SECTION 3: Methodology for computing the input data for the ML model using QGIS.

To estimate the input parameters for the ML model, a methodology based on GIS tools is proposed. The methodology uses a Digital Elevation Model (DEM) for the area of study and QGIS software [55]. Currently, elevation data are available from different sources at different spatial resolutions (e.g. Shuttle Radar Topography Mission (SRTM) and Light Detection and Ranging (LIDAR)). The main steps are explained below.

1. Digital elevation model (DEM):

   A DEM with 1 Arc-Second (30 m) resolution can be downloaded with the plugin SRTM Downloader [70] in QGIS. Other sources can be used as well, for Spain the National Geographic Institute (IGN) offers free DEM at different resolutions [71].

   The steps to download the DEM in QGIS are:

   1. Select the extension of the area of study from the plugin SRTM Downloader.
   2. If several DEMs are downloaded to cover the area, join them using Raster/Miscellanues/Merge.
   3. Remove sinks and spikes on the DEM with the Wang & Liu [72] algorithm (module SAGA [73] in QGIS).

2. Drainage network:

   To identify the main channel or preferred path of the flow, the drainage network of the terrain needs to be estimated, for which the Strahler order method [74] was applied. It allows the identification of the drainage network based on a hierarchical relationship of streams. It works considering the headwater stream as a first-order stream; next, when two first-order streams join, a second-order stream is formed; when two second-order streams join, a third-order stream is created and so on. The Strahler order calculation is available on the module SAGA [5].

   Each pixel of the DEM is classified from 1 to 8, based on the number of streams that converge in the pixel: the higher the class, the bigger the stream. To extract the main channel, the Strahler order classification is filtered using the Raster Calculator tool (Raster/ Raster Calculator).

3. Selection of AoI:

   Manually identifying the AoI is possible with QGIS. For a detail real view of the terrain, a Google Map terrain layer can be imported. The steps to add the AoI to QGIS are:

   1. Create a new connection in XYZ tile, and add the URL for the Google Map terrain layer and add the new layer to the canvas.
   2. Create a new vector layer (Layer/New Later/New Shape File Layer); select point as type of geometry and configure the projection (EPSG:32630-WGS84 UTM 30 N)
   3. Edit the new layer an add points at the location of possible AoI (i.e., houses, roads, crops) and save the changes.

4. Parametrization of AoI:

A breach and reservoir axes are required to parametrize the location of the AoI. The axes are calculated using a rotation matrix with angle θ. Rotated axis are calculated with Equations 1 and 2 (x′ and y′). The selection of the rotation angle depends on the location and direction of the main channel.

$$x' = xcos\theta - y\text{sen}\theta \quad (1)$$

$$y' = xsen\theta + y\cos\theta \quad (2)$$

To add the rotated axis to QGIS:

1. Save the coordinates of the rotated axis in a CSV file.
2. Add a new layer as delimited text (Layer/Add new layer/Add layer as delimited text)
3. Select the CSV file.

The tool V.DISTANCE on the GRASS menu [75] is used to measure the distance between the AoI and the axes (D_{resx}, D_{resy}, and $D_{channely}$). The tool calculates the distance between the nearest element from a vector layer ("source layer") to another vector layer ("to layer"). Then, by selecting the layer of the AoI as the "source layer" and the breach axis as the "to layer", the distances D_{resy} for every AoI are calculated. Similarly, changing the "origin" layer to reservoir axis, and main channel axis, D_{resx} and $D_{channely}$ are estimated. New attributes are added to the AoI layer, corresponding to the distances, which can be exported.

5. Terrain parameters:

With the plugin profile tool [76] in QGIS, profiles of the breach and reservoir axis are drawn. L_B corresponds to the longitude before there is a significant change of slope on the breach axis. The slopes are calculated with the maximum (E_{max}) and minimum elevation (E_{min}) and the distance between these points (X) (Equation 9). The longitudinal slopes (S_{lb}, S_{lc}) are calculated with the profile on the breach (for Section B and C) and transversal slope (S_t) with the reservoir axis profile.

$$Slope(S\%) = \frac{Emax - Emin}{X} x100 \quad (3)$$

To determine the Manning´s coefficient, we recommend following the Methodological Guide for the development of the national flood zone mapping system [77], which includes in Appendix V the assigned Manning coefficient associated with CORINE land uses.