

Application Form for World Centre of Excellence on Landslide Risk Reduction 2023-2026

1. Name of Organization: Amrita Vishwa Vidyapeetham, Amritapuri campus, India
2. Name of Leader: Dr. Maneesha Vinodini Ramesh
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Core members of the activitiesNames/Affiliations: (4 individuals maximum)

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3. Date of Submission of Application: 11-09-2023(Updated version); 12-04-2023(First version);
4. Activity scale and targeted region.

1) Global, 2) Intercontinental, 3) Continental, 4) Regional, 5) National

Short Title characterizing past and planned activities (10 words maximum): Enhancing community resilience for landslide disaster risk reduction.

5. Objectives for 3 years: (5 lines maximum; what do you expect to accomplish?)
We aim to engage in an in-depth participatory study and analysis, with all stakeholders to understand the approaches and techniques utilized for implementing regional scale early warning systems, crowdsourcing systems for mapping assessing and evaluating risk, technological solutions for enhancing community scale resilience on a regional scale. Based on the detailed evaluation and gap analysis, new approaches to improve the early warning models, and community scale resilience will be developed.

6. Background Justification: (10 lines maximum)

Amrita University has been performing research and development for landslide risk reduction for more than a decade. Amrita has deployed India's first landslide monitoring, and early warning system consisting of more than 150 geophysical sensors in Western Ghats, India. This system has collected data from 2009 onwards and has issued real-time warnings in the years 2009, 2011, 2013, 2018, 2019, 2020, 2021 and 2022 thus validating the IoT based technology. Seeing the increase in fatalities in Himalayan belt, the Govt of India has prompted us to deploy an enhanced system in Himalayan region also. The real-time data from this system is also streamed to Amrita University and used for issuing real-time warning in the North East Himalayas in Sikkim, India. One of the major focuses of this research group is to enhance the research capability to cater to the numerous requests for this system in the whole country and to reduce the landslide risk levels.

Amrita has also designed and developed India's first landslide laboratory capable of simulating landslides with respect to the dynamic variation of several geological and hydrological parameters that could trigger a landslide. Amrita University's research and deployment work on the landslide early warning system was appreciated by the Honorable Prime Minister of India Shri. Narendra Modi as one of the best 'Make in India' products and also by the Indian government's apex body 'The Rajya Sabha' and further support have been extended for development of such a system in other states of India. This research work was also awarded one of the prestigious national awards in India, the NABARD award for rural innovation. The innovativeness of the system developed by AMRITA has also brought in two US and one Indian patents for the knowledge and system. This work was appreciated by the UN and invited Dr. Maneesha to

present the work in the conference UNAI (United Nations Academic Impact).

7. Resources available for WCoE activities

Personnel, Facilities, Budgets, and Affiliation and Contribution to ICL/IPL and KLC2020.

Personnel: Apart from the experienced interdisciplinary landslide domain experts in the center, we have experienced geologists (including Dr. S.K. Wadhawan, Retd, Director General, Geological Survey of India), landslide experts, computer scientist and data scientist who had worked for the real-time deployment of landslide monitoring systems in Western Ghats and Himalayas, India.

Facilities: Landslide laboratory for conducting experiments related to landslides, Real-world fields where a monitoring system based on Internet of Things (IoT) is deployed for landslide early warning.

Budgets: Landslide research in Amrita is continuously funded by both international and national bodies at different time windows.

Contribution to ICL/IPL-GPC: As part of the ongoing WCoE we have completed a real-time deployment for monitoring landslides in Sikkim Himalayas. The same has been submitted as a report to the ICL project committee.

8. Description of your past activities related to risk reduction of landslides and other related earth system disasters (30 lines maximum)

Amrita University has developed and deployed landslide monitoring and early warning systems in two major landslide prone areas Western Ghats and Sikkim Himalayas, India. The landslide monitoring and early warning system using Internet of Things (IoT) technology consists of more than 300 geological sensors embedded and installed at various locations on the slope. Early warnings are issued in 2009, 2011, 2013, 2018, 2019, 2020, 2021, 2022 in Munnar Western Ghats and in 2022 in Sikkim, Himalayas.

The landslide monitoring system was deployed in Chandmari, Sikkim as part of the WCoE 2017-2020. Along with this research work the team has initiated research on Landslide Vulnerability mapping in Western Ghats and Himalayan ranges, Pre-disaster studies which includes susceptibility mapping and landslide inventory mapping, Crowdsourcing for Disaster risk reduction, Mobile phone app and game development for educating the community, Community engagement for Disaster Risk Reduction and Post disaster immediate and long term relief work.

