Date of Submission	August, 2, 2024

IPL Project Proposal Form 2023

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title **Modeling landslide susceptibility and volumes using Geographic Information System and Unmanned Aerial Vehicle.**

   Select one of two below.

   (1) New project

   (2) Second stage of ongoing project

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: **Dr. Gabriel Legorreta Paulín**

Affiliation **Instituto de Geografía, Universidad Nacional Autónoma de México (UNAM). Researcher "B".**

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Core members of the Project

Dr. Marcus I. Bursik / The State University of New York, University at Buffalo.

Dra. Lilia Arana Salinas / Universidad Autónoma de la Ciudad de México.

Dr. Fernando Aceves Quesada / Facultad de Ciencias, UNAM.

4. Objectives: **The goals of this project are (1) Complement and prepare a landslide inventory map for the study area in GIS. (2) Prepare a susceptibility map per landform and/or multiple logistic regression for the study area in GIS. (3) Calculate the volume of material delivered to the main river by all landslides in the watershed. (4) Calculate the volume of material delivered to the main river of selected landslides for one year in 2-time periods (before and after a rainy season) (5) Modeling volume distribution of selected landslides. (6) Make the results available to the public through a website and delivered to local municipal authorities.**

5. Background Justification: **Iztaccíhuatl volcano is the third highest elevation (5512 m a.s.l.) in Mexico and presents a great potential threat to population due to the formation of landslides and debris flows triggered by volcano-tectonic earthquakes, high seasonal rainfall that affect large areas of weakened volcanic deposits, and land use changes. Landslides that occur along stream systems are continuously impacting and damaging human settlements and economic activities. The Río Xopanac-Apitzato watershed was selected as a study area. The watershed lies on the eastern flank of Iztaccíhuatl volcano. Landslides along the Río Xopanac-Apitzato threaten towns such as Huejotzingo, Santa María Tianguistenco, and Santa María**

Nepopualco with an overall population of 34,200 inhabitants. In spite of this, there are few or incomplete landslide inventory maps, and this precludes the mapping of landslide susceptibility and volume. The main goal of this project is to address the above deficiencies.

6. Study Area: **The present will use the Xopanac-Apitzato watershed on the eastern flank of Iztaccíhuatl, within the State of Puebla, México**
7. Project Duration: **3 years**
8. Resources necessary for the Project and their mobilization

Summary of Resources Required for Project					
Summary fund heading	Fund heading	Full economic Cost (US dollar)	% UNAM contribution	Summary of staff effort requested	
Directly Incurred	Fieldwork & livings	$14,415.38	100		Months
	Equipment	$50,000.00	100	Researcher (leader)	36
	Software and digital Material	$26,766.15	100	Researcher (co-member)	12
	Training & Diffusion	$11,363.69	50	Technician	24
	Students' scholarship	$40,341.42	100	Other	0
	Other services	$32,769.23	50	Visiting Researcher	3
	Subtotal	$175,665.87	0	Student	24
Directly Allocated	Researchers	$166,153.85	100	Total	99
	Subtotal	$166,153.85			
Total		$341,809.72			

Project Description: **The goals of the project are to complement and prepare a landslide inventory and landslide susceptibility maps for modeling the potential volume delivered to the mainstream by landslides in the watershed. Río Xopanac-Apitzato watershed was selected for this study. The river flows on the eastern flank of Iztaccíhuatl volcano. The watershed is constantly affected by landslides and lahars triggered by volcano-tectonic earthquakes, heavy rain, and land use changes. The study area will be used to develop a method using geographic information systems (GIS) and unmanned aerial vehicle (UAV) mapping to assess landslide susceptibility and to model landslide volumes in volcanic terrains. This will entail a combination of field work, photo interpretation, remote sensing, geomorphologic landforms classification, detailed geometric landslide values (area and volume) and the use of GIS and UAV. The first step will be the development of a landslide inventory map; landslides will be mapped from interpretation of aerial photographs and local field surveys to assess and describe landslide distribution. All landslides will be digitized into a GIS, and the spatial geo-database of landslides will be constructed. The amount of field verification will be held between 10% and 15% of total landslides to enhance the degree of confidence in the mass wasting assessment. Once landslides have been mapped, specific landforms that exist across the study area will be defined according to the classification adopted by Washington State Department of Natural Resources (DNR), USA. These landforms (inner gorges, bedrock hollows, convergent headwalls, etc.) are based on slope gradient and shape, lithology, landslide density, and geomorphology. For each landform a semi-quantitative overall susceptibility rating will be derived by using the landslide frequency rate and the landslide area rate. Alternatively, landslide susceptibility will be calculated by multiple logistic regression. Detailed geometric measurements of individual landslides will be obtained by UAV and will be expressed as landslide area and volume. These measurements will be used to establish an empirical relationship between area and volume that will take the form of a power law. This relationship will be used to estimate the potential volume of material delivered to the watershed. In addition, selected landslides will be used to calculate its volume contribution for one year using 2-time periods and to model volume distribution by using and adapting the LAHARZ program. Its implementation will depend on the availability of time and resources. A written report will include analysis of landslide susceptibility, explanatory text of landform**

