Data requirements and scientific efforts for reliable large-scale assessment of landslide hazard in urban areas

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This study is framed within the PRIN 2017 project - URGENT – UR SAPIENZA

This presentation participates in OSPP

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Introduction

1. In this research, we report and discuss the scientific efforts for a reliable assessment of landslide hazard in one of the more challenging contexts exposed to risk: the urban area of **Rome**, Italy.

2. The hills on which Rome stands, have been affected by landslides that have almost always been associated with heavy rainfall. A total of **356** shallow landslides occurred in the last decades, of which **67** during the storm of **31 January 2014** (Alessi et al., 2014).

3. Reliable data-driven assessments of landslide hazardous areas in urban areas depends on the quality of ancillary data.
   → The city of Rome lacks in high-res DTM as well as detailed landslides inventories
   e.g., landslide initiation points (LIPs), mechanisms of failure, time of occurrence etc.

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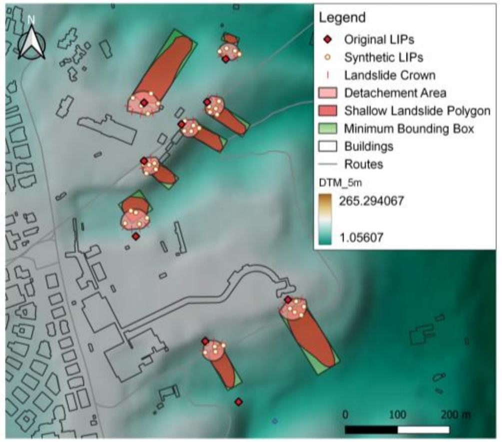
Data & Methods

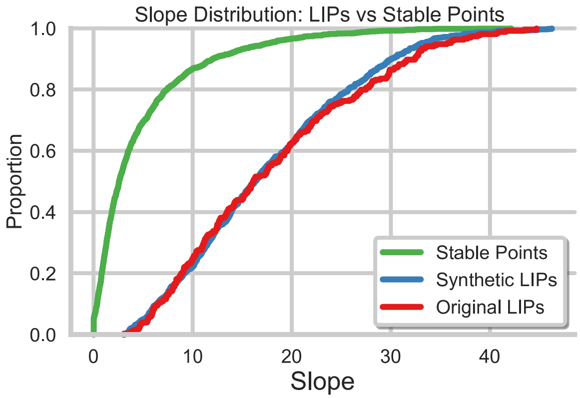


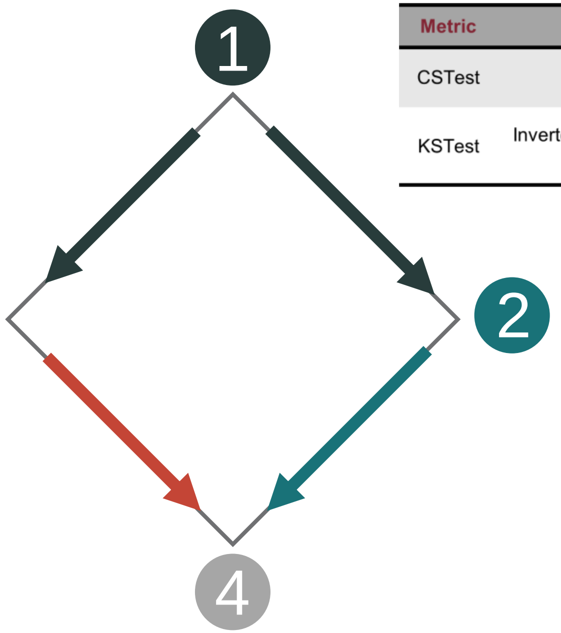
GEOSPATIAL DB PREPARATION

Acquisition and pre-processing of landslide inventories and related predictor variables;
Computing Detachment areas;
Synthetic LIPs extraction.

Original LIPs	289
Synthetic LIPs	810
Overall LIPs	1099 (35%)
Stable Points	1893 (65%)

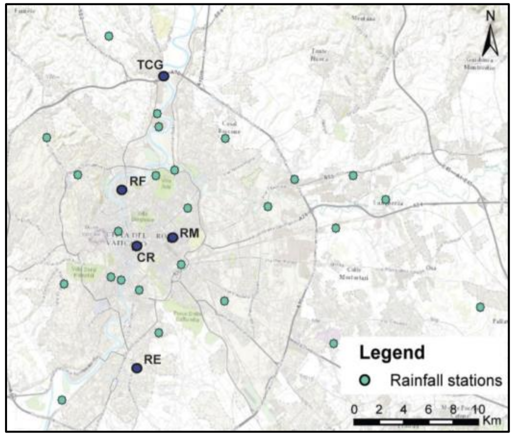
Metric	Name	Score
CSTest	Chi-Squared	0.666
KSTest	Inverted kolmogorov-Smirnov D statistic	0.932





TEMPORAL HAZARD

Rainfall probability curves from GEV analysis on rain intensity.



