List of IPL New Project Proposals

No.	Country	Project Leader	IPL Project Proposal
1	Canada	David Huntley	Slow-moving landslide monitoring project (Ashcroft, BC, and Russell, MN, Canada) – extension of IPL-202
2	China and Italy	Quingkai Meng and Federico Raspini	Monitoring rock glaciers kinematic process using SAR interferometry and offset-tracking in Alpine environment
3	Croatia	Josip Peranić	Investigation of landslide initiation caused by rainfall infiltration using small-scale physical and numerical modeling (ILIRIM)
4	Croatia	Sanja Bernat Gazibara	Optimisation of landslide susceptibility assessment for land-use planning in Croatia: from national to local scale
5	Italy	Filippo Catani	Slope stability in vineyards with different management practices (Acronym: WINESLIDES)
6	Italy	Claudio Margottini	Landslide Risk assessment in AlUla Archaeological sites – Kingdom of Saudi Arabia
7	Italy	William Frodella	Landslide Risk assessment in the High City of Antananarivo
8	Slovenia	Matjaž Mikoš	World-wide-web-based Landslide Observatory (W3bLO)
9	Slovenia	Mateja Jemec Auflič	Deciphering the sensitivity of rock faces to climatic changes and freeze-thaw cycles in permafrost-free regions
10	Sri Lanka	N. N. Katuwala	Societal and Environmental Determinants of Landslide Risk Perception towards Landslide Disaster Risk Reduction; Case Study of Athwelthota Landslide, Baduraliya, Kaluthara, Sri Lanka.
11	Sri Lanka	S S I Kodagoda	Study on Suitable Tools for Modeling and Analysing Rain Induced Slope failure in Sri Lankan Residual Soil

List of IPL New Project Proposals

12	Sri Lanka	Nimani Kulathilake	Review of Rockfall Trajectories of Cut Slopes of Roads Using a Distribution Model Approach
13	Thailand	Peeranan Towashiraporn	Climate Change-Induced Landslide Hazard Assessment - for Aiding Climate Resilient Planning for Road Infrastructure.
14	Vietnam and Chinese Taipei	Nguyen Quoc Dinh and Chih-Chung Chung	The Collaboration of debris flow early warning system between Vietnam and Taiwan

No.1

Date of Submission	December 15, 2021

IPL Project Proposal Form 2022

(MAXIMUM THREE PAGES IN LENGTH)

Project Title

SLOW-MOVING LANDSLIDE MONITORING PROJECT (ASHCROFT, BC, AND RUSSELL, MN, CANADA) – EXTENSION OF IPL-202

Main Project Fields

Fundamental Geoscience – Bedrock and Quaternary Geology, Geomorphology and Landform Evolution, Hydrogeology and Geophysics, Remote Sensing and Photogrammetry

Technology Development – Monitoring and Early Warning, Hazard Mapping, Vulnerability and Risk Assessment

Capacity Building – Technology transfer and capacity building to government and private sector

Mitigation, Preparedness and Recovery – Preparedness, Mitigation and Recovery related to socioeconomic infrastructure, primarily (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. Enhancing Human and Institutional Capacities

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation, C. Recovery

Name of Project leader

David Huntley

Affiliation (office and position):

Geological Survey of Canada, Senior Scientist

Contact (postal address, fax, phone, email):

Geological Survey of Canada, 1500-605 Robson Street, Vancouver, B.C., Canada, V6B 5J3; david.huntley@canada.ca

Core members of the Project, Names/Affiliations (4 individuals maximum):

Dr. David Huntley and Dr. Peter Bobrowsky (Geological Survey of Canada); Prof. David Elwood (University of Saskatchewan); Dr. Jonathan Chambers (British Geological Survey of Canada)

Objectives (5 lines maximum; what you expect to accomplish?):

The Geological Survey of Canada (GSC), universities of Alberta and Saskatchewan, Canadian Pacific Railway

(CP) and Canadian National Railway (CN) are coordinating a multi-partner effort to apply and test a suite of technologies and methods used in the characterization, assessment and monitoring of slow moving landslides in the Thompson River valley, British Columbia (BC), and Assiniboine River valley, Manitoba (MN). Results are being shared with the professional community to improve global landslide monitoring.

Background Justification (10 lines maximum):
Railway transportation networks require sustainable, cost-effective management of service operations to meet future socioeconomic needs and ensure protection of the natural environment. Where transportation corridors traverse unstable terrain, critical rail infrastructure and safe operations are jeopardized, and presents potential local and national economic, social, and environmental challenges. The economic importance of national railway corridors, along with the need to understand and manage the safety issues related to landslides make on-site investigations a strategic priority for governments, the rail industry, and academia. Monitoring unstable slopes and vulnerable infrastructure is a cost-effective hazard management practice that also provides important geoscience information to help develop appropriate mitigation and adaptation measures.

Study Area (2 lines maximum; where will the project be conducted/applied?):
Primary focus is on the Ripley Landslide, but includes several other landslides of concern along the Thompson River, south of Ashcroft, BC, and in the Assiniboine River valley, near Russell, Manitoba.

Project Duration (1 line maximum)
Project may continue indefinitely depending on funding (minimum to 2025)

Resources necessary for the Project and their mobilization (Personnel, Facilities, and Budgets)
This work is funded by Transport Canada and National Science and Engineering Research Council (NSERC). Transport Canada funding over five years will result in direct expenditures of $1 million on landslide research and development for the next five years. Partnership with the railway industry is ongoing.

Project Description (30 lines maximum)
This project aims to gain a better understanding of how extreme weather events and climate change influence landslide activity in the Thompson River valley, British Columbia, and the Assiniboine River valley, Saskatchewan-Manitoba. This fundamental geoscience information will contribute to more robust landslide hazard management strategies to maintain the resilience and accessibility of critical transportation infrastructure along strategically important sections of the national railway network, while also protecting the natural environment, community stakeholders, and Canadian economy. Landslide monitoring technologies have been operational in the Thompson River Valley from 2013-2020 (as part of IPL-202), and have been installed at new sites in the Assiniboine River. The three primary research and development objectives include: 1) Better understand controls on landslide movement, and in particular, the impacts of extreme weather events and climate change. 2) Compare, evaluate, and identify the monitoring technologies which provide the most useful

information on why, how, and when landslides move. 3) Help identify reliable real-time monitoring solutions for critical railway infrastructure (e.g., ballast, tracks, retaining walls, tunnels and bridges) able to withstand the harsh environmental conditions of Canada.

Work Plan/Expected Results (20 lines maximum; work phases and milestones)

Plans for 2021-2025 includes upgrades and repairs to the PRIME, Geocube, GNSS and weather station networks, maintenance and addition of soil moisture probes, and internet connections to Ripley, South and North slides in the Thompson River valley, BC. In addition, efforts will be focused on developing comparative landslide test sites along the Assiniboine River valley, MN. Change detection monitoring will employ advanced UAV photogrammetric, LiDAR and hyperspectral data for all slides that are hazards to railway infrastructure. Ongoing InSAR, SAA, piezometric and weather information will be compiled to develop models for geohazard management and landslide risk assessment. Collaboration with the Canada Centre for Mapping and Earth Observation and private sector will be extended to enhance InSAR data analysis. Partnership with the railway industry will potentially allow developing a quantitative correlation between landslide deformations in the area (satellite InSAR) and railway track serviceability and risk.

Deliverables/Time Frame (10 lines maximum; what and when will you produce?)

Each year (2021-2025), major results from the work plan will be published in the journal *Landslides* and elsewhere. Report of activities will presented at KLC and WLF conferences, and other symposia (to be determined). Annual reporting will be completed for IPL, ICL and KLC. Other publication outlets will include government documents, for example Geological Survey of Canada Open File Reports.

Project Beneficiaries (5 lines maximum; who directly benefits from the work?)

The initial beneficiaries of the project include the two primary rail companies in Canada (CN and CP), but this includes sharing with the professional community in Canada as well. With the number of international publications released to date in the coming years, we expect the global landslide community will benefit from the extension of Project 202. This research and development also benefits training of highly qualified personnel (M.Sc. and Ph.D. students, as well as post-doctoral fellows).

References (Optional) (6 lines maximum; i.e. relevant publications)

Huntley, D., Bobrowsky, P., MacLeod, R., Cocking, R., Joseph, J. and Rotheram-Clarke, D. 2021a Ensuring resilient socio-economic infrastructure: field testing innovative differential GNSS-InSAR-UAV monitoring technologies in mountainous terrain near Ashcroft, British Columbia, Canada. *Journal of Mountain Science*, Vol. 18 (1), pp. 1-20; https://doi.org/10.1007/s11629-020-6552-y

Sattler, K., Elwood, D., Hendry, M., Berscheid, B., Marcotte, B., Abdulrazagh, P. and Huntley, D. Field collection of geotechnical measurements for remote or low-cost data-logging requirements. *Geotechnical Testing Journal.* Vol. 45 (1) https://doi.org/10.1520/GTJ20200323

No.2

Date of Submission	24 Nov. 2021

IPL Project Proposal Form 2022

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: (2 lines maximum)

   Monitoring rock glaciers kinematic process using SAR interferometry and offset-tracking in Alpine environment

2. Main Project Fields

   Select the suitable topics. If no suitable one, you may add new field.

   (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. 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

   Qingkai Meng[1], Associate Professor in Remote Sensing and Physical Geography

   Federico Raspini[2], Researcher in Physical Geography and Geomorphology

   Affiliation: 1 Institute of mountain hazards and environment, Chinese Academy of Science (IMHE-CAS); 2 Earth Sciences Department of the University of Firenze (DST-UNIFI), UNESCO Chair on Prevention and sustainable management of geo-hydrological hazards, University of Florence (UNESCO Chair-UNIFI)

   Contact: No.9, Block 4, Renminnanlu Road, Chengdu,(China)-Phone: (028)85235224

   Core members of the Project:

   Names/Affiliations:

   Xiaoqing Chen, Full Professors, IMHE-CAS

   Nicola Casagli, Full Professor, DST-UNIFI, UNESCO Chair-UNIFI

   Veronica Tofani, Full Professor, DST-UNIFI, UNESCO Chair-UNIFI

4. Objectives: (5 lines maximum; what you expect to accomplish?)

   The main objective of this project is to retrieve surface velocity maps of active rock glaciers in different Alpine environments (*i.e.*,Western Himalaya, Inner Qinghai-Tibet and Alps) using Interferometric and offset-tracking techniques.

5. Background Justification: (10 lines maximum)

   Prominent rock glaciers are a visible climate indicator in cold mountain environments. They can also be the source of rockfalls and debris flows, and eventually evolving into local-scale natural hazards due to warming temperatures and degrading permafrost. Thus, monitoring rock glaciers deformation is considered a valuable tool for risk mitigation. The launch of Sentinel-1 mission has opened a new opportunity to exploit both the phase and amplitude signals of SAR (Synthetic Aperture Radar) acquisitions for the detection of ground displacement. Integration of SAR Interferometrical geodetic with offset-tracking methods accommodate a full spectrum of rock glacier deformation processes from creeping to fast flowing. Leveraging on accessible data, sophisticated data processing and interpretation experience, the final output of the proposed approach will consist on elaborated inventory mapping of active rock glaciers.

6. Study Area: (2 lines maximum; where will the project be conducted/applied?)
   The study area will be the Karakoram (Western Himalaya), Sanjiangyuan National Park (Qinghai-Tibet) and Valle d'Aosta (Italian Alps), specifically selected due to its high sensitivity to climate warming and prone to ground instability phenomena.
7. Project Duration: (1 line maximum)
   The duration of the project is two years.
8. Resources necessary for the Project and their mobilization
   The joint research group collaborates with IMHE-CAS and DST-UNIFI. IMHE-CAS is the national research center for landslides monitoring and prevention in China, which counts 5 professors, 3 associate professors and 3 technicians in this proposed project. DST-UNIFI is one of the largest scientific and technological services centers on geohazard monitoring in Italy, currently composed by more than 50 full-time employees (2 full professors, 3 associate professor, 8 researchers, 9 technicians and several post-doc fellows and PhD students). The joint team has the necessary personnel, dedicated laboratory facilities, instrumentation and a well-established field support for carrying out effective research in the framework of the proposed project. The total budget of IMHE-CAS is related to international and national funding projects in 2020 is more than 400 Million USD. The required budget will be covered by IMHE-CAS for the research part. A contribution by ICL-IPL project budget might be required for dissemination purposes concerning the project results.
9. Project Description: (30 lines maximum)
   Climate change is strongly affecting the global cryosphere and leads to an increase in activity of rock glaciers, creeping downslope and posing a potential threat in QTP (Qinghai-Tibet Plateau), Alps and Greenland due to warming temperatures and degrading permafrost. Understanding how these geohazards occur and their deformation process are highly significant to improve forecasting methods and taking precautions. Specifically, producing a regional-scale active rock glacier inventory map can help researchers and stakeholders to understand the displacement evolution of land terminating glaciers in different places. More importantly, the monitoring results can supplement the current dataset in Qinghai-Tibet where no rock glacier inventory has been conducted. A series of Sentinel-1SAR images in ascending and descending orbits will be acquired and processed by a multi-interferometric (MT-InSAR) approach and Offset-tracking techniques. Time-series of ground deformation maps in different motion directions are generated by combining different geometries. For classifying

deformation patterns in Himalaya, Qinghai-Tibet and Italian Alps, auxiliary datasets and interpretation of long-term deformation trends are forced to be taken into consideration. Active, periodical active, inactive and fossil rock glaciers are expected to be recognized to construct the final rock glacier inventory mapping.