We have also conducted community engagement programs in Munnar and Sikkim regions where we have installed our system for landslide monitoring. We have created a whatsapp group which is an active source of information during monsoon season. With respect to Crowdsourcing for Disaster risk reduction, we have developed a mobile application "AmritaKripa" for crowd sourcing from the people living in susceptible landslide locations. The Amrita Kripa app was very helpful during 2018 and 2019 flood and landslides in Kerala, India and in total it has rescued 408145 people from 17 districts in Kerala, India. The people affected due to flood and landslide participate by providing inputs like, the people standard at different locations, amount of water in a particular area, roadblocks, landslides, requirements in relief camps, the amount of rain, small displacements or cracks noticed in the slope, landslides in their area, emergency requirements, etc in the form of text and images. We have also developed algorithms for analyzing crowd sourcing data. Training sessions were provided for community engagement in Disaster Risk Reduction and short & long term post-disaster relief camp development was performed.

Social media has been used extensively in natural disaster preparedness and management to strengthen situational awareness and improve emergency response. Common public can be informed of authoritative situational notifications by following official natural disaster management organizations on social media. Amrita has started its research by making use of historic and real-time twitter data to arrive at models that provide a spatio-temporal summary of the events related to "heavy rainfall before a landslide or a flood disaster,". These precursor data are collated and evaluated, then the plausible occurrence of natural hazard that can be anticipated is identified using event detection algorithms. Due to the flooding of tweets during heavy rainfall and other disaster pre-cursor conditions, The government officials are unable to decide when to take an event seriously because information is not spatially and temporally quantified. This work

helps the government authorities in decision making and will provide situational awareness for the public and decision makers.

The ever increasing landslides demand data collection of events to enhance disaster management. We designed and developed a dedicated crowd sourced mobile application, for systematic way of collection, validation, summarization, and dissemination of landslide data in real-time. This unique design of mobile app uses a scalable real-time data collection methodology for tracking landslide events through citizen science and is available on Google Play Store and iOS App Store for free, and at <http://landslides.amrita.edu>, with software conceived and developed by Amrita University in the context of the UK NERC/FCDO funded LANDSLIP research project (<http://www.landslip.org/>). This work implemented a structured database that integrates heterogeneous data such as text, numerical, GPS location, landmarks, and images. This methodology enables real-time tracking of landslides utilizing the details such as GPS location, date & time of occurrence, images, type, material, size, impact, area, geology, geomorphology, and comments in real-time. If any landslide experts are reporting from the site the app supports additional features to incorporate their suggestions as well.

In this regard Amrita University has been involved in several facets of Landslide Disaster Reduction.

9. **Regional collaboration:** Collaborations with regional south asian countries such as Sri Lanka, Bangladesh, Nepal, Bhutan, and Thailand will be initiated as part of this proposal. WCoE institutions, ICL-IPL members, Academic institutions and Government organizations in these countries will be invited to collaborate as part of this project.

10. **Planned future activities /Expected Results:** (20 lines maximum; work phases and milestones)

Planned future activities	(2023/2026)					
	Year 1		Year 2		Year 3	
	6	12	18	24	30	36
Stakeholders, collaborators meetings & Institutional mapping	■		■		■	
Data collection		■	■	■	■	
Risk assessment		■		■		
Physical model development			■	■	■	■
Early warning framework draft				■		
Risk, early warning dissemination and communication protocol draft					■	■
Early warning bulletin design draft						■
Enhancing community resilience		■		■	■	
Policy workshops and formulation of policy recommendations		■		■		■
Final report and project recommendations/dissemination					■	■

11. **Beneficiaries of WCoE:** (5 lines maximum; who directly benefits from the work?)

Direct beneficiaries from this project are 1. Public people and their properties. 2. National and State level Disaster management board 3. Government economy

