Date of Submission	30/03/2019

IPL Project Proposal Form 2019

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: **Laboratory physical modeling of rainfall, slope deformation and landslides triggering.**
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,

   (4) Mitigation, Preparedness and Recovery

   A. Preparedness, B. Mitigation,
3. Name of Project leader

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Core members of the Project

Names/Affiliations: (4 individuals maximum)

- **Prof. Eng. Pasquale Versace /** University of Calabria, DIMES, CAMILab, CINID (Interuniversity Consortium for Hydrology).
- **Eng. Gennaro Spolverino /** University of Calabria, DIMES, CAMILab.
- **Eng. Emilia Damiano** / University of Campania Luigi Vanvitelli, DICEA.
- **Prof. Eng. Roberto Greco** / University of Campania Luigi Vanvitelli, DICEA.
- **Prof. Eng. Lucio Olivares** / University of Campania Luigi Vanvitelli, DICEA.

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

   The project aims to understand the mechanisms that control hydraulic processes in unsaturated soils, responsible for triggering landslides, by experimenting with a slope physical model.
5. Background Justification: (10 lines maximum)

   Each year, rainfall events trigger a large number of landslides causing damage and victims. Study and forecast of rainfall-induced landslides is a field of great importance. Infiltration processes and underground water circulation have an important role to define failure processes characteristics. Experimentation with a scale physical model allows to analyze larger soil volumes than those of a specimen, reproducing the natural phenomenon more faithfully, limiting to the maximum boundary effects. Moreover, the possibility of investigating thicknesses closer to real ones, allows to study the behavior of coulters of assigned characteristics and densification degrees with stress states closer to the real ones, thus reaching an interpretation of the more truthful failure phenomena.

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

   Experimentation will be carried out at the University of Calabria using volcanic soils from southern Italy and non-Italian volcanic soils.

7. Project Duration: (1 line maximum)

   3 years

8. Resources necessary for the Project and their mobilization

   Personnel, Facilities, and Budgets

   Eng. Giovanna Capparelli the assistant professor in University of Calabria, will lead the research team. The fundamental facilities will include, flume test, sensors, software and workstations. Group can benefit from funds for laboratory strengthening of the project SILA – PONa3_00341 project An Integrated System of Laboratories for the Environment, plus a budget for three years of 40,000 euros.

9. Project Description: (30 lines maximum)

   To reproduce and investigate the behavior of rainfall-induced landslides, tests can be performed in situ or laboratory analyses can be developed with physical scale models. The latter are based on the reproduction of the physical characteristics of the phenomena in question and the boundary conditions that control their dynamics. There are various configurations, which differ essentially in size, in the instruments installed and in their intrinsic performance potential. Besides having evident scientific utility, such scale models are particularly useful for all those cases which are difficult to monitor with instruments, since they make it possible to observe behavior that results in failure and the transient phases that precede it. The schemes most commonly used are those which reproduce the typical scheme of the infinite slope and, thanks to a suitable sensor system, control various measurements required to understand the phenomenon, such as suction, the degree of saturation, and small displacements. The possibility of creating and setting up large physical models enables larger soil volumes to be analyzed and more faithful reproduction of the natural phenomenon, while minimizing boundary effects. With this in mind, at the CamiLab laboratory of the University of Calabria, in the framework of the SILA – PONa3_00341 project An Integrated System of Laboratories for the Environment – a large artificial channel was built, able to reproduce a rainfall-triggered landslide, analyze the correlated measurements, and observe post-failure evolution (Figure 1). The physical model was designed so as to lend the channel great flexibility and versatility when used. The model consists of two connected variable tilting flume (trigger and propagation) of 1 meter wide and 3 meters in length each. It is equipped with a sensor system to measure the main physical parameters which govern deformation and failure processes. It is equipped with tensiometers for measuring the suction inside the slope, pressure transducers at the bottom of the flume to measure positive water pressures, TDR system for measuring volumetric water content and laser-displacement transducers for measuring surface displacements in the orthogonal direction to the sliding plane. The presence of two independent channels also makes it possible to analyze the propagation phase and allow the positioning of impact structures so as to evaluate any mitigation strategies. Our project uses an integrated approach, the data of experimental sites and tests with a physical model are used to simulate the phenomenon with mathematical models. The intent is to observe and interpret laboratory experiments to reproduce and simulate the phenomenon with mathematical models. After the calibration of all the sensors, tests will be carried out with homogeneous soil deposits formed by several layers. This will allow us to analyze the relationships between the unsaturated soil and slope stability. Furthermore the flows inside the soil layers and the deformations that will be generated due to rain will be analyzed.

