# LANDSLIDE EARLY WARNING SYSTEM USING REAL-TIME SEDIMENT MONITORING BY GEOPHONE



# PRESENTATION OVERVIEW

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- 2. Geophone system features
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#### 1. Intoroduction

- 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.
- O 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.

## DISASTER CAUSED BY DEBRIS FLOW

The importance of measuring flow rate and sediment volume

©This photo shows the landslide disaster that occurred in Hiroshima City in August 2014. The debris flow sacrificed 54 people.

 The cause of the debris flow was record-breaking the local torrential rains
 ; Rainfall: 24hour 287 mm, 3hour 200 mm, maximum hour 121 mm.

©The evacuation advisory was issued after the landslide occurred. In addition, the local torrential rains occurred at night, so residents were unable to evacuate.



© By continuously observing sediment runoff, Geophone could have caught small sediment movement events before debris flows occurred. The government could have issued an evacuation advisory before the debris flow occurred.

# **2.GEOPHONE SYSTEM FEATURES**

#### Sediment monitoring system

© Wire sensors have been installed in many landslide hazard areas. However, They are sometimes cut by falling rocks, fallen trees and driftwoods. These cause malfunctions to the wire sensors.

◎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.

## Conversion Technology to Moving Sediment Volume

©When sediment flowing on the river bottom impacts a steel sensor (pipe or plate type), an impact sound is generated. A microphone phone in the sensor detects the impact sound. Since the impact sound is low, an amplifier amplifies the impact sound.

 $\odot$ It is known by experiment that the integrated sound pressure waveform value is proportional to the momentum(mv) of the sediment. For practical purposes, the flow velocity is neglected because the sediment volume is dominant.

©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.

©The equation for the return to sediment volume should be developed by performing a hydrographic experiment in the field or in the laboratory. The channel experiment should be conducted using local riverbed materials.

# GEOPHONE APPEARANCE AND CONFIGURATION



Iron ball impact experiment device simulating sediment



The integration circuit integrates the acoustic pressure generated by the impact sound of sediment with the geophone



#### **3.LANDSIDE EARLY WARNING SYSTEM**

#### **FEATURES**

O When the Geophone detects an unusual amount of water level and sediment, the Landslide Early Warning System sends warning information to the necessary locations.

• We can observe the site using camera images.

Basic components (Composition)

- Sensor (microphone, integrating board)
- Camera
- MCU (data processing, data storage, control)
- Communication part (antenna, data distribution)
- Power supply (solar panel, controller, battery)

- O The system uploads time-series data to a cloud server for viewing from anywhere.
- O Three thresholds can be set according to the amount of water level and sediment, when the threshold is exceeded, an alarm is sent by e-mail to the necessary locations.
- O Three levels of thresholds and information provision: caution, warning, and evacuation
- It is suggested the Geophone is installed with priority given to areas with a high risk of landslides.







#### LANDSIDE EARLY WARNING SYSTEM BY GEOPHONE

#### **INSTALLATION**

Equipment box

(MCU - Communication unit, Power supply unit, Controller, Battery) Data confirmation and circumstance monitoring from anywhere

Warning information is delivered by e-mail

Plate type Geophone (sensor, microphone, **ICU** device integrating board) Came Solar panel Water level gauge

Hiroshima Pref. Oya-Okawa observation point(C.A=4.06km<sup>2</sup>)

# 4.DISASTER PREVENTION IOT DEVICE SYSTEM Real-time Data Uploaded to Cloud Server (Japan)

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## DISASTER PREVENTION IOT DEVICE SYSTEM

#### Time series charts of water level, flow rate & sediment volume (Japan)



### DISASTER PREVENTION IOT DEVICE SYSTEM

Monitoring of supply voltage 、circuit board temperature& radio wave strength (Japan)



#### DISASTER PREVENTION IOT DEVICE SYSTEM

#### Uploaded river picture to the cloud server (Japan)



#### 5.0YA- OKAWA OBSERVATION RESULTS (JAPAN) JULY 2020 FLOOD



# THE RELATIONSHIP BETWEEN TRACTIVE FORCE (RELATING WATER LEVEL) AND SEDIMENT VOLUME

The importance of measuring water level (flow rate ) and sediment

**©**Figure1 shows that the amount of sediment(Qs) increases after the peak of the tractive force (relating with water level).

The tractive force refers to the force that moves sediment. The red, yellow, and green lines represent the amount of sediment that can be moved according to the sediment load formula. These data are prepared for each sediment grain size.

 $\odot In$  the absence of sediment production, sediment volume increases as water rises.

 $\odot$  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 flows damage.

# 6.The two installation sites(Oman) Wadi AL Kawud Wadi Aluqq Area (sq km) 1673 Area (sq km) 139

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## **Eequipment Installation (Oman)**











 Integrated acoustic pressure
 → Weight of sediment falling down by the following chart



Experiments of soil collision to obtain the right hand chart

## FIELD HYDROGRAPHIC EXPERIMENT (UPSTREAM SITE)



00-50 01-00 01-10 01-00 01-00 01-40 01-50 00-00 00-1

#### Wadi Aluqq Observation Results(Upstream site) (April23,2023small flood)







## 7. 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.

## APPENDIX 1 GEOPHONE CAN MONITOR VARIOUS TYPES OF GEO-HAZARDS



#### APPENDIX 2 DISASTER PREVENTION IOT DEVICE SYSTEM

#### Real-time Data Uploaded to Cloud Server (Oman)

