Date of Submission	June 10, 2025

IPL Project (IPL-249) Annual Report Form

Period of activity under report
from 1 January 2023 to 31 March 2025

1. **Project Number and Title:**
   Development of early warning technology of rain-induced rapid and long-traveling landslides in Sri Lanka
2. **Main Project Fields**
   (1) Technology Development
      A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment
   (2) Targeted Landslides: Mechanisms and Impacts
      A. Catastrophic Landslides, B. Landslides Threatening Heritage Sites
   (3) Capacity Building
      A. B. Enhancing Human and Institutional Capacities
      B. Collating and Disseminating Information/ Knowledge
   (4) Mitigation, Preparedness and Recovery
      A. Preparedness, B. Mitigation, C. Recovery

3. **Name of Project Leader**
   Name: Kazuo Konagai
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   Core members of the Project:
      Asiri Karunawardena and Gamini Jayathissa/ National Building Research Organization (NBRO), Columbo, Sri Lanka A A Virajh Dias / Central Engineering Consultancy Bureau (CECB), Columbo, Sri Lanka Kyoji Sasssa / ICL Headquarters, Kyoto, Japan, Ryo Onishi / Institute of Science Tokyo, Ryosuke Uzuoka / Disaster Prevention Research Institute (DPRI) of Kyoto University, and Shiho Asano / Forestry and Forest Products Research Institute (FFPRI)

4. **Objectives** (5 lines maximum)
   The early warning technology of rain-induced rapid and long-traveling landslides suitable for Sri Lanka is established by integrating newly developed technologies. They are 1) time prediction of heavy rainfalls and pore water pressure build-up, 2) site prediction of landslide initiations and motions, and 3) effective risk communication and public education.

5. Study Area

Two pilot study sites are 1) Aranayaka in Kegalle District and 2) Athwelthota in Kalutara District, Sri Lanka.

6. Project Duration

from 2019 to 2025

7. Report

1) Progress in the project (30 lines maximum)

Influenced by the effects of climate change and, more seriously, by human-induced interventions in landslide-prone areas, the number of tragic Rain-induced Rapid and Long traveling Landslides (RRLLs) in Sri Lanka has been on a soaring trend in general. In this situation, ICL and NBRO started this project in 2020 after the preceding period of 2019.

The critical technologies to develop in Project RRLL include:

(1) 24-hour-in-advance prediction of heavy rainfalls in the mountains

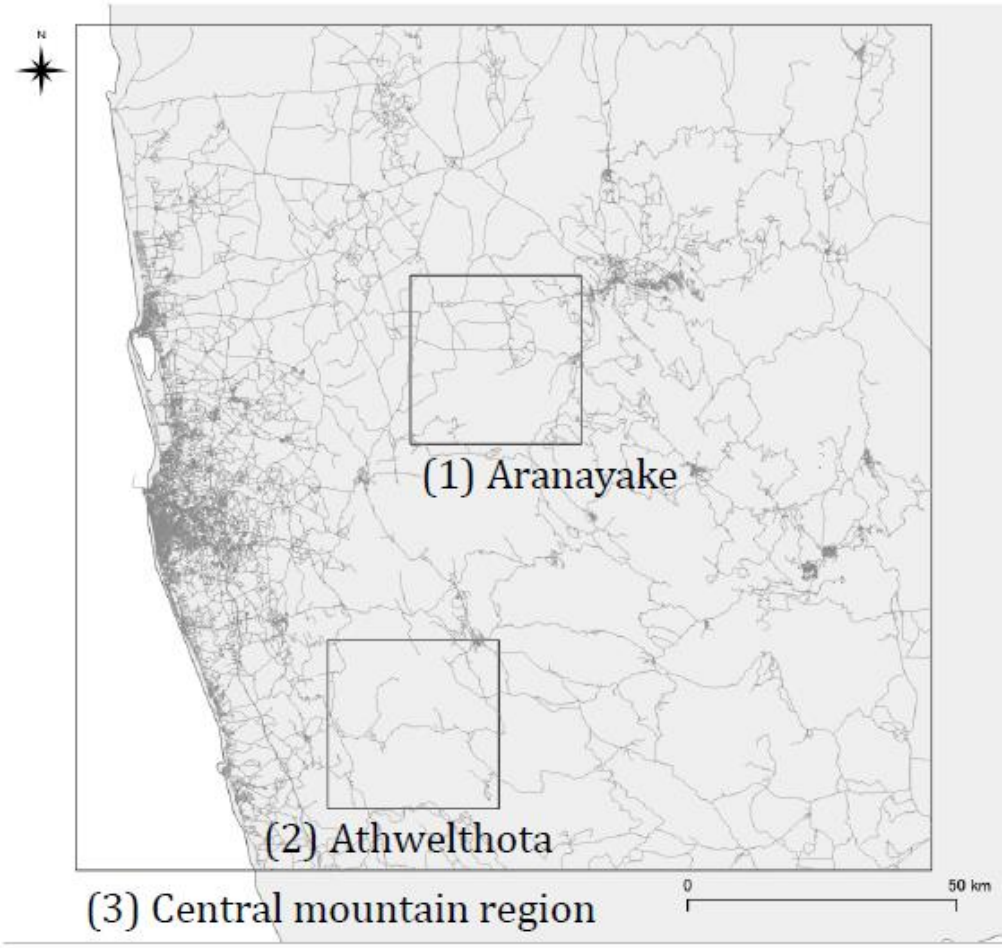
(2) Assessing groundwater pressure buildup, initiation of an RRLL, its flowing dynamics, and

(3) Effective risk communication and public education.