10. Work Plan/Expected Results: (20 lines maximum; work phases and milestones)

    The project includes three Work phases (WP):

    WP1- Multi-interferometric and offset-tracking analysis - which includes the processing of historical archive of Sentinel-1 and mapping elaborated deformation (Performed by IMHE-CAS).

    WP2- Deformation interpretation and analysis - which includes the "radar-interpretation" activity, devoted to assign a geomorphological meaning to the point-wise ground displacements measurements and to obtain an accurate analysis of the phenomenon (Performed by DST-UNIFI and IMHE-CAS).

    WP3- Identification of deformation pattern – which includes the deformation mechanism analysis, supported by auxiliary data superposing calculation (*i.e.*, meteorological, hydrological, geological and geomorphological maps, optical images (both aerial and satellite data). This part is carried out by IMHE-CAS and DST-UNIFI.

    The project is expected to provide a direct contribution to the Kyto Landslide Commitment 2020 (KLC2020) with special reference to the Action 3, related to the improvements of technologies for landside monitoring.

11. Deliverables/Time Frame: (10 lines maximum; what and when will you produce?)

    Information about the deformation velocity of active rock glaciers in China, Italy will be completed in 12-18 months. The final rock glacier inventory map (location, spatial distribution, time-series deformation pattern, type and future risk) will be transferred to local civil protection agencies and international landslides research councils (*e.g.*, ICL, ICIMOD, LEWS). Our monitoring result will be written in a report, and some interesting conclusions are intended to be submitted to the journal LANDSLIDES (*i.e.*, month 18-24 months) and to be presented to the Sixth World Landslide Forum (WLF6), that will be held in Florence in 2023.

12. Project Beneficiaries: (5 lines maximum; who directly benefits from the work?)

    The end-user of this project is local risk management entities of Qinghai-Tibet (China) and Region Authorities of Valle d'Astoa (Italian).

    Enhancing academic communication between IMHE-CAS and DST-UNIFI. PhD students or researchers on both sides will visit and exchange under the support of this project. The detailed fee will be covered by other research projects or fundings.

13. References (Optional): (6 lines maximum; i.e. relevant publications)

Note: Please fill and submit this form by 15 December 2021 to ICL Network <icl-network@iclhq.org> and ICL secretariat <secretariat@iclhq.org>

No.3

Date of Submission	14 December 2021

IPL Project Proposal Form 2022

1. Project Title: **Investigation of landslide initiation caused by rainfall infiltration using small-scale physical and numerical modeling (ILIRIM)**
2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(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. Enhancing Human and Institutional Capacities

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation, C. Recovery

(5) Landslide Modeling

A. Physical modeling, **B. Numerical modeling**

3. Name of Project leader: **Josip Peranić, PhD**

Affiliation: University of Rijeka, Faculty of Civil Engineering; Postdoc

Contact: Radmile Matejčić 3, 51000 Rijeka, Croatia; +385 51 265 943; josip.peranic@gradri.uniri.hr

Core members of the Project

Željko Arbanas/ University of Rijeka, Faculty of Civil Engineering, Head of Geotechnical Chair, Full Professor; zeljko.arbanas@gradri.uniri.hr

Vedran Jagodnik/ University of Rijeka, Faculty of Civil Engineering, Head of Geotechnical Laboratory, Associate Professor; vedran.jagodnik@gradri.uniri.hr

Martina Vivoda Prodan/ University of Rijeka, Faculty of Civil Engineering, Assistant Professor; martina.vivoda@gradri.uniri.hr

Sanja Bernat Gazibara/ University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Postdoc; sanja.bernat@rgn.unizg.hr

4. Objectives: Investigate the hydro-mechanical response of slopes exposed to rainfall using a newly developed platform for testing small-scale physical landslide models under 1g conditions; Use the data obtained together with numerical modeling to investigate the role of rainfall characteristics, soil hydro-mechanical properties, geometric and boundary conditions in landslide initiation by rainfall; Investigate the applicability of the adopted research methodology in defining rainfall threshold values.
5. Background Justification: Despite the considerable progress made in recent decades, understanding the physical processes and mechanisms responsible for rainfall-induced landslides remains a hot topic for

the landslide scientific community. Some of the aspects contributing to the complexity of the problem are related to the highly nonlinear material properties of the soils involved, quantification of boundary conditions, hysterical soil effects, spatial and temporal variation of rainfall characteristics, etc. Small-scale physical landslide models, in combination with advanced monitoring techniques, allow accurate observation of the hydraulic and mechanical response of slopes under precisely controlled initial and boundary conditions. This makes them a valuable tool for the accurate measurement of quantities and variables controlling instability phenomena. At the same time, they provide high-quality data for the validation and calibration of analytical solutions and numerical models.

6. Study Area: The research activities will be carried out in the Geotechnical laboratory of the Faculty of Civil Engineering, University of Rijeka. The results will be applicable to the research topic in general.
7. Project Duration: 4 years
8. Resources necessary for the Project and their mobilization

   Personnel: Four (4) senior researchers, four (4) young researchers, graduate students, one (1) laboratory technician; Facilities: Fully equipped geotechnical laboratory for basic and advanced soil and rock testing, platform for testing small-scale physical landslide models under 1g conditions with rainfall simulator and advanced monitoring equipment (available under ModLandRemSS research project), numerical modeling software (Rocscience, LS Rapid, GeoStudio); Budget: 25,000 USD.
9. Project Description: One of the main objectives of the four-year research project "Physical modeling of landslide remediation constructions' behavior under static and seismic actions", which started in October 2018 at the Faculty of Civil Engineering, University of Rijeka, Croatia, was to develop an advanced platform for physical modeling of small-scale slopes under 1g rainfall conditions. The newly developed platform, equipped with advanced geodetic and geotechnical monitoring systems, enables precise monitoring of displacements and changes in soil moisture and pore pressure of scaled slopes exposed to different simulated rainfall events (Pajalić et al. 2021). The main idea of this project is to use the platform to study the hydro-mechanical response of scaled slopes composed of different soil types, conditions and geometries while subjected to different rainfall loads. The different soil types will be achieved by mixing clean sand as the base slope material with varying amounts of kaolin. This ensures repeatability of tests under controlled installation, geometry, and boundary conditions (BCs) on soil mixtures representative of the behavior of different soil types: from non-plastic, purely frictional sands to cohesive, clayey soils. The data collected on the hydraulic and mechanical behavior of slopes under specific test conditions and rainfall loads will be analyzed and interpreted. Understanding the triggering mechanisms as well as the mathematical description of the processes controlling the transient infiltration process and its effects on slope stability require a complete knowledge of the relevant soil properties. A further important step is therefore an advanced hydromechanical characterization of the soils used in the study. Some of the required tests include the determination of basic soil properties and soil classification. Some of the available devices for determining water retention curves (WRCs), hydraulic conductivity functions (HCFs) and (un)saturated shear strength properties are conventional and modified, axis-translation based oedometers, triaxial (TX) and direct shear apparatuses (DSA), ring shear apparatus, mini tensiometers, moisture content sensors, etc. The

experimentally obtained data and the identified soil properties will be used to calibrate advanced numerical models. Various numerical studies and parametric analyses will investigate the response of slopes under BCs different from those used in the experiments conducted. The results obtained could also be useful to study the role of different variables and define rainfall thresholds for landslide initiation by rainfall.

10. Work Plan/Expected Results: The work plan consists of the following four main phases:

    1st phase: Conducting 1g physical model tests of small-scale landslides with different soil types, geometric and initial moisture conditions, and predefined rainfall conditions: PHYSICAL SMALL-SCALE LANDSLIDE MODELING; Milestone: Obtain data on the hydraulic and mechanical behavior of small-scale landslides under specified test conditions and rainfall loads.

    2nd phase: Analysis of data collected in phase 1, including changes in soil moisture, pore water pressure (positive and matric suction), temperature and landslide movement data: DATA ANALYSIS; Milestone: Analysis and interpretation of data collected from in phase 1.

    3rd phase: Laboratory tests for advanced hydro-mechanical characterization of soils used in small-scale physical landslide models: SOIL TESTING; Milestone: Define material properties required for the interpretation of experimentally obtained results and perform advanced numerical analyses, including: (i) classification and basic soil index properties; (ii) advanced hydraulic characterization of soils, including WRCs and HCFs; and (iii) determination of (un)saturated shear strength properties.

    4th phase: Use the obtained data to perform advanced numerical analyses of rainfall infiltration and slope stability: NUMERICAL MODELLING; Milestone: Use the data obtained in phases 2 and 3 to calibrate numerical models and perform various numerical studies and parametric analyses. Investigate the possibility of using the data obtained to derive rainfall threshold values.

11. Deliverables/Time Frame:

    1st phase: 1g physical model tests of small-scale landslides conducted for different soil types and test conditions. Time duration: within the first two years of the project.

    2nd phase: Data on the hydraulic and mechanical response of small-scale slopes under simulated rainfalls collected, analyzed and interpreted. Time duration: within the first two years of the project.

    3rd phase: Tests for determination of basic soil properties, soil classification and advanced hydro-mechanical characterization performed. Time duration: during the third and fourth year of the project.

    4th phase: Numerical analyses to investigate the hydraulic response of slopes under different rainfall conditions and the triggering mechanisms of rainfall-induced landslides performed. Time duration: during the third and fourth year of the project.

12. Project Beneficiaries: Landslide-affected population, practitioners and scientists dealing with landslides, through new scientific knowledge on rainfall-induced landslides; Researchers involved in the project through gaining valuable experience and knowledge in the field of conducting experiments, soil testing, numerical modelling and triggering mechanisms of landslides initiated by rainfall in general; Institutions and working groups involved in the project through increasing their visibility and capacity.

13. References:

Peranić J, Mihalić Arbanas S, Arbanas Ž (2021) Importance of the unsaturated zone in landslide reactivation on flysch slopes: observations from Valići Landslide, Croatia. *Landslides* 18, 3737-3751

Pajalić S, Peranić J, Maksimović S, et al (2021) Monitoring and data analysis in small-scale landslide physical model. *Appl Sci* 11(11):5040.

Jagodnik V, Peranić J, Arbanas Ž (2021) Mechanism of Landslide Initiation in Small-Scale Sandy Slope Triggered by an Artificial Rain. In: Arbanas Ž, Bobrowsky P T, Konagai K, Sassa K, Takara K. (eds) *Understanding and Reducing Landslide Disaster Risk*. WLF 2020. Springer, Cham. pp 177-184.

Peranić J, Moscariello M, Cuomo S, Arbanas Ž (2020a) Hydro-mechanical properties of unsaturated residual soil from a flysch rock mass. *Eng Geol* 269:105546.

Peranić J, Arbanas Ž (2020) Impact of the wetting process on the hydro-mechanical behavior of unsaturated residual soil from flysch rock mass: preliminary results. *Bull Eng Geol Environ* 79:985–998.

No.4

Date of Submission	22.12.2021.

IPL Project Proposal Form 2022

1. Project Title: Optimisation of landslide susceptibility assessment for land-use planning in Croatia: from national to local scale
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. 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: Sanja Bernat Gazibara, PhD

Affiliation: University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Postdoc
Contact: Pierottijeva 6, 10000 Zagreb, Croatia, +38515535760, sbernat@rgn.hr
Prof. Snježana Mihalić Arbanas (UNI-ZG, Faculty of Mining, Geology and Petroleum Engineering)
Assos. Prof. Martin Krkač (UNI-ZG, Faculty of Mining, Geology and Petroleum Engineering),
Hrvoje Lukačić, Assistant (UNI-ZG, Faculty of Mining, Geology and Petroleum Engineering)
Marko Sinčić, Assistant (UNI-ZG, Faculty of Mining, Geology and Petroleum Engineering)

4. Objectives: The main objective of the proposed Project is to reach methodologies for practical solutions in landslide susceptibility assessment in three different scales for different types of Croatian environments. In addition, landslide susceptibility maps will be used by the national, regional and local administration, policy and decision-makers in spatial planning processes.
5. Background Justification: The need of researching the landslide susceptibility assessment for application in land use planning arises from the national landslide risk assessment (Croatian National Platform for Disaster Risk Reduction, CNPDRR, 2020) that recognised landslides as a second natural risk in Croatia. The preliminary regional landslide susceptibility analysis showed that approx. 20% of the Republic of Croatia area is potentially prone to sliding. Furthermore, the same landslide susceptibility analysis arises that 60% of cities/municipalities (local administrative units) are endangered by Multiple Occurrence of Regional Landslide Events (MORLE) in case of extreme hydrological events. However, despite long-term investigation on landslides, the main problem in the existing landslide risk management practice in the Republic of Croatia is the lack of detailed and sustainable complete landslide inventories and prognostic landslide hazard and risk maps. Based on collaboration with stakeholders from the national, county and local authorities through numerous round

table discussions in the framework of previous projects, it was concluded that it is necessary to implement landslide maps in the Croatian spatial planning system and define the use of maps for the new spatial plans development.