SPATIAL HAZARD

Splitting of event-based inventory (Jan 2014)
Train – Test Split (80/20 ratio)
Select best ML model using K-Fold cross validation
LS Prediction
Hazard Classes definition

SCENARIO BASED RUNOUT MODELING

95th percentile of Class 5 cells to evaluate landslide propagations

LIP: Landslide Initiation Point **ML**: Machine Learning **GEV**: Generalized Extreme Value **LS**: Landslide Susceptibility

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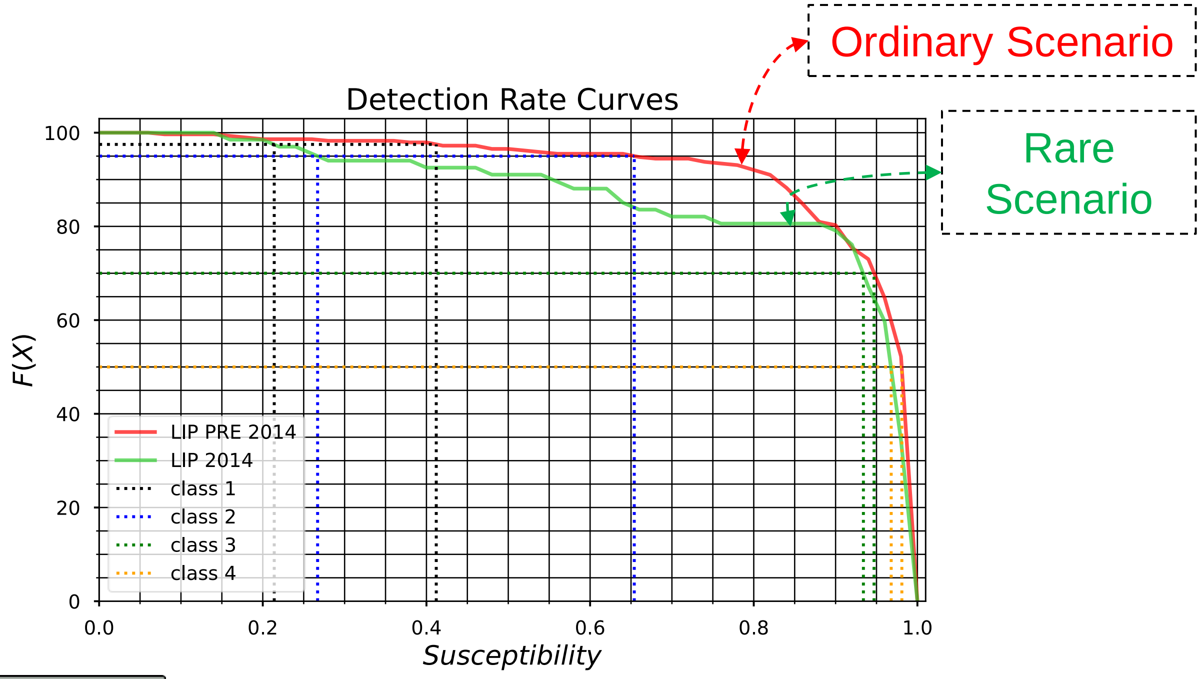
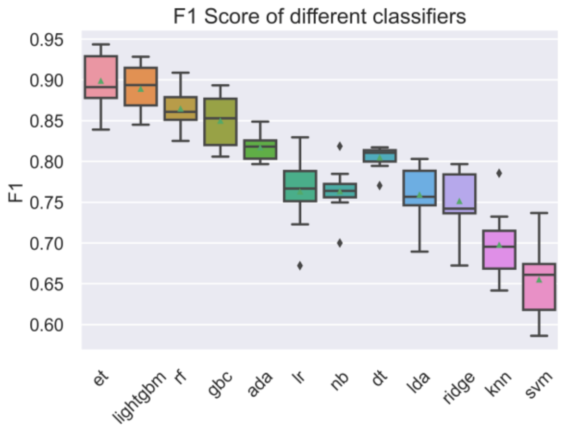
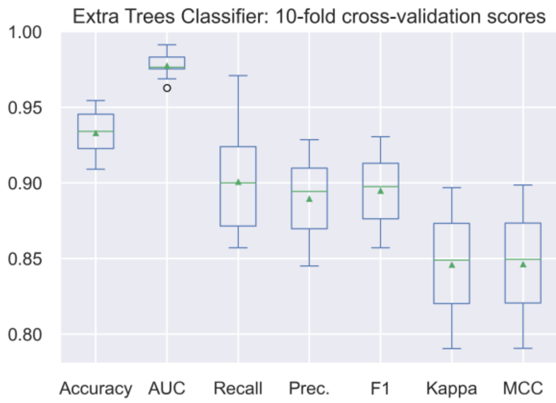
Results

