



スリランカにおける降雨による高速長距離土砂流動災害の早期警戒技術の開発  
Development of early warning technology for rain-induced rapid and long-travelling landslides in Sri Lanka

◆ ICL -SATREPS Key Members visited Sri Lanka to Accomplish the project's goals.

Date: 2022 April – 2023 March

**Arayanake and Kandy Survey Report**

**January 5-14, 2023**

**Prof. Kazuo Konagai**

The Secretariat of the International Consortium on Landslides dispatched a survey mission to Sri Lanka on 5 January 2023. The mission, consisting of eight Japanese and Vietnamese experts and NBRO scientists joining on-site, was split into three teams:

- (1) Landslide assessment team: They studied geomorphological and geological features of the Arayanake area, one of our pilot study sites, and a mountain area near Kandy where unstable soil masses perch on the mountain slopes.
- (2) Seismic monitoring team: A series of ground tremors were reported near Kandy in August 2020. All concerned people felt uneasy because Sri Lanka has not long been experienced intense earthquakes and unaware of how to confront them. No matter how small a ground tremor is, a mountain topography can amplify it so that it will cause an unstable soil mass barely staying in balance on the mountain slope to start sliding. Monitoring ground tremors will help us understand how the mountain terrain can amplify ground motion. The team developed a seismometer layout plan for both Arayanake and Kandy's mountain areas.
- (3) Risk communication team: To maximize the benefit of the leading-edge Early Warning System, which is being developed during Project RRLN, we must know local people's perception of landslide disaster risk reduction. For this purpose, the team conducted

a three-day questionnaire survey in and around Arayanake, where people experienced a devastating large landslide in May 2016.

The scientists at NBRO, Dr. Jagath Gunatilake and Ms. Tania Munasinghe, the ICL/SATREPS Office members in Sri Lanka, provided the team members with every necessary logistic support in the difficult circumstances of the economy that Sri Lanka is facing.



Figure: SATREPS Project Team at the NBRO Headquarters

**Multi-Scale Simulator for the Geo-environment (MSSG)**

**Prof. Ryo Onishi**

Prof. Onishi visited Sri Lanka from 24 to 28 August 2023. He joined the Landslide Technical Forum held at BMICH on 25 and NBRO on 26, where he presented the research and development in the rainfall forecast team. He also visited the ICL SATREPS office on 26 and 28 to set up the updated MSSG weather simulator in the ICL workstation.

## Hydrological Processes in Landslide Slope

**Dr. Shiho Asano**

Field observations have begun at two landslide sites (Aranayake and Athwelthota) with the installation of observation equipment in order to clarify the hydrologic processes during landslide occurrence. Observations are being conducted on meteorological factors such as rainfall, soil moisture in the shallow layer of the forested slope, groundwater in the deeper part of the slope, and slope displacement. Heavy rain, high temperatures, and high humidity make for a difficult environment for the electronics of the observation equipment. Still, with the cooperation of many of the project members, we have continued observations.



Figure: Slope displacement monitoring equipment

## Early Warning System

**November 12-23, 2022**

**Mr. Keisuke Takimoto and Dr. Kouichi Araki**

Mr. Takimoto and Dr. Araki visited the ICL SATREPS office in Sri Lanka from November 12 to 23, 2022 for installation and setting up six workstations for the AR software which shows the result of RRL forecasts as virtual reality on a screen, such as tablet devices and PCs. The installed workstations are a GPU server for landslide simulation using the LS-RAPID, a workstation for controlling the GPU server, a web server for delivery of the result of RRL forecasts, and so on. Also, we set up a network in the ICL SATREPS office in Sri Lanka and a VPN to update, modify, and maintain the AR software from Japan.

Afterwards, Mr. Takimoto visited the ICL SATREPS

office in Sri Lanka from January 25 to 27, 2023, to maintain the network and the VPN. As of April, there were problems with the network and the VPN, and we now work with the NBRO staff to resolve the issues



Figure: workstations for the AR software



Figure: Dr. Araki working for setting up

## Soil Sampling

**November 9-17, 2022**

**Mr. Sandaruwan Karunarathna,**

**Mr. Sajith Bandaranayake,**

**Associate Prof. Satoshi Goto**

One Ph.D. student (Sandaruwan Karunarathna), one M.Sc. student (Sajith Bandaranayake), and their supervisor (Associate Prof. Goto) at the University of Yamanashi, Japan, conducted a field survey mission in Sri Lanka on 9-17, November 2022. The survey focused on the pilot site used for the research work called “Aranayake Landslide” in Kegalle, Sri Lanka. The



primary purpose of the field survey mission was to obtain the complete particle size distribution of the debris from five locations in the downslope propagation zone of the Aranayake landslide. Carefully prepared vertical cut without disturbing the deposited debris particles was captured by a high-resolution camera, and the representative sample for laboratory sieve analysis was obtained in each location. The combined methodology of scaled image analysis and laboratory sieve analysis was used for the complete particle size distribution result.