6. Study Area: Landslide susceptibility assessment will be carried out for seven pilot areas: (i) the Republic of Croatia; (ii) Zagreb County, Karlovac County and Primorje-Gorski Kotar County; and (iii) the pilot areas in the City of Zagreb (20 km^2), Hrvatsko Zagorje (20 km^2), Karlovac City (50 km^2) and Istria (20 km^2).
7. Project Duration: 4 years (January 1, 2022 – December 31, 2025)
8. Resources necessary for the Project and their mobilisation: The project budget is approx. 150.000 EUR, approved in 2020 by the Croatian Science Foundation in the framewok of project *Methodology development for landslide susceptibility assessment for land-use planning based on LiDAR technology* (LandSlidePlan, HRZZ IP-2019-04-9900) and European Structural and Investment Funds in the framework of project *Applied landslide research for development of risk mitigation and prevention measures* (PRI-MJER, KK.05.1.1.02.0020), covering purchase of LiDAR data and terrain verification costs.
9. Project Description:

   In the proposed Project, we attempt to focus on the primary purpose of a landslide susceptibility maps to assist spatial, urban and infrastructure planning and to avoid areas of potential slope instability and locations of existing landslides. The research aims to compare different landslide susceptibility models and methods due to available input data, reclassification of landslide conditioning factors and application of different mapping units. The purpose of comparing these landslide susceptibility models is to define the most suitable landslide maps for application in spatial planning at national, regional and local levels. The research will be based on innovative technologies, realistic limitations related to the availability of spatial data in Croatia (limited amount of geological data) and urgent needs for efficient solutions applicable in the Croatian system of spatial planning in line with European and global requirements related to sustainable development, human and environmental protection. Furthermore, the landslide susceptibility assessment will be carried out due to different natural conditions and land use types in different parts of Croatia. Therefore, the proposed Project will result in a large number of landslide susceptibility maps for various pilot areas: (i) Landslide susceptibility map of Croatia on a scale of 1:100.000; (ii) Landslide susceptibility maps of Zagreb County, Karlovac County and Primorje-Gorski Kotar County on a scale of 1:25.000; (iii) Landslide susceptibility maps of the pilot areas in the City of Zagreb, Hrvatsko Zagorje, Karlovac City and Istria on a scale 1:5.000. Planned methodology of scientific research includes (i) data collection for landslide susceptibility assessment; (ii) data analyses using heuristic approach or statistical methods; (iii) verification of landslide susceptibility models using Receiver operating characteristic (ROC) curve; (iv) classification of resulting susceptibility maps according to spatial planners requirements, i.e., comparing susceptibility zoning with land use and cadastral data; (v) implementation of the resulting landslide susceptibility maps in the Croatian spatial planning system. Methodology development for landslide susceptibility assessment in national and regional scales will be carried out using a heuristic approach (Fuzzy Logic method) and available topographical and geological data. Methodology development for landslide susceptibility assessment on a local scale will be carried out using statistical methods (bivariate statistical methods, including Information Value method and Weights of Evidence method, multivariate statistical methods, including Logistic Regression and Discriminant Analysis, and machine learning methods, including Support Vector Machine and Random Forest), airborne LiDAR data and available geological data. Landslide susceptibility models will be computed using different scenarios of input data (mapping units and causal factors), and the landslide training group represented as visually mapped landslide polygons, the point features at the head scarps of mapped landslides, and the point features corresponding to the centroid of landslides. The final goal is to define the methodology for landslide susceptibility assessment in Croatia based on specific environmental/engineering geological conditions, landslide types and level of zonation, and the application of final landslide maps in spatial planning.

10. Work Plan/Expected Results:

    1st phase: Preparation of input data sets: (i) Landslide causal factors for landslide susceptibility modelling in national and county scale; (ii) LiDAR-derived DEM and LiDAR-based landslide inventory for landslide susceptibility modelling in local scale; Milestone: Prepared input datasets for landslide susceptibility modelling.

    2nd phase: Landslide susceptibility modelling and verification. Milestone: Conducted landslide susceptibility modelling based on heuristic approach and different statistical methods, input datasets, mapping units and level of zonation.

    3rd phase: Classification and validation of landslide susceptibility maps for land use planning. The organisation of round tables with stakeholders at the national, county and local level; Milestone: Classified landslide susceptibility maps for each pilot area based on the optimal classification method and spatial planers requirements.

    4th phase: Implementation of the resulting landslide susceptibility maps in the Croatian spatial planning system; Milestone: Feedback from spatial planners after using landslide susceptibility maps.

11. Deliverables/Time Frame:

    1st phase: Input datasets for landslide susceptibility modelling at the national, county, and local scale. Time duration: within the first year of the Project.

    2nd phase: Selected the most accurate landslide susceptibility map for each pilot area. Time duration: within the first two years of the Project.

    3rd phase: Classified landslide susceptibility maps for each pilot area. Time duration: during the second and third years of the Project.

    4th phase: Implemented landslide susceptibility maps in Croatian spatial planning system. Time duration: during the last year of the Project.

12. Project Beneficiaries:

    Ministry of Physical Planning, Construction and State Assets, county and local authorities and spatial planners, landslide-affected population, and landslide scientists.

13. References: -

Date of Submission	22 December 2022

IPL Project Proposal Form 2022

1. Project Title: **SLOPE STABILITY IN VINEYARDS WITH DIFFERENT MANAGEMENT PRACTICES (Acronym: WINESLIDES)**

2. Main Project Fields

(1) Technology Development

A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment

3. Name of Project leader

Filippo Catani

Affiliation: UNESCO Chair on Prevention and Sustainable Management of Geo-Hydrological Hazards - University of Florence (UNIFI) (ITA) – Full Member ICL. Secondary affiliation: Full Professor of Engineering Geology, Department of Geosciences, University of Padova - Contact: Via Gradenigo, 6, Padova (Italy), Tel 0039 0498279193, Email: filippo.catani@unipd.it, (secondary: filippo.catani@unifi.it)

Core members of the Project

- Domenico Calcaterra: Full Professor, Earth Sciences Department (UNINA), University Federico II, Naples (ITA)
- Fulvio Celico: Full Professor, Dept. of Chemistry, Life Sciences and Environmental Sustainability, University of Parma (ITA)
- Claudia Meisina: Full professor, Department of Earth and Environmental Sciences (ITA) - University of Pavia (UNIPV)
- Paola Revellino: Associate Professor, Dipartimento di Scienze e Tecnologie (UNISANNIO), University of Sannio, Benevento (ITA)
- Veronica Tofani: UNESCO Chair on Prevention and Sustainable Management of Geo-Hydrological Hazards - University of Florence (UNIFI) (ITA) – Full Member ICL. Secondary affiliation: Associate Professor, Earth Sciences Department (UNIFI), University of Florence (ITA)

4. *Objectives*: (5 lines maximum; what you expect to accomplish?)

1) Analyze the effects of agronomic management practices on shallow landslide triggering in vineyards;
2) Connect geohydrological information with soil biodiversity in order to understand the influence of soil fauna on shallow landslides;
3) Identify agronomic management practices, sustainable in terms of economic profitability and impact on the environment, which allow to prevent shallow landslides;
4) Development of guidelines of agronomic management practices which can help local communities to

develop effective policies and strategies for reducing the risk of shallow landslides in vineyards.

5. *Background Justification*: (10 lines maximum)

Vineyards cover currently 7.5 Mha corresponding to about 0.5% of the entire agricultural areas in the world (OIV, 2017) and are frequently damaged by rainfall-induced shallow landslides. Different agricultural practices adopted to manage the inter rows, like maintenance of bare soil, continued use of heavy machinery for tillage or permanent grass cover, influence soil physics and hydrology, i.e. soil density, water content, hydraulic conductivity (Bordoni et al., 2019). Management, as well, has an important impact on the distribution of grapevine roots in the soil. The density of roots together with their mechanical behavior related to shear and/or tensile forces, increases soil stability (Bischetti et al., 2009; Cohen and Schwarz, 2017) and is often used as an effective tool to decrease the occurrence of shallow landslides, which are widespread in areas characterized by traditional viticulture. For this reason, a quantification of root reinforcement of grapevines in vineyards with different management practices is fundamental to understand the practices that might promote the stability of sloping vineyards and the ones that cause slope instability.

6. *Study Area*: (2 lines maximum; where will the project be conducted/applied?)

   Vineyards with different management practices in Italy (Oltrepò Pavese in Northern Italy, Chianti in Central Italy and Campania in Southern Italy).

7. *Project Duration*: 3 years

8. *Resources necessary for the Project and their mobilization*

   Partners are among the most important Italian institutions dealing with landslides and will provide expertise in engineering geology (UNIPD, UNIPV, UNINA and UNISANNIO), geotechnics, hydrogeology, and soil zoology (University of Parma), field measurements and susceptibility mapping (UNIPD, UNIFI). All partners belong to the Italian ICL network and ensure a multidisciplinary approach to such item. UNIPV and University of Benevento have funds to finance studies becoming from national and European projects (LIFE). The ICL financial support will eventually support disseminations and public engagement activities such as a specific website, periodic dissemination initiatives and non-technical publications. By the way, guidelines for the selection of the best agronomic practices in steep slope vineyards, which allow to obtain a reduction of the shallow landslide hazard should be an important goal to reach at the end of the project and will be foreseen as an ICL open document to be published in the ICL Journal Landslides.

9. Project Description: (30 lines maximum)

   Task 1 – <u>Engineering geological model of the study areas</u>. Inventory of the shallow slope stabilities.

   Task 2 – <u>Geotechnical, pedological soil characterization of the test sites</u>. Disturbed and undisturbed soil samples will be collected in the identified horizons of the soil profile for laboratory analysis: A. geotechnical analysis for the determination of physical properties, volumetric characteristics, mechanical properties; B. soil analysis (calcium carbonate, organic matter, pH); C. hydrological analysis (retention curves, permeability);

The geotechnical analyzes will be performed by PhD students at the Laboratory of Applied Geology and Geotechnics of UNIPV and UNINA. Field measurements, where needed, will be performed by UNIFI and UNIPD by using portable tensiometers, BSTs and constant head permeameters at key locations, according to the methods highlighted in Bicocchi et al. (2019).

The Soil Saturated hydraulic conductivity (Ks) will be measured in field through different devices as a constant head permeameter at different depths.

In the excavated pits the grapevine root length and root size distribution will be determined at different distances from the rootstock.

Task 3 - Data analysis. The data measured in the task 2 will be integrated in order to evaluate the influence of the management techniques on:

A. the geotechnical (texture, volumetric characteristics and their vertical variations) and pedological parameters (calcium carbonate, organic matter, main ions, pH, etc. ..).

B. the hydrological parameters (hydraulic conductivity, infiltration).

C. the biological parameters (soil fauna biodiversity).

D. the density and reinforcement operated by the root system in the soil.

Task 4 - Shallow landslide assessment. The role of the different management practices in vineyards on the shallow landslides will be assessed through a physically based model that couples a hydrological model with a mechanical one. The input data will consist of the mechanical parameters (task2), the hydrological parameters (task 2), the root reinforcement values obtained for different management practices, quantified in task 2. The shallow landslide hazard will be assessed with different precipitation scenarios, in relation to climatic changes and to the variations of management techniques in vineyards over time.

Task 5 – Guidelines development. Guidelines will be drawn up aimed at the application, on a territorial scale, of those agronomic practices that are able to reduce shallow landslide hazard in steep vineyards.

10. Work Plan/Expected Results: (20 lines maximum; work phases and milestones) M = month

Task 1 (M1-M3): Engineering geological model of the study areas

Task 2 (M2-M12): Geotechnical, pedological and biological soil characterization

Task 3 (M12-M28): Data analysis

Task 4 (M28-M32): Shallow landslide hazard assessment

Task 5 (M30-36): Guidelines development

Milestones

M12: Characterization of the pilot areas from the geological, geotechnical, pedological and biological point of view. Use of soil fauna as indicator of soil degradation processes, linked to the hydraulic features.