12. **Publication plan:** In the course of three years publications will be focussed on the following areas
 - (1) Impact of south asian monsoon on a regional scale and the identification of regions with high landslide risk
 - (2) Survey of existing landslide early warning protocols for landslide in various regions of south asian countries
13. **References:** 10 lines maximum, i.e., relevant publications, international/regional/national recognition supporting items 9-10.
 - [1] Multilevel Rapid Warning System for Landslide Detection; MV Ramesh, D Pullarkatt, H Thirugnanam, N Kumar... - US Patent App. 17/509,734,
 - [2] Ramesh, Maneesha Vinodini. "Design, development, and deployment of a wireless sensor network for detection of landslides." *Ad Hoc Networks* 13 (2014): 218.
 - [3] Ramesh, Maneesha V., and Nirmala Vasudevan. "The deployment of deep-earth sensor probes for landslide detection." *Landslides* 9.4 (2012): 457-474.
 - [4] Ramesh, M. V. (2014). U.S. Patent No. 8,692,668. Washington, DC: U.S. Patent and Trademark Office.
 - [5] Geethu Thottungal Harilal., Dhanya Madhu., Maneesha Vinodini Ramesh., Divya Pullarkatt. "Towards establishing rainfall threshold for a real-time landslide early warning system in Sikkim, India." *Landslides* published online 15-August-2019
 - [5] <https://www.amrita.edu/news/nabard-rural-innovation-award-amrita>
 - [6] Hemalatha T, Sebastian Uhlemann, Reshma Reghunadh, Maneesha V Ramesh and Venkat P Rangan, "Review of Landslide Monitoring Techniques With IoT Integration Opportunities," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 15, pp. 5317-5338, 2022, doi: 10.1109/JSTARS.2022.3183684.
 - [7] Hemalatha, T., Maneesha Vinodini Ramesh, and Venkat P. Rangan. "Adaptive Learning Techniques for Landslide Forecasting and the Validation in a Real World Deployment." *Workshop on World Landslide Forum*. Springer, Cham, 2017.
 - [8] Ramesh, Maneesha Vinodini, et al. "Wireless Sensor Networks for Early Warning of Landslides: Experiences from a Decade Long Deployment." *Workshop on World Landslide Forum*. Springer, Cham, 2017.
 - [9] Guntha, Ramesh, Sangeeth Kumar, and Balaji Hariharan. "Scalable, secure, fail safe, and high performance architecture for storage, analysis, and alerts in a multi-site landslide monitoring system." *Workshop on World Landslide Forum*. Springer, Cham, 2017.
 - [10] Hemalatha, T., Maneesha Vinodini Ramesh, and Venkat P. Rangan. "Effective And Accelerated Forewarning of Landslides Using Wireless Sensor Networks and Machine Learning." *IEEE Sensors Journal* (2019).
13. If your organization is an ongoing WCoE 2020-2023, please attach the articles as pdf files reporting activities of WCoE, IPL project and ICL network published/contributed or a list of planned reports of WCOE 2020-2023 to either journal "Landslides" or/and "P-LRT books."
(Those organizations with no activity report/no achievement in WCOE 2020-2023 will not be accepted as the candidate of WCOE 2023-2026 to be submitted to the Independent Panel of Experts for WCOEs.)

Published work in Landslides Journal:

[1] Arnaud Watlet, Hemalatha Thirugnanam, Balmukund Singh, Nitin Kumar M, Deepak Brahmanandan, Cornelia Inauen, Russell Swift, Phil Meldrum, Sebastian Uhlemann, Paul Wilkinson, Jonathan Chambers, Maneesha Vinodini Ramesh "4D electrical resistivity to monitor unstable slopes in mountainous tropical regions: an example from Munnar, India" *Landslides* 2023

- [2] Hemalatha Thirugnanam, Maneesha Vinodini Ramesh, Venkat P Rangan. “Enhancing the reliability of landslide early warning systems by machine learning” *Landslides* 2020
- [3] Wadhawan, S. K., Singh, B., & Ramesh, M. V. (2020). Causative factors of landslides 2019: case study in Malappuram and Wayanad districts of Kerala, India. *Landslides*, 17, 2689-2697.
- [4] Geethu Thottungal Harilal., Dhanya Madhu., Maneesha Vinodini Ramesh., Divya Pullarkatt. “Towards establishing rainfall threshold for a real-time landslide early warning system in Sikkim, India.” *Landslides* 2019
- [5] Ramesh, Maneesha and Nirmala Vasudevan. "The deployment of deep-earth sensor probes for landslide detection." *Landslides* 2012

Book chapters in P-LRT

- [1] Maneesha Vinodini Ramesh, Hemalatha Thirugnanam, Balmukund Singh, M Nitin Kumar, Divya Pullarkatt “Landslide Early Warning Systems: Requirements and Solutions for Disaster Risk Reduction—India” *Progress in Landslide Research and Technology*, Volume 1 Issue 2, 2022; Pages 259-286
- [2] Hemalatha Thirugnanam “Deep Learning in Landslide Studies: A Review” *Progress in Landslide Research and Technology*, Volume 1 Issue 2, 2022; Pages 247-255

Note: Please fill and submit this form **by 30 March 2023** to **KLC2020 secretariat** <klc2020@iclhq.org>