LANDSLIDE SUSCEPTIBILITY

A landslide susceptibility map identifies areas which are subject to landslides and is measured from low to high. The landslide susceptibility map takes into account where the landslides occur and what causes them (slope, aspect and the impact of the flow of water in an area). Landslides are one of the most widespread and devastating geohazards in the world. Landslide susceptibility mapping is a key preliminary step in risk mitigation strategies. Susceptibility maps depict the spatial probability levels for a certain area to be prone to landslides, based on local environmental variables. A second key step is exposure assessment which implies counting (or estimating) of people, property, systems, or other elements present in hazard zones. Exposure is defined as “the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas”. As stated in the UNIDRR glossary, “measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest”. Exposure can be assessed by overlaying susceptibility maps with the spatial density layers of those elements within the considered areas.

STUDY AREA:

The study area with coordinates south of city Bormio has a varied surface and population depending on its specific location within the Italian Alps.

SURFACE:

As a mountainous region within the Italian Alps, the study area is characterized by a rugged and diverse surface. It may include high peaks, deep valleys, rolling hills, and flat plains. The topography can vary significantly, with steep slopes, rocky terrain, and glacial features in some areas. The surface is likely covered by a combination of

vegetation, including forests, meadows, and alpine flora, as well as bare rock surfaces in higher elevations.

POPULATION:

The population of the study area can vary greatly depending on the specific location within the Italian Alps. Generally, the Alps are not densely populated compared to urban areas in Italy. However, there are numerous towns, villages, and communities scattered throughout the region, particularly in the valleys and lower elevations. The population density in the Alps tends to be lower in comparison to the more urbanized areas of Italy. Many settlements in the Alps have a small to moderate population.

LANDSLIDE SUSCEPTIBILITY MAPPING
REQUIRED DATASET FOR THE

ANALYSIS:

- DTM (Digital Terrain Model) – Raster data set representing the terrain surface (12.5 m/pix). The DTM is widely used in various fields, including geology, hydrology, urban planning, environmental assessment, and engineering. They provide valuable information about the elevation, slope, aspect, and shape of the terrain, which is essential for many applications.

- DUSAF (Land use and land cover) – data from the geographic information base of the land use destination of the Lombardy Region.

- Landslide inventory – data from IFFI catalogue (scale1:10,000). Includes the information about the type of landslide. An LS (Landslide Inventory) refers to a collection or database of landslide occurrences and related information within a particular geographic area. It serves as a comprehensive record of landslides that have been documented or observed, providing valuable data for landslide research, hazard assessment, and mitigation planning.

- Data (Road, river network, distance to geological faults) - road and river networks are derived from OpenStreetMapas vectors and faults from GeoPortale Lombardia. For each network, buffer zones have been created for 50, 100, 200, 500 and more than 500 meters.

- Data (Normalized Difference Vegetation Index) - The Normalized Difference Vegetation Index (NDVI) is a measure of the greenness of a biomas. The Normalized Difference Vegetation Index (NDVI) is an indicator used to assess the presence and health of vegetation in a particular area. It is calculated from remotely sensed data, such as satellite imagery or aerial photographs, and provides valuable information about the amount and vigor of vegetation cover.

STEP 1. DATA PREPROCESSING FOR SUSCEPTIBILITY MAPPING

- Slope - The angle of slope is in a strong relationship with the occurrence of landslides. With the increase of the angle the shear stress is increasing and, the possibility of a movement is higher.

- Aspect – depicts the direction of the slope.- Plan and Profile curvature - the curvatures highlight the profiles of the slope in both directions, where important classes are the concave which can block a water runoff and augment higher water saturation on the surface and the convex where the accumulated mass could lead to slope failure.

Train_Test	Hazard	Number of points
Training	0	350
Training	1	350
Testing	0	150
Testing	1	150

- Data (Non-landslide areas) – define areas where the probability of landslide according to the Slope angle. Assume No-Landslide Zones (NLZ) are where the Slope is <20° or >70°. Remove the NLZ zones that are overlapping with the Landslide Inventory polygons.

- Training and Testing - New field ‘Hazard’ in the attribute tables of both Landslide Inventory and NLZ. Assign 0 to the NLZ and 1 to the Landslide Inventory. Decide a training-testing ratio that we use for our machine learning model (e.g., 70/30). Assign the value ‘Training’ or ‘Testing‘ according to the select polygons.

- Sample the environmental factors (Slope, Aspect, Plan and Profile curvature, Road, river, faults, NDVI, DUSAF, DTM) with the training and testing point layers by using the Point Sampling Tool plugin.

STEP2— SUSCEPTIBILITY MAP GENERATION.

- The R in QGIS used the Model Map package to generate Susceptibility map.

- For validating the resulted map used Accuracy assessment and sampling Python script.

STEP3—DATA PREPROCESSING FOR EXPOSURE ASSESSMENT.

- Download the population raster dataset (World Pop map) and reprojected.

- Reclassify the susceptibility raster map (obtained in Step 2) using 4 classes such as: low (0, 0.25); moderate (0.25, 0.5); high (0.5, 0.75); very high (0.75, 1).

- Compute the population counts in each susceptibility class by using Raster layer zonal statistics.

- Plot the percentage of population per each susceptibility class.