M24: Role of the different vineyard inter rows management techniques on soil hydrological parameters.

M36: Guidelines.

The project results will impact in the following Sustainable Development Goals (SDGs) of Agenda 2030: Goal 2 , Goal 13.1 , Goal 13.2 , Goal 15.3. The project will also contribute to actions 2 and 5 of the Priority Actions of KLC2020.

11. Deliverables/Time Frame: (10 lines maximum; what and when will you produce?)

M14: Use of soil fauna as indicator of soil degradation processes, linked to the hydraulic features

M28: Role of the different vineyard inter rows management techniques on soil hydrological parameters and root reinforcement

M36: Best agronomic practices in steep slope vineyards, which, by welding the hydrological, biological and pedological aspects with the agronomic ones, allow to decrease the shallow landslide hazard.

12. Project Beneficiaries: (5 lines maximum; who directly benefits from the work?)

Landslide professionals, researchers, policy makers developing policies and strategies for reducing the risk of shallow landslides in vineyards, farmers and people living in areas with vineyards and similar cultivations, insurance companies, land use planners.

13. References (Optional): (6 lines maximum; i.e. relevant publications)

Bicocchi, G., Tofani, V., D'Ambrosio, M., Tacconi-Stefanelli, C., Vannocci, P., Casagli, N., Lavorini, G., Trevisani, M. & Catani, F. 2019, "Geotechnical and hydrological characterization of hillslope deposits for regional landslide prediction modeling", Bulletin of Engineering Geology and the Environment, vol. 78, no. 7, pp. 4875-4891.

Bischetti, G.B., Chiaradia, E.A., Epis, T.,Morlotti, E., 2009. Root cohesion of forest species in the Italian Alps. Plant Soil 324, 71–89.

Bordoni, M., Vercesi, A., Maerker, M., Ganimede, C., Reguzzi, M. C., Capelli, E., Wei X.; Cohen, D., Schwarz, M., 2017. Tree-root control of shallow landslides. Earth Surf. Dynam.
5, 451–477.

Mazzoni E.; Simoni S.; Gagnarli E. & Meisina, C. (2019). Effects of vineyard soil management on the characteristics of soils and roots in the lower Oltrepò Apennines (Lombardy, Italy). Science of The Total Environment, 693, 25 November 2019, ISSN: 00489697, 10.1016/j.scitotenv.2019.07.196.

Organisation Internationale de la Vigne et du Vin (OIV), 2017. State of the Vitiviniculture World Market-April 2017. http://www.oiv.int/en/technical-standards- and documents/statistical-analysis/state-of-vitiviniculture〉, Accessed date: 2 October 2018.

Parisi, V., Menta, C., Gardi, C., Jacomini, C., Mozzanica, E., 2005. Microarthropod community as a tool to assess soil quality and biodiversity: a new approach in Italy. Agric.Ecosyst. Environ. 105, 323–333.

Prosdocimi,M., Cerdà, A., Tarolli, P., 2016. Soilwater erosion on Mediterranean vineyards: a review. Catena 141, 1–21.

Remelli, S., Petrella, E., Chelli, A., Conti, F.D., Lozano Fondon, C., Celico, F., Francese, R., Menta, C. 2019. Hydrodynamic and soil biodiversity characterization in an active landslide. Water, doi: 10.3390/w11091882.

Note: Please fill and submit this form by 15 December 2021 to ICL Network <icl-network@iclhq.org> and ICL secretariat <secretariat@iclhq.org>

Date of Submission	Dember 22nd, 2021

IPL Project Proposal Form 2020

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: Landslide Risk assessment in AlUla Archaeological sites – Kingdom of Saudi Arabia
2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(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~~. 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 Claudio Margottini

Affiliation: UNESCO Chair on prevention and sustainable management of geo-hydrological hazards, University of Florence), Contact: (Via G. la Pira 4, Firenze 50121; Mobile: +39 348 7371805)

Core members of the Project

Names/Affiliations: Daniele Spizzichino - The Italian Institute for Environmental Protection and Research – ISPRA, Rome, Italy); José Ignacio Gallego Revilla (Royal Commission of AlUla, Executive Director Kingdoms, Tel. +34651309284 / +966553565026, j.revilla@rcu.gov.sa),

4. Objectives: (5 lines maximum; what you expect to accomplish?)

The focus of the project is to perform an updated landslide risk assessment in the AlUla archaeological sites (HEGRA, DADAN and AlUla old Town), not only for the protection and conservation of the whole cultural heritage sites but also for suggesting mitigation measures as a contribution for the site's management plan. Capacity building with local authority will be carried out as a first step for training local expertise in landslide risk assessment and for enhancing resilience and landslide risk perception of the local Oasis community.

Background Justification: (10 lines maximum)

The AlUla heritage site is one of the most important cultural heritages of the whole Saudi Arabia. Located at 1.100 km West from Riyadh, AlUla covers an archaeological area of more than 22.000 mq (2,2 ha), where it is possible to walk in a luxuriant oasis passing by ancient world heritage site through rock cut landscape shaped for thousand years. Its best-known site is Hegra, the first UNESCO World Heritage Site in Saudi Arabia, main southern city of the Nabataean kingdom, and a Roman outpost, that conserves over 130 monumental tombs with elaborated facades carved into the sandstone rock. In addition to Hegra, AlUla hosts a number of fascinating historical and archaeological sites such as its

Old Town, surrounded by an ancient oasis; Dadan, the capital of the Dadan and Lihyan kingdoms, considered one of the most developed cities of the first millennium BC in the Arabian Peninsula. To ensure long-term conservation of sites affected by natural threats, detailed investigations and monitoring techniques, both related to internal parameters (mechanicals and physical) and external agents responsible of their conservation, are required.

5. Study Area: (2 lines maximum; where will the project be conducted/applied?)
   The project will be implemented in the main affected sites by landslide hazard. More in detail the LRA will carried out in HEGRA, DADAN and in the surrounding of AlUla old Town;
6. Project Duration: (1 line maximum)
   The expected project duration will be three years.
7. Resources necessary for the Project and their mobilization
   The project will involve the UNESCO Chair and the ISPRA personnel, instrumentation, laboratories and software. The Royal Commission of AlUla will offer and host the necessary logistics and connections with the local administrations, as well as archeological support during filed survey also by the involvement of different other institution (e.g. AFAlUla, UNIMIB, UNIROMA1, UNIBO). The budget of the Project will be financed by an agreement between the UNESCO Chair and RCU.
8. Project Description: (30 lines maximum)
   The UNESCO Chair will collaborate with RCU, for assessing landslide risk in AlUla heritage sites. The first step will be assessing landslide hazard by integrating field surveys, remote sensing data and geotechnical modeling. In detail, the following steps will be carried out: i) creation of a slope-scale landslide inventory for all the selected sites; ii) geotechnical characterization of the involved materials; iii) analysis of landslide hazard and 2D/3D stability analysis in weak rock masses affected by the rock fall phenomena; iv) landslide kinematic analysis of the unstable rock mass; v) simulation of rockfall trajectories. Detailed topographic data and cadastral data will be integrated with the previously mentioned analysis in a GIS platform to produce thematic maps and databases. Therefore the vulnerability of the exposed elements and related wealth will be evaluated. In this context the use of in situ GBR interferometry can give an important contribution in order to assess potential deformation patterns along open wide area, and to guarantee sustainable tourist exploitation.
9. Work Plan/Expected Results: (20 lines maximum; work phases and milestones). 10. Deliverables/Time Frame: (10 lines maximum; what and when will you produce?)
   The final goal of the Project is to implement a tailored, innovative and sustainable strategy to be shared with the institutions and actors involved in the protection of AlUla heritage sites and used as a tool for land-use planning and management, for the detection of conservation criticalities, as well as for improving the site's resilience to geohazards. Expected outcomes are also the improvement of the sustainable and safety site's touristic exploitation in order to support the local economy and stimulate a community empowerment approach to sustainable heritage management.

In the following table a preliminary work plan, including workpackages and the related deliverables is reported:

Time table

Workpackages (WPs)			Year 1	Year 2	Year 3
WP1	**Tasks**	Field survey and identification of endangered areas in Dadan, Hegra and AlUla Old Town. Landslide hazard assessment (field surveying, data collection, geotechnical analysis and modeling,); TLS acquisition; Definition of a monitoring network. Capacity building; Project management.			
	Deliverables	Landslide hazard maps and general master Plan for mitigation measures;.			
WP2	**Tasks**	Vulnerability assessment of exposed elements (field surveys, topographic-cadastral data collection, GIS integration); Installation of a monitoring network; Project management.			
	Deliverables	Collection and elaboration of monitoring network.			
WP3	**Tasks**	Landslide risk assessment and mitigation; Collection of monitoring data; Scaling unstable blocks and preliminary intervention.			
	Deliverables	Thematic maps and design, Suggestions for mitigation measures.			
WP4	**Tasks**	Consolidation of unstable areas; Project management; Dissemination.			
	Deliverables	Project reports. Scientific publications and participation to scientific venues-forums.			

10. Project Beneficiaries: (5 lines maximum; who directly benefits from the work?)

The actors involved in the protection of the AlUla, such as RCU, the local and governmental authority, research community.

11. References (Optional): (6 lines maximum; i.e. relevant publications)

Note: Please fill and submit this form by 15 December 2021 to ICL Network <icl-network@iclhq.org> and ICL secretariat <secretariat@iclhq.org>

Date of Submission	Dember 15th, 2021

IPL Project Proposal Form 2020

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: Landslide Risk assessment in the High City of Antananarivo
2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(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. 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: William Frodella

Affiliation: UNESCO Chair on prevention and sustainable management of geo-hydrological hazards, University of Florence

Contact: Via G. la Pira 4, Firenze 50121; Phone: +39 0552757559; Mobile: +39 3407651280; Fax: +39 0552055317

Core members of the Project

Names/Affiliations: Veronica Tofani/UNESCO Chair on prevention and sustainable management of geo-hydrological hazards, University of Florence; Daniele Spizzichino/The Italian Institute for Environmental Protection and Research–ISPRA, Rome; Claudio Margottini/UNESCO Chair on prevention and sustainable management of geo-hydrological hazards, University of Florence: Francois Cristofoli/RC-Heritage consultants, Tamara Teissedre-Philip/Paris Region Expertise Madagascar – PRX; (Representative of the *Région Ile-de-France à Madagascar*).

4. Objectives: (5 lines maximum; what you expect to accomplish?)

The focus of the project is to perform a comprehensive landslide risk assessment in the High City of Antananarivo, for both the protection and conservation of the cultural heritage site, and also for suggesting sustainable mitigation measures as a contribution for the site's management plan. Capacity building with locals will be carried out as a first step for training local expertise in landslide assessment and for enhancing resilience and landslide risk perception of the local High City community.

Background Justification: (10 lines maximum)

The High City of Antananarivo, built on a hilltop elevating above the Ikopa river valley, is renowned for its baroque-style palaces and neo-gothic cathedrals dating to the XIX century. For this reason, is one of the most important cultural heritage sites of Madagascar, and since 2016 is part of the UNESCO Tentative List. During the winter of 2015 cyclones hit the urban area of Antananarivo triggering flash floods and shallow landslides, while between 2018 and 2019, several rockfalls occurred from the hill granite cliffs. All these landslide phenomena caused evacuees, damage to housings and infrastructures as well as several casualties. In this complex geomorphological setting the rapid and often uncontrolled urbanization, and a not proper land use-planning seriously exacerbates slope instability and soil erosion, posing a high risk to the local population, as well as the High City cultural heritage.