As Output for (1) 24-hour in-advance prediction of heavy rainfalls in the mountains, we used MSSG (Multi-Scale Simulator for the Geo-Environment) as our generic platform for the precise weather forecast. The MSSG has demonstrated that the accuracy of rainfall prediction has been improved by reflecting the effects of turbulence caused by mountain topography. To shorten the computational time, the relevant members have developed a machine-learning scheme called the "Super-Resolution Model," which allows downscaling a 2 km x 2 km resolution image to a 500 m x 500 m resolution image, thus remarkably reducing the renewal time from 6 hours to 3 hours (Bandara, et al., 2025).

As Output for (2) predicting RRLL occurrences and their runouts, we utilize two numerical tools, LS-Rapid and the SLIDE model, which have been developed and used for many years since 2010. The parameters of the SLIDE model were adjusted to match the results of ring shear tests on soil samples taken from the soil layer in which the sliding surface was formed. As a result, the SLIDE and LS-Rapid models could reproduce past RRLL occurrences and runouts satisfactorily.

As Output for (3) effective risk communication and public education, the members in charge have developed an Augmented Reality (AR) Viewing System (Fig. 1). This system overlays the real world, showing predicted rains and RRLLs on a Google Earth map image, rendering a 3D representation of the terrain profile.



(1) For Aranayake with a 500 m resolution
https://satreps.godai.co.jp/maptest/index810.php?AREA_NAME=Area1&MODE=1

(2) For Athwelthota with a 500 m resolution
https://satreps.godai.co.jp/maptest/index810.php?AREA_NAME=Area2&MODE=1

(3) For the mountain region (MSSG child domain) covering both Aranayake and Athwelthota with a 2 km resolution
https://satreps.godai.co.jp/maptest/index810.php?AREA_NAME=Area1&MESH_SIZE=2000&MODE=1
(The links are subject to change.)

Fig. 1 Links to the Augmented Reality (AR) views

2) Planned future activities or statement of completion of the Project (15 lines maximum)

The AR Viewing System has been in operation in Aanayake and Athwelthota since the summers of 2023 and 2024, respectively. Despite improvements in the accuracy of rain and RRLL predictions and the timely distribution of information, many individuals remained unaware of safe locations and evacuation routes nearby. As a result, the project team conducted educational activities focused on Landslide Disaster Prevention, including village watching. Consequently, the project has achieved all its intended objectives. The overall goal, representing the long-term outcome our team is dedicated to achieving, is to implement the established early warning system in other key areas of Sri Lanka. To reach this goal, team members need to enhance the accuracy of rain and RRLL forecasts and persist with community engagement initiatives, such as village watching.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

The beneficiaries of cutting-edge rainfall forecasts that physically describe the boundary-layer turbulence effect on rainfall over mountain terrains and the scientific RRLL-forecasting methods include the Early-Warning (EW) receivers and the disseminators. The EW receivers are residents in landslide-prone areas, while the EW disseminators include disaster management personnel (including scientists) and institutions who issue early warnings. Out of 25 administrative districts in Sri Lanka, 14 districts, approximately 30% of the island's total land area, are the most prone to landslides, with about 38% of the population of Sri Lanka gathered in these areas. In one of our pilot study sites (Aranayake), there are five communities (GN divisions) with a total population of about 5,000. The second pilot site, Athwelthota, has 3 GN divisions with about 3,000 inhabitants. The EW disseminators are the National Building Organization (NBRO), the counterpart organizations of the project, the Disaster Management Center (DMC), the Department of Meteorology (DOM), the Department of Irrigation, and administrative agencies such as Districts, Divisional Secretaries, and the Central Engineering Consultancy Bureau on the Sri Lankan side. The EW disseminators and receivers are also involved in disaster-prevention education based on the newly developed EW system.

4) Results (15 line maximum, e.g. publications)

The project members have gotten seven peer-reviewed papers published in Landslides, 24 articles (original articles, technical notes, etc.) in the ICL's open-access book series, "Progress in Landslide Research and Technologies," seven articles in the "Contribution to Landslide Disaster Risk Reduction book series (CLDRR)," and 16 peer-reviewed papers in other international journals. They include:

About overall achievements:

Konagai K, Karunawardena A, Sassa K, Jayathissa G., et al. (2025) Development of Early Warning Technology for Rain-Induced Rapid and Long-Travelling Landslides in Sri Lanka - Achievements and Future Challenges of the SATREPS Project RRLL (IPL-249) -, Progress in Landslide research and Technology, Volume 4, Issue 2, accepted for publication

About 24-hours-in-advance prediction of heavy rainfalls in mountains:

Bandara H. A. A. I. S., Onishi R. (2025) Local Rainfall Predictions for Operational Landslide Early Warning in Sri Lanka, Progress in Landslide research and Technology, Volume 4, Issue 2, accepted for publication

About social implementation activities:

Fujita K, Abe M, Ariyarathna I, et al. (2025) Landslide Early Warning Technology and the Protocol for the Social-implementation Activities, Progress in Landslide research and Technology, Volume 4, Issue 2, accepted for publication

Note:

1) If you will change items 2-6 from the proposal, please write the revised content in Red.
2) Please fill and submit this form to ICL Network <icl-network@landslides.org>
3) Reporting year must be one or two years (Maximum).