descriptions, landslide triggering mechanisms, and sediment yield of landslides. The method has potential to be the foundation of an integrated means to handle and support prognostic studies of slope instability in volcanic areas of Mexico. The results and methodology will be handed to local municipal authorities to support landslide hazard mitigation and planning. Also, the material will be available to the public through a website.

9. Work Plan/Expected Results: (**Work plan for the first year: (1) Gather and analyze aerial photographs, satellite images, thematic cartography to map landslides. (2) Fieldwork I: Gather descriptive and geometrical (area and volume) information at landslide site. Improve the landslide inventory map by adding landslides that are not visible on aerial photographs or satellite images. (3) Prepare a detailed landslide inventory map for the Rio Xopanac-Apitzato watershed. (4) Design and implement a prototype database with the information gathered in the field. (5) Establish contact with local municipal authorities. Work plan for the second year: (1) Identify and mapping landforms. Landforms will be defined by geomorphologic parameters, statistical analysis, expert knowledge and empirical evidence, and an adaptation of the Landslide Hazard Zonation Protocol of the Washington State Department of Natural Resources, in a GIS-based technology. (2) Fieldwork II. Measure landslide geometry with a UAV. (3) Calculate the landslide frequency rate and the landslide area rate. (4) Calculate the overall susceptibility rating for each landform and for the Xopanac-Apitzato watershed. (5) Submit maps, new information, and findings at national or international conferences. Work plan for the third year: (1) Fieldwork III. Use a UAV to measure in detail complementary landslide geometry (length, width, and depth). (2) Develop an empirical relationship in the form of a power law to estimate the potential total volume of material delivered from all landslides in the watershed. (3) Model landslide volume of selected landslides for one year using 2-time periods (4) Model volume distribution of selected landslides. (4) Disseminate the findings in national and/or international journals.**
10. Deliverables/Time Frame: **First year: (1) Finalize the landslide inventory map for the study area and its database. (2) Disseminate the findings at national conferences and publish the results in the Landslides journal or in ICL open-access books. Second year: (1) Finalize the landform map. (2) Finalize the landslide susceptibility for each landform and for the Xopanac-Apitzato watershed. (3) Obtain the landslide geometry and volume of selected mapped landslides with a UAV. (4) Submit maps, new information and findings at national or international conferences such as the Landslides journal or in ICL open-access books. Third year: (1) Obtain and finalize the landslide volume delivered per landform and for selected landslides using 2-time periods for one year. (2) Deliver to local municipal authorities the final written report with the landslide inventory, landslide susceptibility rate per landform and the potential landslide volume delivered in the watershed. (3) Deliver the result and method to the public through the Institute of Geography's WEB page and with authorities and stakeholders within the hazards community. (4) Organize a seminar for students and local municipal authorities to explain methods and resulting materials. Its implementation will depend on the availability of time and resources. (5) Disseminate the findings in national and/or international journals such as the Landslides journal or in ICL open-access books.**
11. Project Beneficiaries: **Landslide mapping will assist local authorities such as the civil protection agencies of Puebla state and other governmental organizations in hazard mitigation and planning.**
12. References (Optional): (6 lines maximum; i.e. relevant publications)

Note: Please fill and submit this form by 15 July 2023 to:

ICL Network <icl-network@iclhq.org> and KLC secretariat <klc2020@iclhq.org>