5. Study Area: (2 lines maximum; where will the project be conducted/applied?)
   The UNESCO Core-Buffer zones of the High City and surrounding natural and urban areas.
6. Project Duration: (1 line maximum)
   The expected project duration will be three years.
7. Resources necessary for the Project and their mobilization
   The project will involve the UNESCO Chair and the ISPRA personnel, instrumentation, laboratories and software. Paris Region Expertise (PRX) of Madagascar will offer the necessary logistics and connections with the local administrations (e.g., the Antananarivo Municipality), Universities (Higher Polytechnic School of Antananarivo) and actors involved in risk management BNGRC (*Bureau National de Gestion des Risques et des Catastrophes).* RC-Heritage will provide social/economic analysis. The budget of the Project will be financed by an agreement between the UNESCO Chair and PRX Madagascar.
8. Project Description: (30 lines maximum)
   The UNESCO Chair on Prevention and Sustainable Management of Geo-Hydrological hazards will collaborate with PRX, the municipality of Antananarivo and BNGRC (*Bureau National de Gestion des Risques et des Catastrophes*) for assessing landslide risk in the High City, and therefore support the nomination of the site for the UNESCO World Heritage List. The first step will be assessing landslide hazard by integrating field surveys, remote sensing data and geotechnical modeling. In detail, the following steps will be carried out: i) creation of a multi-temporal slope-scale landslide inventory; ii) geotechnical characterization of the involved materials; iii) analysis of landslide susceptibility and 2D/3D stability analysis in soils/loose deposits affected by the shallow landslide phenomena; iv) run-out analysis of mud-debris flows; v) landslide kinematic analysis of the unstable rockmass; vi) simulation of rockfall trajectories; vii) assessment of the landslide triggers by analyzing rainfall data. Detailed topographic data and cadastral data will be integrated with the previously mentioned analysis in a GIS platform to produce thematic maps and databases. Therefore, the vulnerability of the exposed elements and related wealth will be evaluated. In this context the use of EO data can give an important contribution in order to assess the growing urban pressure and climate change. Satellite multi- and hyper-spectral data will be applied in a multi-scale methodology for an updated assessment of land cover-use, for highlighting areas prone to erosion/landsliding, for the evaluation of the urban sprawl in the Antananarivo urban area, as well as for the remote classification of the building vulnerability in the UNESCO core zone.
9. Work Plan/Expected Results: (20 lines maximum; work phases and milestones). 10. Deliverables/Time Frame: (10 lines maximum; what and when will you produce?)
   The final goal of the Project is to implement a tailored, innovative and sustainable strategy to be shared with the institutions and actors involved in the protection of the High City of Antananarivo and used as

a tool for land-use planning and management, for the detection of conservation criticalities, as well as for improving the site's resilience to geohazards. The use of open-source data, platforms and tools can promote capacity building of local practitioners and end users (to be trained as local experts) and can facilitate the reproducibility of the methodology in other sites characterized by similar geomorphological, social and urban scenarios. Expected outcomes are also the improvement of the site's touristic fruition in order to support the local economy and stimulate a community empowerment approach to sustainable heritage management.

Hereafter a work plan table, including work packages and the related deliverables is reported:

Workpackages (WPs)		**Time table**	**Year 1**	**Year 2**	**Year 3**
WP1	**Tasks**	Landslide hazard assessment (field surveying, data collection, geotechnical analysis and modelling, run-out assessment, analysis of rainfall triggers); Capacity building; Project management.			
	Deliverables	Landslide inventories and landslide hazard maps			
WP2	**Tasks**	Vulnerability and Wealth assessment of exposed elements (field surveys, topographic-cadastral data collection, GIS integration); Capacity building; Project management.			
	Deliverables	Landslide vulnerability maps; definition of the estimated value for each exposed element or cluster of elements at risk.			
WP3	**Tasks**	Landslide risk assessment and mitigation			
	Deliverables	Thematic maps, Suggestions for mitigation measures			
WP4	**Tasks**	Capacity building; Project management; Dissemination.			
	Deliverables	Training of local young professional in landslide risk assessment. Project reports. Scientific publications and participation to scientific venues-forums.			

10. Project Beneficiaries: (5 lines maximum; who directly benefits from the work?)

The actors involved in the protection of the High City Cultural Heritage and civil protection activities, such as Paris Region Expertise (PRX) Madagascar, the municipality of Antananarivo and BNGRC (Bureau National de Gestion des Risques et des Catastrophes). The students of Higher Polytechnic School of Antananarivo as well as all the population of the High City will benefit from the project capacity building and landslide risk mitigation activities.

11. References (Optional): (6 lines maximum; i.e. relevant publications)

Date of Submission	December 15, 2021

IPL Project Proposal Form 2021

1. Project Title: World-wide-web-based Landslide Observatory (W3bLO).
2. Main Project Fields: (1) Technology Development: B. Hazard Mapping, Vulnerability and Risk Assessment.
3. Name of Project leader: Professor Matjaž Mikoš, dr. sc. techn. ETH.

   Affiliation: University of Ljubljana, UNESCO Chair on Water-related Disaster Risk Reduction.

   Contact: UL FGG, Jamova c. 2, SI-1000 Ljubljana, Slovenia, Mobile: +38641761186, E-mail: matjaz.mikos@fgg.uni-lj.si

   Core members of the Project: Jošt Sodnik, PhD (UL FGG), Nejc Bezak, PhD (UL FGG), Mateja Jemec-Auflič, PhD (Geological Survey of Slovenia – GeoZS), Mitja Jermol, MSc (Chair of IRCAI – Research Centre on Artificial Intelligence, Institute Jožef Stefan, Ljubljana, Slovenija – under auspices of UNESCO), and Joao Pita Costa, PhD (IRCAI, IJS).
4. Objectives: Development of a web-based Landslide Observatory, capable of collecting/presenting a nearly now-casted information on the present status of selected indicators relevant for landslide risk reduction at the global scale. For its development Artificial Intelligence (AI) techniques will be applied (e. g. Deep Learning, other algorithms), and selected large databases with data from public domain. The observatory is a first step towards building of a Digital Twin of Landslide Risk Assessment.
5. Background Justification: Landslides of diverse forms are threatening many parts of the world (Petley, 2012), and the situation will worsen during pronounced climate change in the next decades (Gariano & Guzzetti, 2016). It is important to strengthen joint efforts to reduce landslide disaster risk (Sassa, 2021). A proposed important step can be a development of an observatory of the current situation with landslide risk at the world scale. This world-wide-web-based Landslide Observatory could be used by multiple stakeholders, including the Intergovernmental Panel on Climate Change (IPCC) when working on a special report on climate-change related landslide risk at the global scale. Such an observatory could also serve as the tool to develop a unique dynamic Global Landslide Risk Index to be proposed as an indicator for SDGs (e. g. National Risk Index by FEMA in the USA: https://hazards.fema.gov/nri/landslide).
6. Study Area: global scale using different on-line satellite data (i. e. Sentinel) and large web databases.
7. Project Duration: 3 years (July, 2022 – June, 2025).
8. Resources necessary for the Project and their mobilization: The total project budget is estimated at 50.000 EUR, covered by the UNESCO WR DRR Chair from Slovenian national sources and in-kind, and IRCAI from current EU projects. Personnel to work on the projects are up to three post-doc researchers, part-time. Technical facilities are available (computer power, databases).
9. Project Description: IRCAI has already developed algorithms to analyze satellite data at the global scale, mainly by using Sentinel data. UNESCO WR DRR Chair experts will contribute their expertise

in debris flows and rainfall-induced landslides for development of the W3bLO (Mikoš and Petkovšek, 2019). The web platform for the W3bLO has been developed and is under further refinement for the Water Observatory (NAIADES project: https://naiades.ijs.si). A »Water Observatory« (WO) is a website, monitoring water related events. WO enables insights into water related issues through data analysis and AI and is built for water experts and the general public, a more in-depth description is available (NAIADES, 2021). A similar global observatory with the focus on floods already exists: https://floodobservatory.colorado.edu/, initiated in 1993 as the Dartmouth Flood Observatory (DFO) that moved in 2010 to University of Colorado. An observatory on landslide disaster risk will be built around existing AI technologies. The new observatory will combine existing landslide-related products, such as: Global Landslide Hazard Map (https://www.arup.com/projects/global-landslide-hazard-map), EM-DAT International Disaster Database (www.emdat.be) or NASA Earth Observatory, covering also landslides (https://earthobservatory.nasa.gov/topic/landslides), the NASA Global Landslide Catalog of rainfall-induced landslides (https://catalog.data.gov/dataset/global-landslide-catalog-export) (Kirschbaum et al., 2010; 2015; NASA, 2015) – the largest openly available global inventory of rainfall-triggered mass movements, and Landslide Susceptibility Map (Kirschbaum et al., 2016; Stanley et al., 2017; NASA, 2017; Emberson et al., 2020). NASA products are compiled at: https://gpm.nasa.gov/applications/landslides#modelingandreportinglandslides, NASA has developed Landslide Hazard Assessment for Situational Awareness (LHASA) Model using global models for precipitation (Emberson et al., 2018; NASA, 2018).

10. Work Plan/Expected Results: The project will be organized around the following work packages:
    WP I – Development of AI tools and techniques to be used for LO. The newest review literature will be used: prediction methods for emergency management (Huang et al., 2021), applications of AI for disaster management (Sun et al., 2020), AI in natural disaster management (Tan et al., 2021), detecting changes on the Earth's surface using remote sensing and AI for disaster management (Shi et al., 2021).
    WP 2 – Building up the observatory using available and curated open datasets and filtered news feeds.
    WP3 – Structuring of the observatory by interpreting the observatory knowledge and validating it at local/regional scale.
    WP4 – Testing of the observatory using data and expertise from ICL partners.
    WP5 – Developing a Global Landslide Risk Index to be used as an SDG indicator.
11. Deliverables/Time Frame: The development and validation/testing at local scale will take 2 years, the third year will be used for larger validation at regional scale in selected countries. The last year will also be used to develop and proposed a new dynamic Global Landslide Risk Index, in a different way as the static FEMA National Risk Index covering also landslides (https://hazards.fema.gov/nri/landslide).
12. Project Beneficiaries: The methodology for developing a Landslide Observatory will be tested in Slovenia and elsewhere, if publicly available databases could provide sufficient data for validation. Thus, other ICL members are invited to support the development in its second phase to provide data, and test the observatory in their country. After the final inauguration of the observatory, general public

and experts worldwide will be able to use it to plan prevention measures to mitigate and reduce landslide risk at regional and local scale.

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No.9

Date of Submission	8th December 2021

IPL Project Proposal Form 2022

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: Deciphering the sensitivity of rock faces to climatic changes and freeze-thaw cycles in permafrost-free regions
2. Main Project Fields: A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment
3. Name of Project leader: Dr Mateja Jemec Auflič

Affiliation: Geological Information Centre, Geological Survey of Slovenia

Contact: Dimičeva ulica 14, SI-1000 Ljubljana, Slovenia, Mobile: +38631717099, E-mail: mateja.jemec@geo-zs.si

Core members of the Project: Tina Peternel, PhD (GeoZS), Jernej Jež, PhD (GeoZS), Prof. Matjaž Mikoš (UL FGG), Assist. Prof. Nejc Bezak (UL FGG)

4. Objectives: The main objective of the proposed project is to decipher the sensitivity of rock faces to climatic changes and variations in freeze-thaw cycles in permafrost-free regions. In order to achieve this objective, we will apply a multi-method approach consisting of in-situ measurements, observations and monitoring that will allow us to determine the initial state of rock instability, the associated rockfall volume and its frequency, and the near-surface rock temperature.
5. Background Justification: Rockfalls are result of a long geological process (tectonics, weathering, etc.), but the fall is sudden. The questions most often asked are what trigger a rockfall (what causal factors) and how it happens (what mechanisms)? In the case of a meteorological factor, several physical mechanisms may be involved, which may manifest as rockfalls initiated by a slide or a fall. The periodic freeze-thaw cycles induce the joint cracks to expand continuously, which will lead to the failure of the rock mass. Thermal shock occurs due to rapid temperature change which leads to significant variation of stresses and displacements in brittle rocks. In transient heat flow, rapid cooling leads to large tensile stresses at the surface, while rapid heating causes large compressive stresses. The redistribution of stresses can lead to the appearance of microcracks, and the development of microcracks can lead to the failure of a rock face.
6. Study Area: In the proposed project, we will study sensitivity of rock faces to climate changes and variations in freeze-thaw cycles in two pilot areas in eastern part of Slovenia.
7. Project Duration: 3 years (October 1, 2021 – September 30, 2024)
8. Resources necessary for the Project and their mobilization: The total project budget is 300.000 EUR, approved in 2021 by Slovenian Research Agency, covering materials and personnel costs for 50 man-months (principal researchers from GeoZS, research collaboration with UL FGG).
9. Project Description: In the proposed project, we attempt to focus on deciphering the sensitivity of rock faces to climatic changes and freeze-thaw cycles in permafrost-free regions, applying multi method

approach. There is an increasing concern that rising air temperatures and intensive rainfall may affect slope stability not only in high mountain regions but also in permafrost-free areas. In term of identifying of the research problem, we will focus on two hypotheses. The first is that climate change has an impact on rockfalls in permafrost-free regions and the second is the change of near-surface rock temperature affect the expansion of joint cracks. To decipher the sensitivity of rock faces to climate change and freeze-thaw cycles in permafrost-free areas, we will consider the following key parameters: engineering-geological conditions of the rock faces (engineering-geological units, spacing of discontinuities, aperture of joints, infill, weathering, compressive strength, orientation of discontinuities, determination of mechanical properties); geotechnical monitoring (crack propagation patterns); climate change scenarios (historical and future projections). Monitoring areas are selected based on the following criteria: frequency of rockfalls, risk to population and infrastructure, and diversity of rock composition (carbonate and igneous rocks). We will study the sensitivity of rock faces to climate change and variations in freeze-thaw cycles. Each individual rock type has different engineering properties and predisposing factors that may affect exfoliation, discontinuity formation and fractures. However, the type of bedrock, its mineralogical setting, anisotropy, or isotropy very often determine the susceptibility to fracture formation and subsequent opening. The study will allow us to decipher the sensitivity to climate change and freeze-thaw cycles in two different rock types in permafrost-free areas. Pilot monitoring areas have already been equipped with geotechnical sensors (rain gauges, sensors for air temperature and humidity, tiltmeters, kit for measuring rock stress and deformability, laser distance gauges, crackmeters and near-surface rock temperature sensors). The results will also directly confirm or reject the postulated hypotheses and provide new insights into rock mechanics. In addition, the results of the proposed project will fill the gap in scientific knowledge of the impacts of climate change in permafrost-free regions, which are rarely the subject of scientific studies.