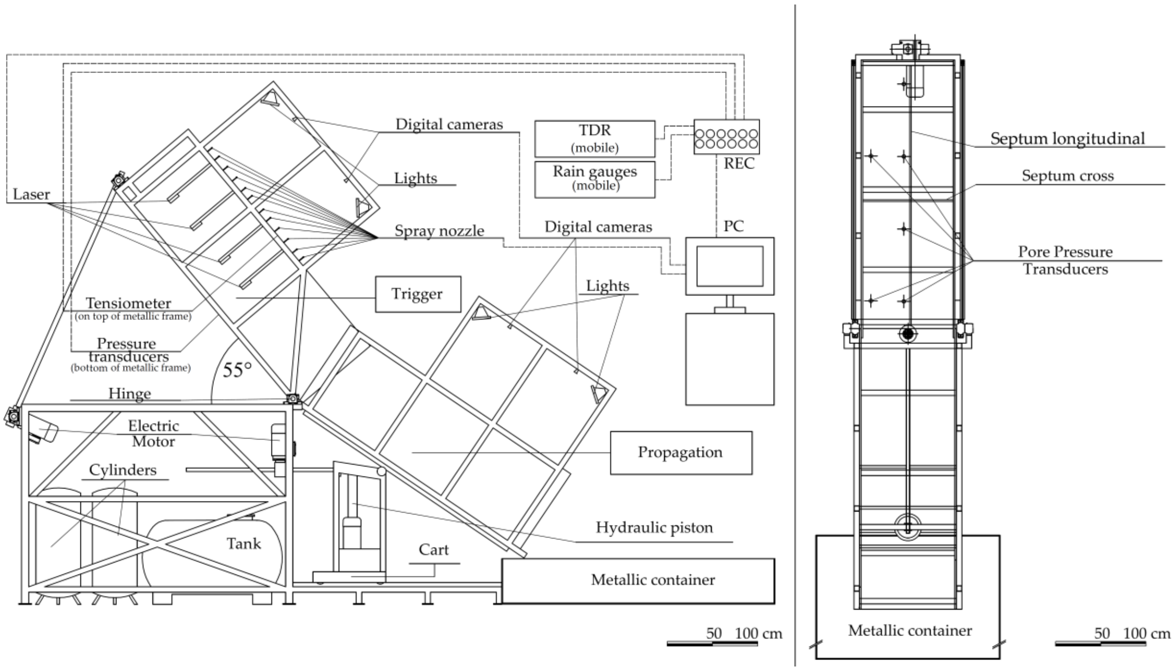

Figure 1. Section and plan of the mechanical components of flume.

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

The project is started in January 2018 and it will be ended in January 2021. The project encompasses sequential stages, and will be divided into 4 main:

- First stage - Calibration of all sensors. (First year)
- Second stage – Soil characterization used for the tests. (First year)
- Third stage - Flume tests (homogeneus soils, stratified soils). (First and second and year)
- Fourth stage - Numerical modeling. (Third year)

As of today, all the calibration activities of the sensors have been completed and some tests have been started to allow the validation of all devices.

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

During the first year, calibration of all sensors will be performed and tested. In addition, soil sampling, soil characterization and laboratory tests will be conducted and flume tests will begin (homogeneus soil). In the second year, flume tests will be completed (stratified soils) and and the deformations and flows from the layers will be analyzed. The last year will be devoted to completing the tests and implementing the numerical model. Using an integrated approach, the data of experimental sites and flume tests will used to simulate the phenomenon with mathematical models. The scientific production will be done in all three years and will cover all the phases of the project.

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

    Rainfall-induced landslides cause diffuse damage to people, structures and infrastructures. A good predictive model can allow the implementation of an equally good warning system, reducing the risk caused by such phenomena. Knowing infiltration evolution in the soils formed by granulometrically different layers, allows improving the warning systems. The main beneficiaries will be the national civil protection and those who implement warning systems.

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

- Capparelli G., Spolverino G. and Greco R. (2018). *Experimental determination of TDR calibration relationship for pyroclastic ashes of Campania (Italy)*. Sensors, 18, 3727; doi:10.3390/s18113727
- Capparelli G., Spolverino G., Damiano E., Greco R., Olivares L. (2018). *Physical model study of the infiltration processes in pyroclastic slopes subject to instability*. Vienna, Geophysical Research Abstracts Vol. 20, EGU2018-13625, 2018 EGU General Assembly 2018.
- Damiano E., Greco R., Guida A., Olivares L.and Picarelli L. (2017). *Investigation on rainwater infiltration into layered shallow covers in pyroclastic soils and its effect on slope stability.* Engineering geology, 220, 208-218.
- Spolverino G., Capparelli G., and Versace P. (2019). *An Instrumented Flume for infiltration process modeling, landslide triggering and propagation*. Geosciences, 9(3), 108; doi: 10.3390/geosciences9030108