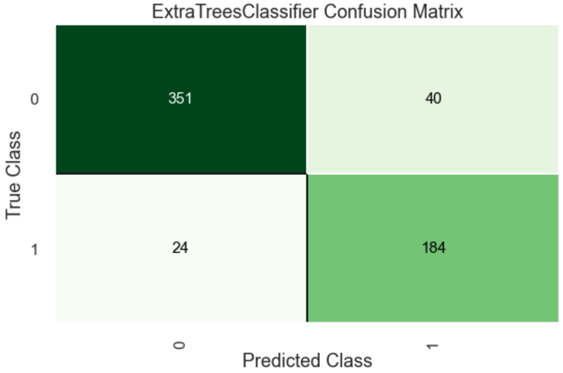
1. Extra Trees Classifier (et) outperform other ML models.
2. **$\mu_{(F1\ Score)}$ = 0.895; $\mu_{(Accuracy)}$ = 0.933**
3. Slope Angle and Relative Relief being the most conditioning features.
4. About **89% TP** and **90% TN** for Test Data.
5. Jan 2014 rainfall-induced landslides generally have lower probability to failure.

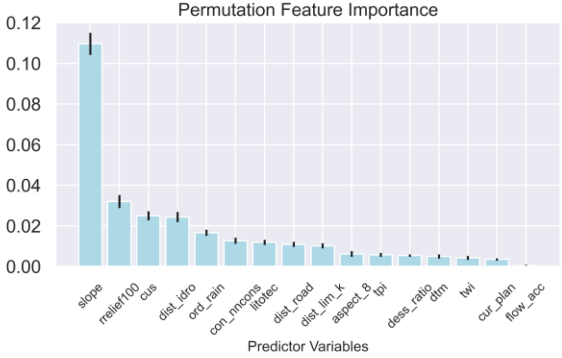


TP: True Positives **TN**: True Negatives









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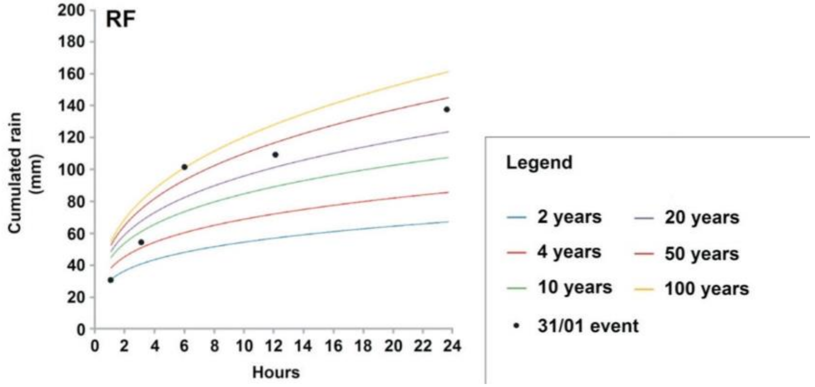
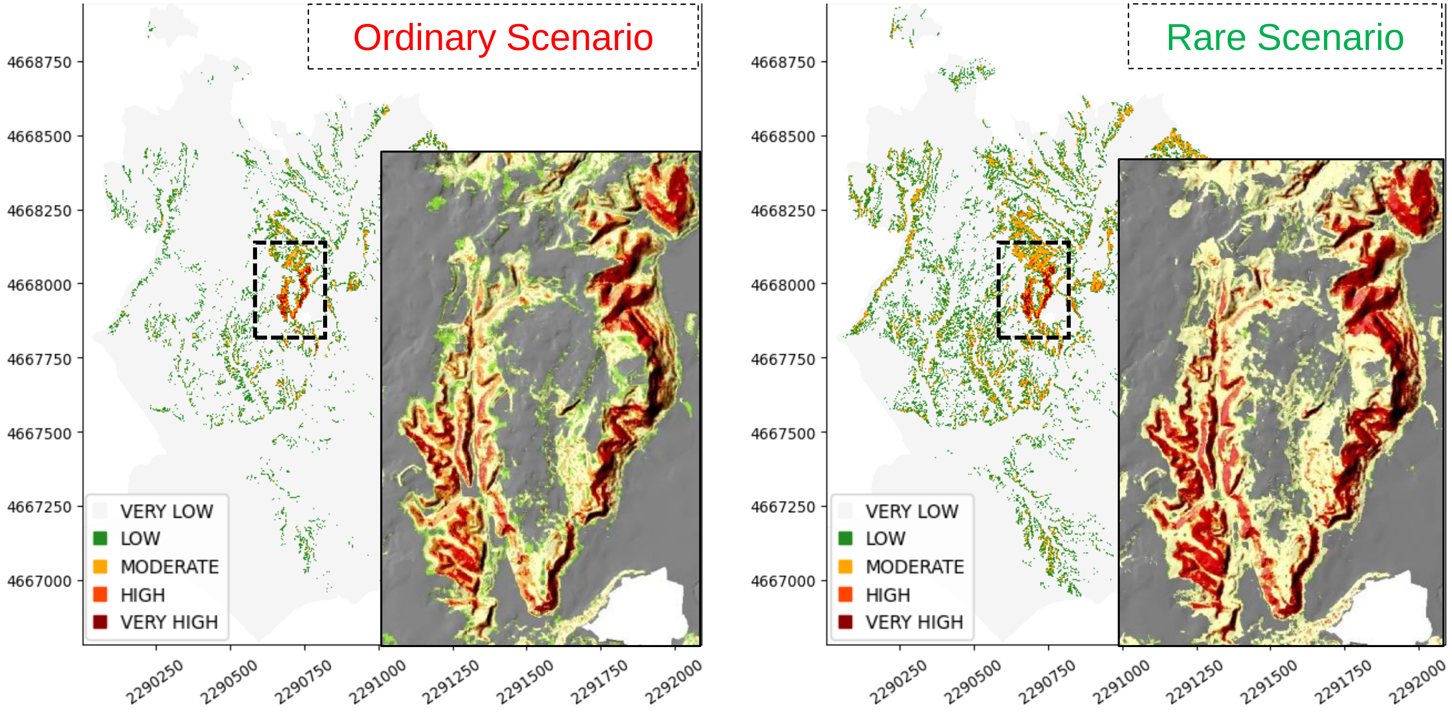
Results