10. Work Plan/Expected Results: The structure of the proposed 3-year research project consists of 6 Work Packages and two compulsory Work Packages (5 and 6) that are included in the rest of Work Packages:
WP1 Geological, geomorphological and geotechnical investigations in pilot areas
WP2 Climate Change effect
WP3 Thermo-mechanical numerical simulations
WP4 Analysis of the occurrence of rockfalls and freeze-thaw cycles
WP5 Dissemination of project results
WP6 Project management and reports
A detailed plan for the implementation of each work package of the project, timetable for the 3 years is shown in Table 1.
Table 1: A detailed plan for the implementation of each work package of the project

WP/TASK		YEAR 1	YEAR 2	YEAR 3
WP 1	**Geological, geomorphological and geotechnical investigations in pilot areas**			
1.1.	Engineering-Geological Characterization of the Rock Mass (RO: GeoZS)			
1.2.	Collecting geotechnical measured data (RO: GeoZS)			
1.3.	Sampling of rockfall debris (RO: UL BT, GeoZS, UL FGG)			
1.4.	Geomechanical investigations on drilled rock samples and on sample rock debris (RO: GeoZS, UL FGG)			
WP 2	**Climate Change effect**			
2.1.	Analyses of precipitation patterns on rockfall occurrences (RO: UL FGG)			
2.2.	Analyses of temperature variations on rockfall occurrences (RO: GeoZS)			
WP 3	**Thermo-mechanical numerical simulations**			
3.1.	Development of a numerical model for crack propagation in rocks (RO: UL FGG)			
3.2.	Analyses of temperature changes on crack initiation and propagation (RO: UL FGG, GeoZS)			
WP 4	**Analysis of the occurrence of rockfalls and freeze-thaw cycles**			
4.1.	Analyses of rockfall temporal variability (RO: GeoZS)			
4.2.	Analyses of freeze-thaw cycles (RO: GeoZS, UL FGG, UL BT)			
WP 5	**Dissemination of project results**			
WP 6	**Project management and reports**			
6.1.	Project management (RO: GeoZS, UL FGG, UL BT)			
6.2.	Annual and final report (RO: GeoZS, UL FGG, UL BT)			

11. Deliverables/Time Frame: We start the project with WP 1, which includes the engineering geological characterization of the rock faces, sampling of rockfall debris and rocks. In the first year (2021-2022), we will also begin WP2. WP3, task 3.1 will start in the first year of the project and will be completed in the second half of the second year (in 2023). After that, Task 3.2 will start and will be completed at the end of the project (in 2024). At the beginning of the second year, we will start with tasks 2.2 and 4.1, followed by task 4.2 which will continue until the end of the project. Based on the results obtained in the tasks of WP 2, WP 3 and WP 4, we will confirm or reject the research hypotheses. As part of the dissemination of the project results (WP 5), we will present the obtained results at international scientific conferences (e.g. EGU, WLF, ReSyLAB, etc.) and as original papers in international journals (e.g. Science, Landslides). The tasks outlined in WP 6 will take place throughout the project.
12. Project Beneficiaries: Civil protection administration, Slovenian Infrastructure Agency, local authorities, Slovenian Railways operator, Ministry for the Environment and Spatial Planning
13. References (Optional): https://glvn.geo-zs.si/

No.10

Date of Submission	22nd December, 2021

IPL New Project Proposal 2022

1. Project Title:

Societal and Environmental Determinants of Landslide Risk Perception towards Landslide Disaster Risk Reduction; Case Study of Athwelthota Landslide, Baduraliya, Kaluthara, Sri Lanka.

2. Main Project Fields - 3. Capacity Building

3. Name of Project leader :

Ms. N. N. Katuwala - B. Sc. (Computational Chemistry), Reading for M. Sc. (Environmental Management) **e-mail: nkatuwala@gmail.com**

Affiliation: **Environmental Chemist**

Contact: **Natural Resources Management & Laboratory Services,**
Central Engineering Consultancy Bureau (CECB), No. 415, Bauddhaloka MW, Colombo 07, Sri Lanka; Fax: +94 112 598215; Tel: +94 112 505688;

Core members of the Project :

Eng. A. A. Virajh Dias – B.Sc.(Civil Eng.), MPhil(Earth Science); CEng, MASCE,MIESL

Ms. K. P. C. Perera – B.Sc. (Chemistry), Reading for M. Sc.(Environmental Science)

4. Objectives: The objective of this research is to identify the insights, perceptions and expectations from a cross section of the society towards the existing mitigation measures developed on landslide disaster risk reduction and to identify the environmental sensitivity on the same.

5. Background Justification: Social vulnerability to natural disasters is usually determined based on individual characteristics of the people including socio-economic status, gender, race, age, employment, occupation, residential property, infrastructure and lifelines, education and family structure [Kuhlicke, 2011 and Lin, 2008]. Even though there have been numerous risk mitigation strategies that have been undertaken on landslide prone areas, the loss of lives due to landslide continues. That means risk perceptions of the local people are rarely incorporated in the preparedness and control programme for landslide risk management. Besides fragility of the natural settings, environmental sensitivity, human mismanagements, location specific attraction and addition to the locality have also paved the way for landslides risk in the area. Analysis of risk perception of disasters and natural hazards is imperative for devising policies for preparedness and mitigation actions. In such scenario it is important to identify the actual requirement of the society to identify the gaps and improvements needed to better cater the victims.

6. Study Area: Case study: The landslide occurred in Athwelthota area in Baduraliya District Secretariat Division, Kalutara at around 0500hr on 26.05.2017. Nine deaths were reported at the location while 4 houses were completely damaged due to the landslide disaster. Special landslide investigations were carried out by CECB (Weerasinghe, 2014) and NBRO at the location recommending evacuation, infrastructure remedial measures and bio engineering applications to reduce the landslide risk.

7. Project Duration: Two years (December 2021 –August 2023)

8. Resources necessary for the Project and their mobilization

Item	Description of Personnel and Facilities	Cost USD	Mode of Contribution
1	Survey and associated peripherals	1,000.00	By CECB
2	Field data collection	1,000.00	By CECB
3	Dissemination of Information	2,000.00	Research grant
	Total USD	**4,000.00**	
	Total grantee contribution (USD)	2,000.00	By CECB
	Total expected through funding (USD)	2,000.00	Through a grant

9. Project Description: Socio-economic characteristics of the households greatly affect their perceptions about landslides. Social vulnerability or socio-economic vulnerability is defined as the inability of the people, organizations and societies to combat the impacts of natural disasters [Myers, et.al., 2008]. The effects of risk perception and sense of place and the surrounding nature on disaster preparedness have been widely reported. In other words, prolong period of associated surrounding nature looks predominant factor on economic viability at which addiction to place dependence variables were more likely to adopt a greater number of disaster preparedness behaviors. Additionally, individual and household socioeconomic characteristics—education, loss, distance from hazard site, information acquisition channel, and housing material— were all related to household disaster preparedness behavior. The questionnaire consists of questions regarding socio-economic characteristics of the respondents and risk perceptions about landslides. Due to the current pandemic situation, it is expected to carry out an online survey via Google forms to obtain the perception and views from schoolchildren to academics in landslide prone areas. Considering the variations in geology, debris deposition, populations at risk, and economic development levels, the perception survey is focused on categories -adults and younger. These perception surveys will be analysed using a software- NVivo 12, to identify the actual requirement or the view of the majority so that it can be useful in future decision making. This study contributes to the current literature by improving the understanding of the relationships of risk perception and sense of place to disaster preparedness in farming households threatened by geological disasters in Athwelthota area at Baduraliya in Kalutara District.

10. Work Plan/Expected Results:

January, 2022- December, 2022:

(a) The first step is to draw up a list of data required, corresponding to specific objectives. All the experts, technicians, economists, sociologists, etc. will participate in this operation. Quantifiable parameters or indicators will have to be chosen in preparation for the assessment of the existing and updated records of the Athwelthota landslide mitigation work and management and must help in the choice of sub-activities where the techniques and methods will be developed.

(b) The questionnaire survey equally represents socio-economic and cultural differences among the respondents and their perceptions about landslide risk, the study area will be divided in to (i) most sensitive zone (ii) surrounding locality and threatened area due to the existing landslide and (iii) community of adjoin village.

(c) All contact be made with the people through their community leaders, mountain people, who are most often isolated, are very concerned by all that affects their customs and their land and, above all, by everything that comes from outside their area. They live in fear of seeing the Government or the "Companies" take their land and force them to emigrate, especially since they often occupy these lands illegally.

January, 2023- December, 2023:

(d) Development of a detailed evaluation model using NVivo 12 software, one of the latest qualitative data analyzing technique which can be used to identify the impression of stakeholder communities having their statements provided during the surveys as input data for the software.

(e) Conduct the Cluster analysis which is an exploratory technique that can be used to visualize patterns which group the similar attribute values, which are coded similarly by nodes. Ultimately cluster analysis will provide a graphical representation of groups which have similarities and differences among them.

(f) Next the word frequency test can be conducted to identified groups in the cluster analysis, in order to identify frequently highlighted words (ideas) used by each group to express their attitudes towards the risk management projects undertaken by the government.

(g) Then it is necessary to realize whether these attitudes are actual or whether it is just a fear due to inadequate awareness.

(h) Accordingly, actions should be implemented to provide solutions to actual scenarios and/or conduct empowerment campaigns to eliminate the identified fears.

11. Deliverables/Time Frame:

January 2022 : Created Google forms/ questionnaires / Google forums for target group discussions

June 2022 : Collate the data obtained and use them as input data for NVivo 12 software.

January 2023 : Output of the cluster analysis and word frequency test and presenting the insights/perceptions/expectations of the focused groups.

June 2023 : Organizing empowerment programmes in webinar basis /physical sessions

August 2023 : Presenting the final output of the stakeholder perceptions after conducting the empowerment programmes

12. Project Beneficiaries: The landslide professionals, academics, researchers, planners and people residing in landslide prone areas in Sri Lanka are the beneficiaries of this project.

13. References

1. Weerasinghe, K.M., (2014),Utilization of Inferred Landslide Hazard Information as a Web Based Decision Making Tool for Landslide Disaster Risk Reduction and Early Warning, In: Landslide Science for a Safer Environment, Vol. 3, 319 - 332.

2. Kuhlicke C, Scolobig A, Tapsell S, et al. (2011) Contextualizing social vulnerability: findings from case studies across Europe. Nat Hazards 58: 789–810.

3. Lin S, Shaw D, Ho MC (2008) Why are flood and landslide victims less willing to take mitigation measures than the public? Nat Hazards 44: 305–314.

4. Myers CA, Slack T, Singelmann J (2008) Social vulnerability and migration in the wake of disaster: the case of Hurricanes Katrina and Rita. Popul Env 29: 271–291.

Date of Submission	22 December 2021

IPL New Project Proposal Form 2021

1. Project Title: **Study on Suitable Tools for Modeling and Analysing Rain Induced Slope failure in Sri Lankan Residual Soil**

2. Main Project Fields - Slope behavior modeling

3. Name of Project leader :

Ms.S S I Kodagoda- B. Sc.(Civil Engineering), M. Eng. (Geotechnical Engineering), C Eng, MIESL

Affiliation: Civil Engineer

Contact: Centre for Research & Development (CRD), Natural Resources Management and Laboratory Services (NRM & LS), Central Engineering Consultancy Bureau (CECB), No. 11, Jawatta Road, Colombo 05, Sri Lanka;

Fax:+94112598215; Tel:+94112505688; e-mail: sudheeraik@gmail.com

Core members of the Project

Ms. H M. J. M. K Herath- B. Sc. (Geology Special), M. Sc. (Water Resources Management) MIMM

Mr. H. M. M. S. Jayaweera–B. Sc. (Geology Special),

Mr. T. S. Wickramasooriya– B.Sc(Civil Eng); CEng, MIESL

Mr. A. A. Virajh Dias –B.Sc(Civil Eng); CEng, PG.Dip; MASCE,MIESL

4. Objectives:

The objective of this research is to find out the applicability of available slope stability analysis tools for rain induced slope failure in Sri Lankan residual soil

5. Background Justification:

Considerable loss to lives and property are caused annually due to slope instability in Sri Lanka. This is mainly triggered by high rainfall. Conventional tools are used to analyse the problematic areas followed up by risk mitigation proposals. Effectiveness of the approaches greatly depends on the applicability of the tools used. Therefore a guide for selection of suitable tools for analysis will immensely benefit the society.

