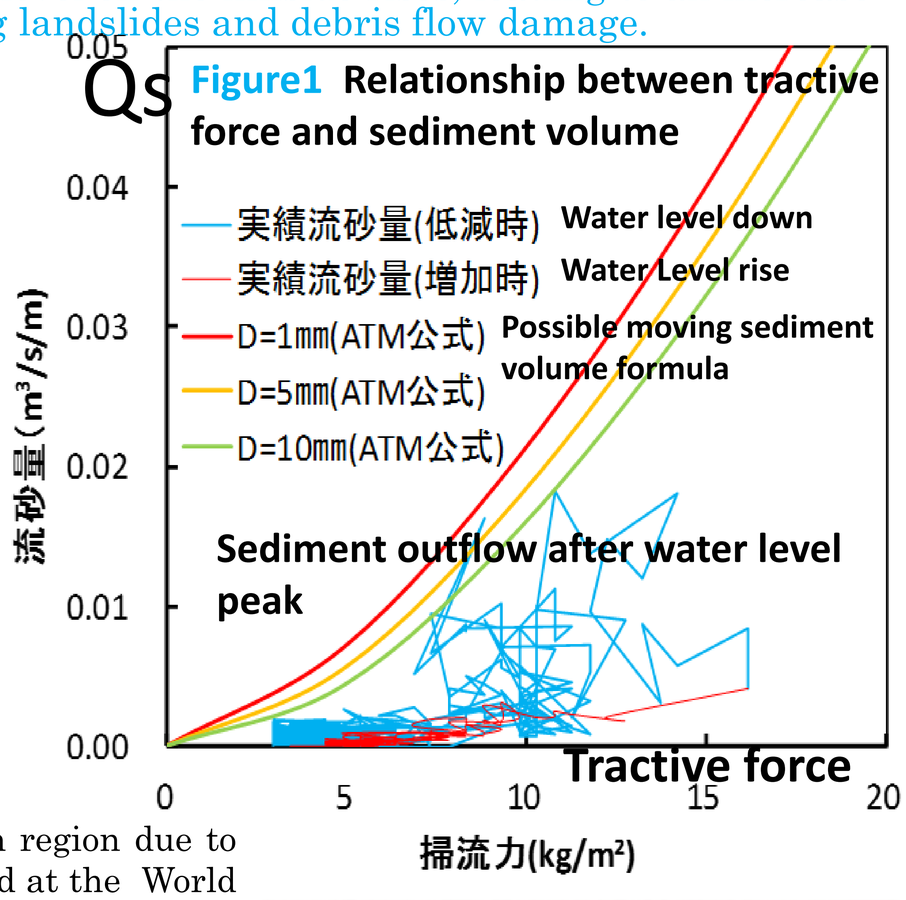
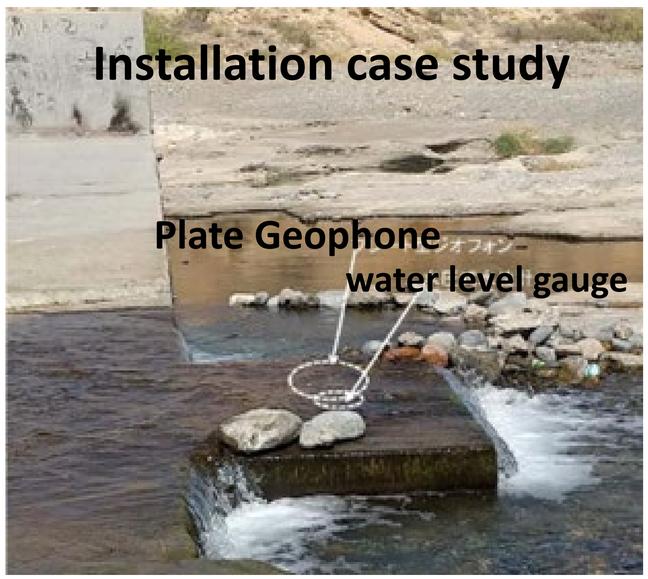


Figure1 Relationship between tractive force and sediment volume

3. Installation Case Study: Flash Floods in Wadi (Dry Desert River)

Recently, flash floods have occurred frequently in Wadies in the Middle of East and North African region due to climate change. Loss of lives and economic damages are increasing . A notable event was the flash flood at the World Heritage Site of Petra in Jordan in November 2018. 3,000 tourists were evacuated. In response, Kyoto University and our company installed two Geophone systems in the Wadi Al Khuwd, Oman in order to observe and study flash floods.



4. Summary

The Tokyo Metropolitan Industrial Technology Research Institute has approved our landslide early warning system through real-time sediment monitoring, which was tested over three years on the Oya Okawa River in Hiroshima. Understanding sediment transport phenomena requires direct sediment measurement, however, current observational records and historical data on sediment transport are limited. It is essential to understand sediment discharge phenomena, which increase during flooding, in addition to rainfall and runoff data.

The landslide early warning system continuously monitors water level and sediment volume, facilitating a clearer understanding of sediment transport phenomena.

The system can also detect anomalies upstream and can trigger public evacuation warning. Given the heightened risk of landslides and flooding after earthquakes, we recommend installing this system in earthquake-prone areas.