The second purpose is to identify the geotechnical properties of the landslide initiation area. Dynamic Cone Penetration (DCP) test was conducted to obtain the soil depths. An in-situ sand cone test was conducted to obtain field density and field moisture content. Also, the undisturbed sample was obtained for the direct shear test. Part of the disturbed soil was shipped to the University of Yamanashi in Japan to conduct laboratory experiments. The results obtained from this field survey and laboratory tests were used for the ongoing research at the University of Yamanashi, bounded by SATREPS.

The field officers in the Geotechnical Engineering Division (GED) in the National Building Research Organization (NBRO) provided their fullest support for the field survey and the laboratory tests. The ICL/SATREPS office members provided all the required logistic support for this field survey mission.

### Ring Shear Test

**Mr. Taketoshi Marui**

**Mr. Osamu Hiroi**

**Mr. Masahiro Yoneda**

**Mr. Makoto Ishikawa**

**Mr. Yuji Ikari**

Marui & Co. Ltd. had developed a ring shear apparatus, ICL-2. The inspection was conducted with Mr. Sanchitha Jayakody, PhD candidate at Kyoto University /engineer at NBRO, and Mr. Doan Loi at ICL before the shipment in May 2021. After the confirmation of the normal operation of the apparatus, it was shipped from Kobe Port in October 2021 and arrived at Colombo Port in November 2021. After passing customers, it was transported to NBRO. International travel between Japan and Sri Lanka had many restrictions because of the Covid. Initially, the visit was planned for the end of July

2022. However, it was postponed because of the political change on July 8. Finally, we could travel on October 25 from Narita to Colombo. The apparatus was already placed in the lab. The engineers at NBRO and we confirmed the energization by connecting the main apparatus, measurement unit, and power supply unit. In addition, normal operation was confirmed by testing the test items before shipping. In the lab, we explained how to operate the apparatus to Mr. Maduranga, Ms. Amali, and other members. We thank the RLL project members in Sri Lanka that we could smoothly place the ring shear apparatus ICL-2.



Figure: Inspection by Mr. Sanchitha and Mr. Loi at Marui Factory

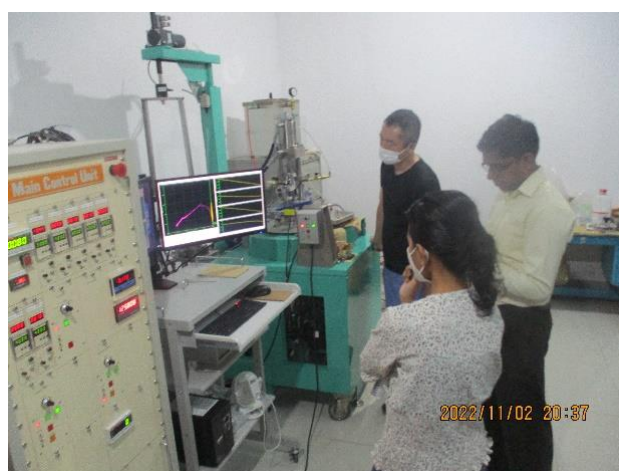


Figure: Mr. Yoneda, Mr. Maduranga and Ms. Amali

## Observation of Seismic Motion and Tilt in Landslide Area

**Prof. Koji Matsunami**

Seismic motion and ground tilt are monitored using MEMES-type accelerometers. We introduce tilt fluctuations in the Aranayake and Kalugala regions for five months from April. The rock sites in both areas have very small and stable fluctuations, but the landslide areas have significant fluctuations. A step-like change can be seen simultaneously in S02 and S03 of Aranayake. There was no earthquake, so an earthquake did not cause it.