1. Rainfall Probability Curves demonstrate that the Jan 2014 storm is characterized by Return Periods up to 100 years.
2. The Monte Mario hill faces a significant increase in landslide susceptibility when moving to the rare scenario.
3. Preliminary runout simulations suggest potential road invasions along the Monte Mario slope.

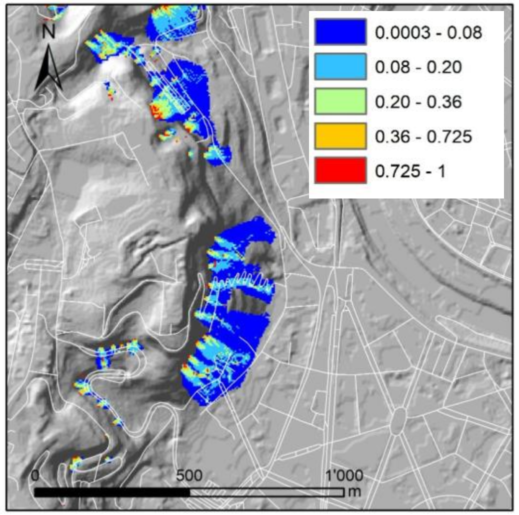
Rainfall Probability Curves for hourly cumulated rainfall at the **R**oma **F**laminio station

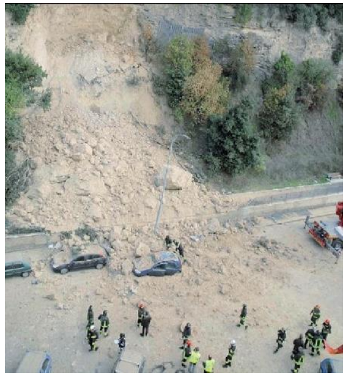


Landslide Susceptibility Maps



Shallow Landslides Runout Simulations





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Conclusions

1. The proposed framework represents the first and solid landslide susceptibility product in the municipality of Rome and the first overview for the hazard quantification and aware management of territory.

2. A complex sequence of supervised and unsupervised optimization strategies of available data sources can be performed to boost present information, by processing integrated data according to data-driven and knowledge-based methods.

3. The integration of GIS tools and Machine Learning techniques allowed to estimate landslide susceptibility based on both real and synthetic Landslide Initiation Points (LIPs).

4. Detection Rate Curves show that the landslides triggered by the Jan 2014 rainfalls occurred in areas less prone to failure.

5. Rainfall Probability Curves demonstrate the temporal dependence of rainfall-induced shallow landslides, thus enabling the scenario-based hazard maps.

EGU General Assembly 2022

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THANKS FOR YOUR ATTENTION

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