6. Study Area:

Mountainous area of Sri Lanka covering the Central, Sabaragamuwa, and Western province

7. Project Duration: Two years (January 2022-December 2023)

8. Resources necessary for the Project and their mobilization

Item	Description of Personnel and Facilities	Cost USD	Mode of Contribution
1	Filed sample selection, preparation, testing	4,000.00	50% by CECB and rest through a grant
2	Modeling, analysis and documentation	2,000.00	50% by CECB and rest through a grant
	Total USD	**6,000.00**	
	Total grantee contribution (USD)	3,000.00	By CECB
	Total expected through funding (USD)	3,000.00	Through a grant

9. Project Description:

The project proponent (CECB), World Center of Excellence on landslide disaster reduction for 2014-2017, 2017-2020 and 2020-2023 has involved in landslide analysis and mitigatory works since 1998. It has access to large amount of data through field studies, e-conference, IPL project work and other collaborative works. Therefore the sample locations can be selected and required preparation can be carried out aiming at achieving useful results. It is expected to select suitable locations in slopy areas for sample preparation and then expose to simulated rain conditions. Observations with respect to deformation and shear failure will be recorded.

Also CECB is capable of modeling the slopes using the results of investigations obtained through Laboratory and geotechnical investigation facilities. Then available tools will be used for analysis. Required modifications will be carried out for obtaining more accurate results. Recommendations on selection of suitable tools for analysis will be made based on the results.

10. Work Plan/Expected Results:

January 2022-December 2022:

(a) Literature review, data collection and Identifying the requirements (b) Selection of sample locations for models (c) Sample Testing, collection of subsurface data

January 2023-December 2023

(a) Modeling the slopes, analysis and comparison with results, (c) Re testing for clarifications and revised analysis (e) Development of recommendations

11. Deliverables/Time Frame:

May 2022: Sample locations and testing procedure

December 2022: Results of sample testing and investigation(Pahse 1)

March 2023: Results of Preliminary Analysis

July 2023: Results of sample testing and investigation –(phase 2)

September 2023: Results of revised analysis

December 2023: Recommendations on suitable tools for analysis

12. Project Beneficiaries:

The landslide professionals, academics, researchers, planners and people residing in landslide prone areas in Sri Lanka are the beneficiaries of this project.

13. References

- ICL Landslide Teaching Tools (ISBN:978-4-9903382-2-0)
- Rain Triggered Slope Movement as Indicators of Landslide Dynamics, RK Bhandari, AAV DIAS 7th International Symposium on Landslides, Trondheim, Norway,1996 1, 1515-1520
- Shallow modes of slope failure in road earth cuttings in Sri Lanka, HMJMK Herath, SSI Kodagoda, AAV Dias

Date of Submission	22nd December, 2021

IPL New Project Proposal 2022

1. Project Title: Review of Rockfall Trajectories of Cut Slopes of Roads Using a Distribution Model Approach
2. **Main Project Fields -** 1. Technology Development (database and hazard assessment)
3. Name of Project leader :

Ms. Nimani Kulathilake – BSc (Earth Resources Eng.), C.Eng, MIESL

Affiliation: Earth Resources Engineer

Contact: **Natural Resource Management & Laboratory Services**

Central Engineering Consultancy Bureau (CECB), No. 415, Bauddhaloka MW, Sri Lanka.

Fax: +94 112 598215; Tel: +94 112 505688; e-mail: nimanikulathilake@gmail.com

Core members of the Project

Ms. J. M. K. Herath – BSc. (Geology Special), MSc. (Water Resources Management)

Mr. E.H.Navoda Premasiri – BSc. (Civil Eng.)

Mr. A. A. Virajh Dias – BSc. (Civil Eng.); MPhil (Earth Science); C.Eng. MASCE,MIESL

4. Objectives:

The objective of this research is to review the different patterns of failures and trajectories of cut slopes (rocks) of roads in hill country of Sri Lanka.

5. Background Justification:

A relatively high density road network is a significant observation in Sri Lanka's mountainous hill slopes and is the island at its most scenic, a land of emerald peaks and stupendous views of hillsides carpeted with tea and agricultural plantations and also graced by astonishing waterfalls. During recent past, it has been recognized that the rocky slopes associated in road construction are frequently affected by small to medium volume fragmental rock falls, especially initiation during high to medium rainfall events in hill country, Sri Lanka (Herath H.M.J.M.K et.al.,2018). The associated failures are usually recognized as; a) falls in rock blocks, topples often due to the lack of support of the underlying layer affected by planar sliding, b) wedge failure and rock fall after detachment of cutting face or in hanging rock faces, c) Large translational rock slide involving both soil and rock layers, d) planar rock slide along the mains structural setting and one or more combined setting meeting at once above. The project proponent, the Natural Resources Management and Laboratory Services of the CECB has already studied geotechnical features of landslides and rock slope failures and carries a many research finding which are needed to be organized in design standards, guidelines and policy framework under the World Center of Excellence on landslide disaster reduction during the period of 2014-2017, 2017-2020 and will be continued 2020 – 2023, in Sri Lanka.

6. Study Area: Mountainous area of Sri Lanka, covering the Central, Sabaragamuwa, and Uva, administrative provinces.
7. Project Duration: Three years (January 2022–December, 2024)

8. Resources necessary for the Project and their mobilization:

Item	Description of Personnel and Facilities	Cost USD	Mode of Contribution
1	Database server and associated peripherals	1000.00	By CECB
2	Field data collection	2,000.00	By CECB
3	Dissemination of Information	2,000.00	Research grant
	Total USD	**5,000.00**	
	Total grantee contribution (USD)	3,000.00	By CECB
	Total expected through funding (USD)	2,000.00	Through a grant

9. Project Description:

Rock fall is a relatively small landslide confined to the removal of individual and superficial rocks from a cliff face (Selby,1982). The study will be performed by a comprehensive scheme of investigations including geotechnical characteristics of rocks, orientation records, mapping of rock joints and statistical analyses from various forms of available data or will be determined by means of geomechanical field surveys, rock mass classification through scan lines techniques, and laboratory tests on rock blocks shall be incorporated. Rock fall research has been popularized in the past by simpler point mass and 2D models because of their computational efficiency, which will be considered as initial simulations. The 3D rockfall simulation with complex shape models is now becoming competitive due to fast and easy use in personal computers. The present study is also concerned with the development of a fully three-dimensional rigid body rockfall trajectory model that accounts for rock shape and, therefore, provides a more accurate and physically consistent description of the rock–terrain interaction. The GIS based model will be made through the RocFall (4.0) (Wen-lian Liu et.all.2021) is a statistical analysis program designed to assist with assessment of slopes at risk for rock falls. Energy, velocity and "bounce height" envelopes for the entire slope are determined by the program, as is the location of rock endpoints. Distributions of energy, velocity and bounce-height are also calculated along the slope profile; Distributions can be graphed and comprehensive statistics are automatically calculated.

Since the proposed project carries information requirement through various other agencies including Road Development Authority (RDA), Department of Railways and Ministry of Transport and their collaboration will be made. Many records need further review or the expressing the accuracy levels shall be done by direct visiting to each site and conducting field survey, as applicable.

10. Work Plan/Expected Results:

January, 2022- December, 2022:

(a) Scrutinizing already available information and continuing collection of data and if new rockfall occur, site visits and field data verification.

(b) Determination of geotechnical characteristic of rock slopes, shear strength parameters and interpretation of parametric variation of rock properties in rocks.

(c) Determination of different modes of rock fall trajectories related to the case model and identification of modeling parameters which are considered to be position dependent, such as the friction and restitution coefficients etc.

(d) Conducting a full 2D (2Dhorizontal and 2Dvertical) simulation model for rockfall based on the non-smooth contact dynamics method with hard contact.

(e) Development of a terrain model which is based on a case record of railroad section / highway road section and development of a high resolution digital elevation model.

January, 2023- December, 2023:

(f) Preliminary interpretation of rock fall trajectories using RocFall to assist of slopes at risk for rock falls including energy, velocity and "bounce height" envelopes for the entire slope.

(g) Simulation of various patterns of road cut-slope rockfall trajectories.

January 2024-December, 2024:

(h) Numerical verification, field verification and detailed interpretation of the study.

11. Deliverables/Time Frame:

July 2022 : Interpretation and statistical projection of rock slope failure along road sections at Central, Sabaragamuwa and Uva

December 2022: Finding of locations for detailed interpretation of rock slope assessment

July 2023 : Interpretation of properties of rocks including density, shear strength, point load index, poissons' ratio, elastic parameters and their relationship

December 2023: 2D model simulation and 3D model simulation using RocFall

December 2024: Verifying rock fall trajectories and distribution model approach

12. Project Beneficiaries:

The landslide professionals, academics, researchers, planners and people residing in landslide prone areas in Sri Lanka are the beneficiaries of this project.

13. References

- Selby, M.J., (1982), Hill slope materials and processes, New York, Oxford University Press.
- Herath H.M.J.M.K., Jayasooriya J.A.D.N.A., Virajh Dias A.A.,(2018), Pairwise comparisons of Geological evidences in rockfall hazard rating system (RHRHS) for the evaluation of road based potential slope failures in Sri Lanka ,Proceedings of the CECB symposium, Sri Lanka
- Wen-lian Liu, Jia-xing Dong ,Han-hua Xu,Su-gang Sui, Run-xue Yang and Lun-shun Zhou, Trajectory Analysis and Risk Evaluation of Dangerous Rock Mass Instability of an Overhang Slope, Southwest of China, Advances in Civil Engineering,Volume 2021, Article ID 7153535, 15 pages
- RocFall user guide 1998 - 2002 Rocscience Inc.
- Nimani S. Kulathilake L.K., Herath H.M.J.M.K.,Virajh Dias A.A.,(2018),Strength and Elastic Deformation of prominent load bearing Metamorphic rocks in Sri Lanka., Proceedings of the CECB symposium, Sri Lanka.

Date of Submission	20 December 2021

IPL Project Proposal Form 2022

1. **Project Title:** Climate Change-Induced Landslide Hazard Assessment - for Aiding Climate Resilient Planning for Road Infrastructure.

2. **Main Project Fields**

   (1) Technology Development

   B. Hazard Mapping

3. **Name of Project leader:** Dr. Peeranan Towashiraporn

   Affiliation: Asian Disaster Preparedness Center (ADPC), Bangkok, Thailand.

   Contact: peeranan@adpc.net

   Core members of the Project

   Names/Affiliations: Dr. nat.techn. I Putu Krishna Wijaya, Anggraini Dewi, Susantha Jayasinghe /ADPC

4. **Objectives**

   This proposed study will investigate how the precipitation-induced landslide susceptibility and hazard are affected by climate change. More specifically, the study will develop a relation between climate change scenarios, their impact on rainfall events and the landslide susceptibility and hazard of a study area. The results will guide long-term infrastructure planning in landslide prone areas.

5. **Background Justification**

   Climate change-induced extreme hydro-meteorological conditions have increased the prevalence of landslides that have attributed to significant damages to the transportation infrastructures such as roads and bridges. Long term planning for constructing and maintaining the transportation infrastructure, especially in landslide prone areas, need to consider the impact of climate change on the landslide susceptibility and hazard. To overcome these problems, studies focusing on climate-induced landslides are very important to be conducted. Unfortunately, only a few authors have tried to investigate the influence of climate change on landslides (Komori et al. 2018, Bernardie et al. 2021, and Kim et al. 2014). Gariano & Guzetti (2016) mentioned that in recent years, the proportion of papers on landslide-climate research has been lower than the overall landslide literature. In the context of climate change, no research has clearly defined the degree of damage on road infrastructures to future landslide area. Thus, integrating landslide susceptibility and detailed landslide hazard assessment in short, medium, and long-term climate change projection is critical to ensure the most effective mitigation measures.

6. **Study Area**

   The project will be applied in Java Island since more than 1,000 landslide events were reported in this most populous island in Indonesia where tens of thousands of people were impacted by the landslides.

7. **Project Duration**

   The project duration is estimated to be started on 1st March 2022 and finished by 24th July 2024.