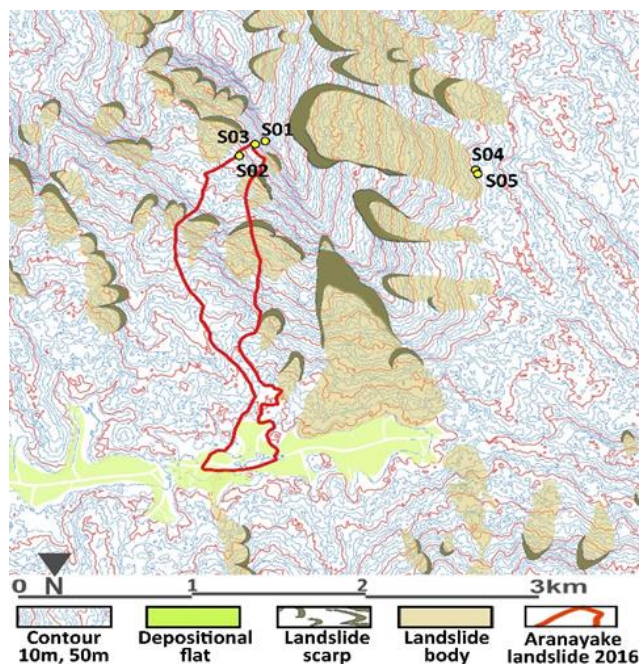


Figure: Map of Station Location

Aranayake: S01(rock), S02(debris), S03(scarp)

Kalugala: S04→S10(soil), S05(rock)

