Date of Submission	30 April 2026

IPL Project (IPL-279) Annual Report Form

Period of activity under report
from 1 January 2025 to 31 December 2025

1. **Project Number and Title: Project IPL-279. Integrated Toolsets for the Assessment of Landslide Impact scenarios (ITALI)**

2. **Main Project Fields**

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

(1) Technology Development

B. Hazard Mapping, Vulnerability and Risk Assessment

3. **Name of Project Leaders:**

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Core members of the Project:

All members of the ICL Italian Network

4. **Objectives**

The research project aims to contribute to decision-making processes (with a focus on large-scale planning and/or nowcasting) through the development of toolboxes that, starting from already existing and available tools and analysis methods, enable the comprehensive evaluation of landslide event scenarios in a risk-oriented perspective and considering the entire chain that takes into account predisposing factors and preparatory and triggering processes, as well as the propagation of failed masses.

5. Study Area

The study of ground instabilities is essential for effective hazard assessment and risk mitigation, particularly in geologically complex regions such as Italy, with diverse geomorphic, geologic and tectonic settings. This project activities started from a comprehensive review of landslide processes across the whole Italian territory, drawing on an in-depth analysis of a series of case studies (Learning Examples, LEs) which represent a collection of past experiences. It has also to be stated that part of the remaining research activity will be mainly carried out on "virtual" sites, intended as realistic but not necessarily real contexts to prove the reliability of the proposed solutions. Each LE was translated into detailed information on the specific phenomenon and its characteristics to enhance the understanding of how different factors contribute to instability. They cover both onshore and offshore ground instability, the latter being particularly relevant in a country as Italy, with extensive coastlines and mountainous areas, as subaqueous processes present unique challenges for monitoring and analysis. Further, they were inventories distinguishing the different geographical and environmental setting at which they are referred to, with data deriving from on-site monitoring, remote sensing, deterministic analysis, statistical analysis and machine learning. In some cases, to address possible under-representation of some typologies of landslides, additional examples from international literature on the Mediterranean area were used to complement the Italian LEs inventory.

6. Project Duration: 3 years

7. Report

1) Progress in the project

During 2025, activities of the project focused on the collection of ancillary and field data, aimed at building up a comprehensive review of landslide processes across the Italian territory, drawing on an in-depth analysis of a series of case studies (Learning Examples, LEs), which represent a collection of past experiences. These include cutting-edge analyses in the theme of characterization of predisposing factors and in the spatial and temporal quantification of susceptibility, with the aim of selecting the most complete case studies that allow to extract learning and principles that could be extended to other contexts.

The Les inventory covers both onshore and offshore ground instability, the latter being particularly relevant in a country as Italy, with extensive coastlines and mountainous areas, as subaqueous processes present unique challenges for monitoring and analysis. Subaerial landslides were categorized into distinct typologies based on their kinematics, primarily differentiating

between Slow landslides and Rapid landslides: Slow subaerial landslides are characterized by gradual movement, whilst rapid subaerial landslides are characterized by sudden and fast movement, presenting significant risks to human assets.

Based on the inventoried learning examples the main predisposing factors have then been identified for both subaerial and submarine landslides, subdivided into the following macro-categories: Geology, Geomorphology, Physical and Mechanical Properties, Sesimotectonics, Land Cover & Vegetation, Groundwater, Erosion, Climate, and Anthropogenic Factors.

Then, an expert-based methodology was adopted to identify the suitable susceptibility methods for weighting the factors predisposing ground instabilities. Following a detailed scrutiny of existing literature, through a review that highlighted the numerous potential methods for weighting these factors, we broadly classified them into expert-based, physically-based, and data-driven methods.

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

The first phase of the project was addressed to the in-depth study and systematization of case studies, to be considered cornerstones, as the object of development and validation of analytical methods for the assessment of the effects of predisposing factors and/or preparatory and triggering processes on slope stability conditions. In the next phase, integrated methods, also to be understood as a concatenation of individual analytical tools, will be developed for the assessment of potential instability conditions and the prediction of event scenarios for specific forcings, considering multi-hazard effects (particularly compound and cascading). In detail, we will proceed with deepening and rationalization of the analysis tools. In view of setting homogeneous toolboxes (i.e., dealing with specific landslide types and made up of tools linkable one to another), each analytical tool will be characterized in terms of: factors/processes dealt with (i.e., predisposing, preparatory and triggering or propagation), applicability/validity constraints (i.e., analysis scale and boundary conditions such as morpho-climatic and geological settings), input requirements (quality and quantity of input data), and output metrics (qualitative, quantitative, semi-quantitative). In this way we will focus on the generation of predictive scenarios.

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

The main beneficiaries of this project include the Civil Protection offices and institutions, Public administrations, Managing Authorities, and, more in general, all stakeholders involved in landslide risk prevention and management. Given the high number of Universities which researchers participate to the project, the Italian scientific community working on Ground Instability issues will benefit of the project outcomes as well, and, in turn, the broader society.

From a scientific perspective, the project contributes to the overall advancement of knowledge on ground instability processes, providing improved conceptual and predictive models that could result in supporting future research and educational activities on these issues, which also in recent months are strongly impacting the Italian territory. As regards the societal perspective, the results are of direct relevance to all authorities that are responsible, at different levels (from the national, to the regional, to the local) for management and land-use planning of territories prone to landslides and other types of ground instabilities. The final results of the project will therefore provide a contribution to increase the societal awareness on ground instability issues.

4) Results

The huge variety of ground instability processes in Italy, combined to the widespread presence of human infrastructures and inhabited areas in the country, make its territory strongly vulnerable to slope movements. The social and economic impacts deriving from landslide occurrence (Glade and Crozier 2005; Highland and Bobrowsky 2008; Woo 2025) is therefore among the highest in the world. The first outcomes of the project focused on the predisposing factors of subaerial and submarine landslides, also through a critical review of the most advanced methods for landslide susceptibility, pointing out that, notwithstanding the significant amount of work available in the scientific literature, there is still a long way to go toward a comprehensive understanding of the landslide processes, also aimed at properly managing the Italian territory in order to contribute to a significant mitigation of the landslide risk. Future efforts should be directed toward the application of causative conditions which typify the relationships between preparatory and triggering factors, as well as the onset of landslide events. At this regard, digital twins trained by monitoring systems and middle-to-long term recorded datasets could represent a validating tool for reconstructing scenarios of effects. These scenarios can be regarded as a fundamental tool for territory planning in a risk mitigation perspective and to increase the resilience of human communities, in synergy with the Civil Protection authorities.

The results of the activities carried out in WP1 during 2025 have been object of a publication in the Open Access Book Series P-LRT (complete reference below), and have been as well presented during the ICL/KLC conference.

Berti M., Bozzano F., Calcaterra D., Ceramicola S., Ciccarese G., Colacicco R., Di Martire D., Esposito C., Fanti R., Forte G., Liso I.S., Martino S., Parise M., Tacconi Stefanelli C. & Tofani V. (2025) *Ground Instability processes in the Italian territory: outcomes for Advances Susceptibility Methods from a national review of Learning Examples.* Progress in Landslide Research and Technology, Volume 4 Issue 2, 2025, Springer.