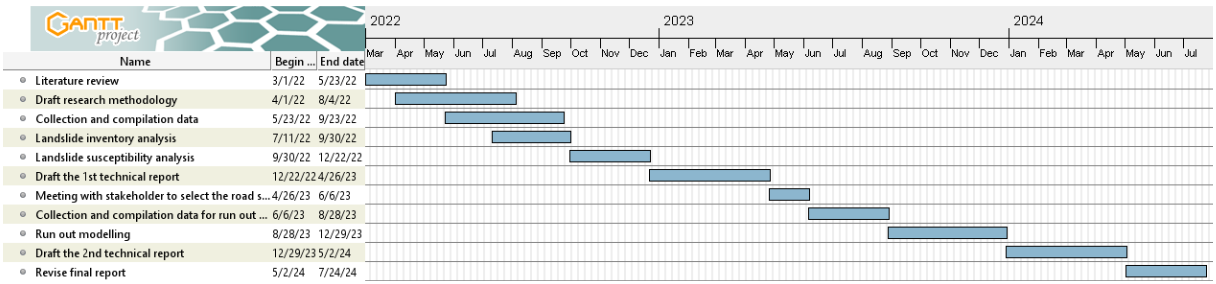
8. Resources necessary for the Project and their mobilization

Personnel, facilities	Budgets
Landslide specialist, DRM advisor, Risk Assessment Specialist, Climate Specialist	To be discussed
Landslide inventory	InSAR data
Elevation, slope, aspect	Open-source. DEM data from https://tanahair.indonesia.go.id/demnas/#/demnas
Land use	Open-source. Land use and land cover (https://livingatlas.arcgis.com/landcover/)
Lithology and lineaments	Open-source. Geological maps (https://geoportal.esdm.go.id/geologi/)
Streams	Open-source. (https://data.humdata.org/)
Mean annual rainfalls (baseline, 2030, 2050, 2080) derived from climate projection data - The NEX-GDDP (CMIP5 models)	Open-source. (https://www.nccs.nasa.gov/services/data-collections/land-based-products/nex-gddp)
LAHARZ, debris flow modelling software	Free software developed by USGS

9. Project Description

In this project, a comprehensive regional to local scale landslide hazard mapping will be performed with an integration between the statistical method (weighted of evidence method) and the run out modelling (using LAHARZ software) under a GIS-based environment in different climate change scenarios (Figure 1). The landslide inventory will be created using InSAR, and all data sources of landslide controlling factors will be compiled from open-source data. We will develop high-resolution 1km x 1km downscaled extreme rainfall projections with representative concentration pathways (RCP 4.5 and RCP 8.5) scenarios for the baseline period and future time horizons 2030s, 2050s, and 2080s. Based on these extreme rainfall scenarios, we will model and map the landslide susceptibility. The stakeholder will select the road segments that are located in the high to very high susceptible zone for a detailed landslide hazard assessment. In the next step, by performing a run out modelling approach using LAHARZ, we can precisely define the degree of damage on road infrastructures in selected road segments to future landslide areas.

10. Work Plan/Expected Results



11. **Deliverables/Time Frame**

Deliverable	Timeline
Technical report of climate change-induced landslide susceptibility assessment for aiding climate resilient planning for road infrastructure.	4/26/2023
Technical report of detailed landslide hazard assessment on selected road segments.	5/2/2024
Guideline of an integrated statistical model of landslide susceptibility mapping (regional/large scale) and landslide runout modelling (local/small scale).	7/24/24

12. **Project Beneficiaries**

Finally, the landslide susceptibility and detailed hazard maps produced in the study is useful for planners and engineers for planning and designing roads and other infrastructures to obtain a better understanding of future climate-induced landslide and their potential impacts on road networks in a more precise way, for planning new roads and rehabilitation/retrofitting of the existing roads in the study area.

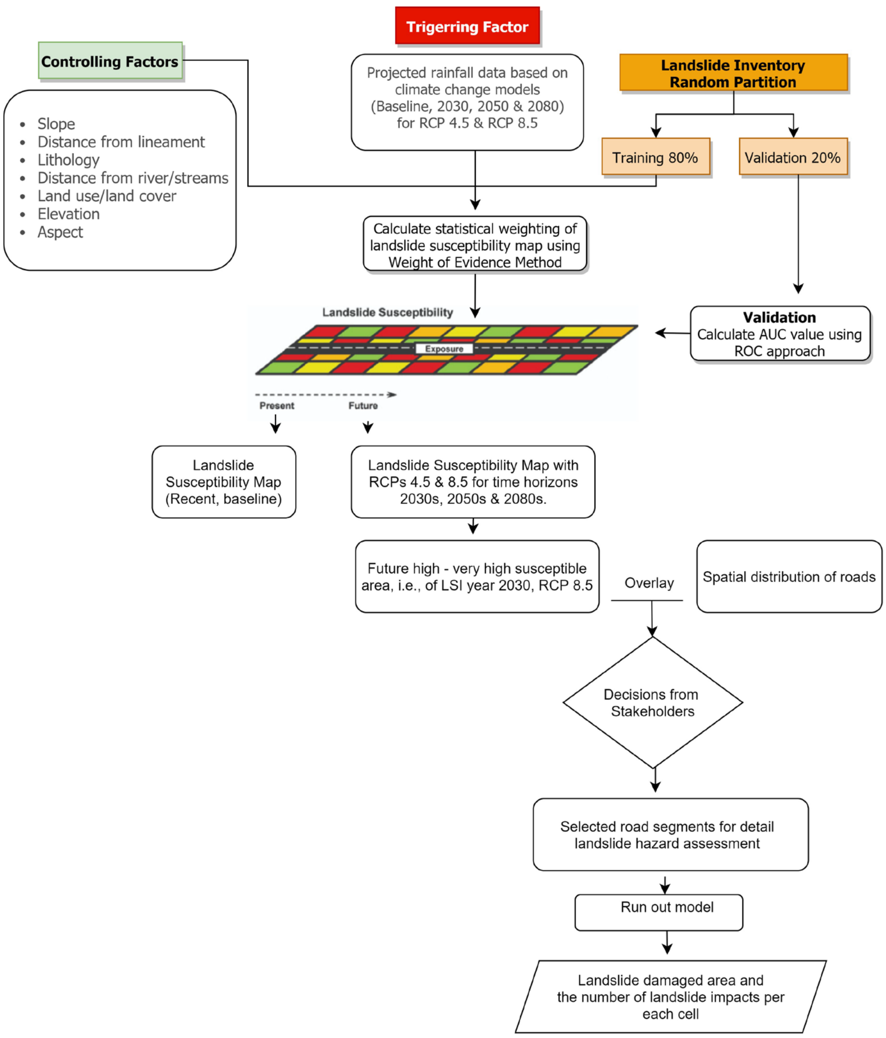


Figure 1. Flow chart of study framework.

No.14

Date of Submission	2021/12/17

IPL Project Proposal Form 2022

1. **Project Title:** The Collaboration of debris flow early warning system between Vietnam and Taiwan

2. **Main Project Fields**

(1) Technology Development

A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment

3. **Name of Project leader (PI):** Nguyen Quoc Dinh

Affiliation: Head of Economic Geology and Geomatics Department, Vietnam Institute of Geosciences and Mineral Resources (VIGMR), Vietnam.

Contact: 67, Chien-Thang-Str., Ha Dong, Ha Noi, 100000, Viet Nam

Phone: +84917703233,

Email: dinhnq@gmail.com

Co- Project leader (Co-PI): Chih-Chung Chung, National Central University, Taiwan (ccchung@ncu.edu.tw)

Core members of the Project:

1. Dr Nguyen Thanh Long, Economic Geology and Geomatics Department, Vietnam Institute of Geosciences and Mineral Resources (VIGMR), Vietnam
2. Mr. Nguyen Van Hoang, Economic Geology and Geomatics Department, Vietnam Institute of Geosciences and Mineral Resources (VIGMR), Vietnam
3. Assoc. Prof. Tseng, Kuo-Hsin, Center for Space and Remote Sensing Research, NCU. Taiwan.
4. Assoc. Prof. Chiang, Shou-Hao, Center for Space and Remote Sensing Research, NCU. Taiwan.

4. **Objectives:**

- Study and develop a smart and real-time debris flow early warning system in mountainous areas of Vietnam. Pilot study in Da Bac district, Hoa Binh province is to support the early warning of this natural disaster for authorities and local people.

5. **Background Justification:**

Debris flow is a dangerous disaster that regularly happens in the mountainous areas of Vietnam. According to VNDMA[1] statistics in the past 20 years (2001 - 2019), there have been 590 debris flows occurred in Vietnam. In which most of them appeared in the Northern mountainous provinces in Vietnam such as Hoa Binh, Ha Giang, Lao Cai, Lai Chau, Son La, Tuyen Quang, Cao Bang, Bac Kan,etc. On average, there are about 30 debris flow happening in Vietnam every year. The damage caused by debris flows from 2001-2017 in only 15 northern mountainous provinces of Vietnam indicated that 748 people was deathl, 52,544 houses were damaged; 3,910 households had to relocate. Therefore, study for developing a smart and real-time debris flow early warning system is very important for reducing debris flow damages in mountainous areas in Vietnam.

6. **Study Area:**

The case study for developing a smart and real-time debris flow early warning system in focused mountainous areas of Da Bac district, Hoa Binh province in Vietnam

7. **Project Duration:** 2 year (2022-2023)

[1] Vietnam Disaster Management Authority

8. **Resources necessary for the Project and their mobilization**

Personnel, Facilities, and Budgets

The Economic Geology and Geomatics Department includes 16 scientists, 3 PI, focusing on the application of remote sensing and GIS in geosciences, especially landslide study.

We have equipped with range of facilities from geotechnic laboratory, UAV, and software for RS and GIS analysis.

Budget: 60000 usd (the IPL will partly support based on their budget; VIGMR and NCU will secure different source of funding from Vietnam and Taiwan as matching funds)

9. **Project Description:** (30 lines maximum)

Da Bac is a mountainous district belonging Hoa Binh province with rough terrain, stiff slope, high frequent landslides and debris flows seriously threatening local people lives and property. In 17/17 communes and towns of the district, there are 83/122 villages and hamlets still at high risk of landslide and debris flow disasters, with 170 places at high risk of landslides and debris flows. In the whole district, there are about 850 households located in disaster-prone areas, of which 630 households are located in areas at risk of landslides; 190 households are located in the area at risk of debris flow. In particular, there are 4 places with dense population of lakes in hamlets such as: Bua Xen, Coi, Duoc (Nanh Nghe commune) with 74 households located in the area of debris flow since 2018. Tuong Bai hamlet (Muong Chieng commune) has 51 households located below the subsidence point since 2016 and the debris flow since 2017. In Rang hamlet (Cao Son commune) there are still 14 households located in landslides and debris flow since 2017. Rieng hamlet (Tu Ly commune) has 12 households located in the landslide since the rainy season in 2016.

Hence, study for developing a smart and real-time debris flow early warning system is very important for reducing debris flow damages in Da Bac distritc is very important. In this study, some work components are as following:

- CP1: Assessing the current status of landslide and debris flow inventory in Da Bac district, Hoa Binh province. On that, identification and delineation of high-risk sub-basins of debris flow is done;

- CP2: Develop landslide risk maps as a basis for determining the most suitable location to develop a smart and real time debris flow early warning station in Da Bac district, Hoa Binh province;

- CP3: Develop a report on designing a debris flow early warning system in the selected basin in Da Bac district, Hoa Binh province; in which using InSAR for landslide/debris flow monitoring will be enhanced.

- CP4: Install and operate 01 debris flow early warning system in selected basin in Da Bac district, Hoa Binh province.

- CP5: Develop a draft process of constructing and installation of a real-time smart debris flow early warning system in mountainous areas of Vietnam.

- CP6: Write and complete the final report.

- CP7: International publication and support for training and research capacity building for young staff of the Institute of Geosciences and Mineral Resources.

10. Work Plan/Expected Results: (20 lines maximum; work phases and milestones)

The project will be started from 2/2022 to 4/2024

11. Deliverables/Time Frame: (10 lines maximum; what and when will you produce?)

No	Deliverables	Timeline	Organization

1	Report of current status of landslide and debris flow inventory in Da Bac district, Hoa Binh province	02/2022 - 04/2022	VIGMR
2	Landslide risk map for Da Bac district, Hoa Binh province.	04/2022 - 08/2022	VIGMR&NCU
3	Install and operate 01 debris flow early warning system in selected basin in Da Bac district, Hoa Binh province, in which using InSAR for landslide/debris flow monitoring will be enhanced.	08/2022 - 12/2022	VIGMR&NCU
4	Report for process of constructing and installation of a real-time smart debris flow early warning system in mountainous areas of Vietnam	01/2023 - 04/2023	VIGMR&NCU
5	Final report	04/2023 - 09/2023	VIGMR&NCU
6	International publication	01/2023 – 12/2023	VIGMR&NCU

12. Project Beneficiaries: (5 lines maximum; who directly benefits from the work?)

13. References (Optional): (6 lines maximum; i.e. relevant publications)

Note: Please fill and submit this form by 15 December 2021 to ICL Network <icl-network@iclhq.org> and ICL secretariat <secretariat@iclhq.org>