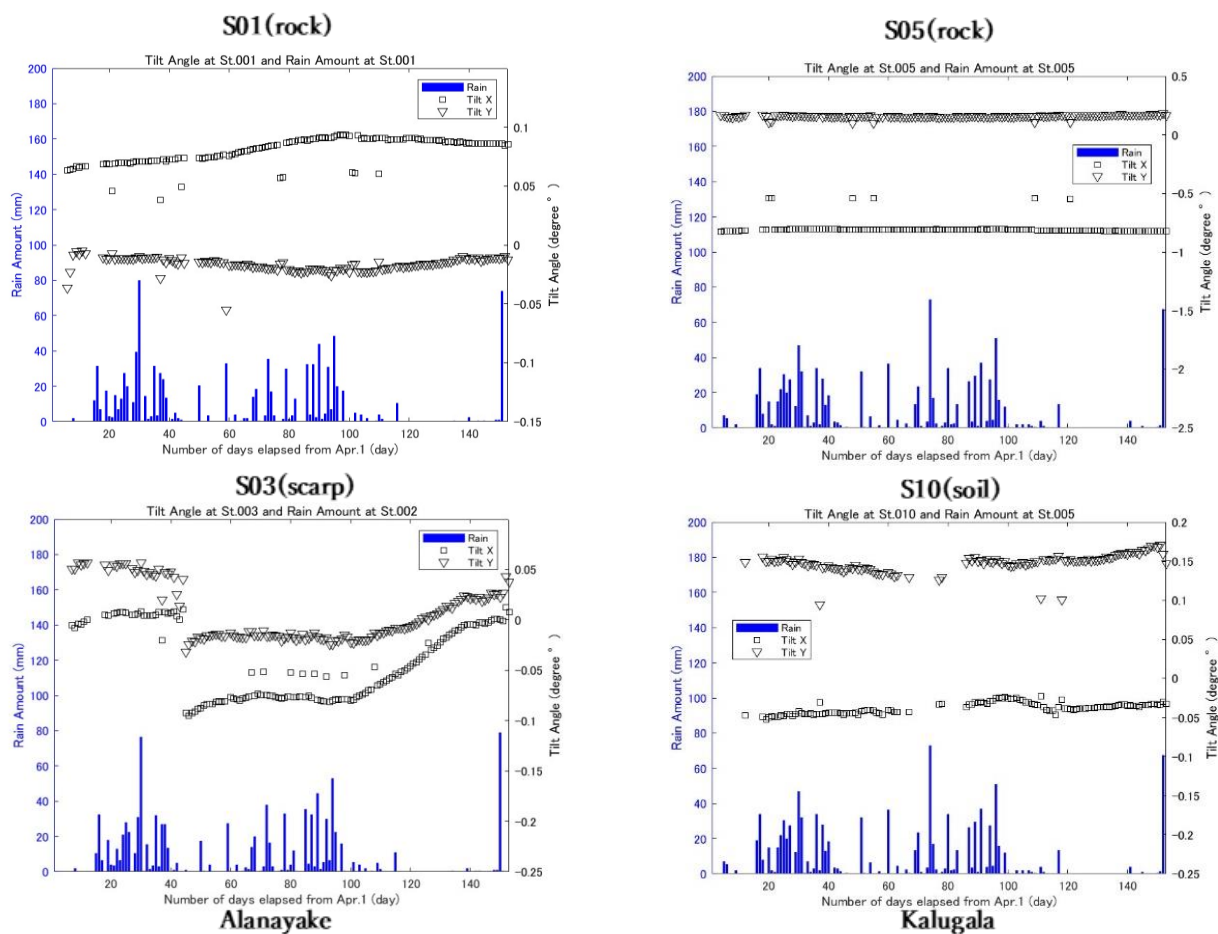


Figure: Tilt and Rain Amount



## Questionnaire Survey for Local People

January 5-17, 2023

Dr. Kumiko Fujita

A questionnaire survey was conducted at Arayanake to know the local people's perception of landslide disaster risk reduction. There are five categories of questions as follows:

1. Demographic information: Q1-11
2. Livelihood: Q12-14
3. Experience of landslide: Q15
4. Hazard map and early warning: Q16-29
5. External help: Q30-36

In the selected areas, there were 50 respondents, 16 males and 34 females.

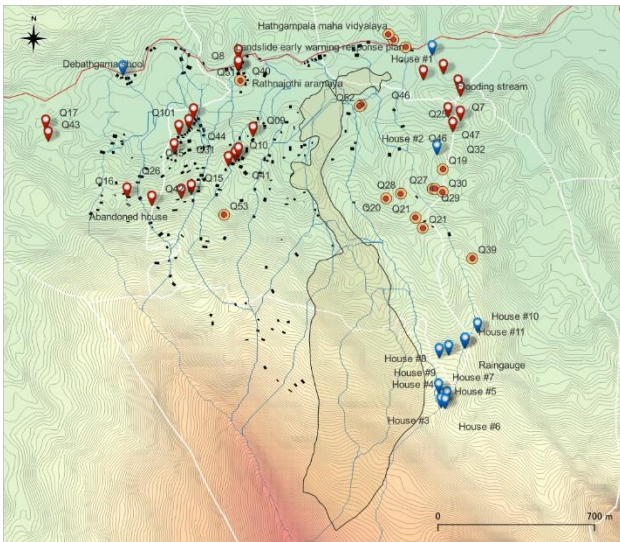


Figure: 50 visited locations in the selected field

The respondents living in the hillside area do not have any particular evacuation places; however, the respondents living near the main road answered certain evacuation places such as temples.

Though the signal is weak in some areas, SMS can receive early warning since the rate of mobile phone holders is high, and they use mobile phones daily. Twenty-eight respondents answered that they saw the hazard map of their living area. They are well educated to interpret the map, and many of the 28 people can tell the locations of their houses on the hazard map. Many respondents expect disaster education.

## ◆ Greetings from the project leaders

Since we saw good signs that the problematic situation triggered by the economic crisis in Sri Lanka was calming down in the latter half of 2022, our in-person activities have shifted into high gear. As reported in the previous and this newsletter (No. 5 and 6), we dispatched Japanese engineers to Sri Lanka to provide short in-person training courses on the Ring-shear apparatus and field trips for landslide-terrain interpretations. Relevant Japanese and Sri Lankan Researchers conducted questionnaire surveys in January, April, and May 2023. We organized four-week training courses (February 8 to March 7, 2023) on "Ring shear apparatus," "LS-Rapid," and weather simulations using the Multi-Scale Simulator for the Geo-environment (MSSG), etc. Also, we have installed ten seismometers, given the growing concern about the recent seismic events occurring in and around the island. The Augmented Reality (AR) software, allowing stakeholders an interactive experience combining the real world (geographic information of pilot study sites) and computer-generated content (rain and RRL forecasts), is now ready to use. As a whole, we are catching up on the Plan of Operation (PO). All details have been reported in the successful Landslide Technical Forum on Aug. 25 and 26, held at Jasmine Hall of the Bandaranaike Memorial International Conference Hall (BMICH) (August 25) and NBRO (August 26), Colombo. We, the project leaders, thank our members and JICA/JST officers for their dedication to the project.

### Project Leaders

Kazuo Konagai  
International Consortium on Landslides (ICL)

Asiri Karunawardena  
National Building Research Organization (NBRO)