



Comprehensive RISk assessment of basic services and transport InfraSTRUCTure



## **Comprehensive Risk Assessment of Basic Services and Transport Infrastructure**

101004830 - CRISIS - UCPM-2020-PP-AG

**Cross-border database platform for risk and emergency management**

WBP version 1.0 – User manual

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## **Cross-border database platform for risk and emergency management**

WBP version 1.0 – User manual

WP-5 | D.5.3

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## 1 Platform overview

To access the CRISIS platform, the user has to fill out the form of Figure 1.1 with his username and password and click on the “Login” button. Once entered, the user displays the main page of the web tool (see Figure 1.2), consisting of a series of buttons surrounding a map centred on the area of the project interest, i.e. the cross-border region of North Macedonia, Albania, and Greece. The latter is also divided into municipalities and colour coded:

- purple for Albania;
- yellow for North Macedonia;
- blue for Greece.

Figure 1.1: Login page.

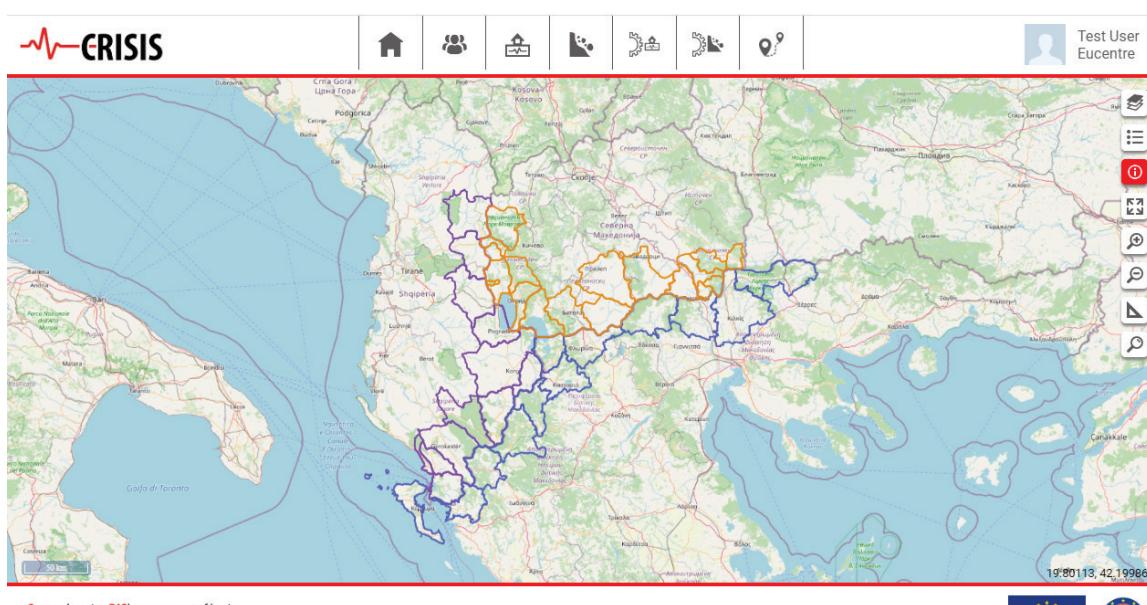


Figure 1.2: Main page.

The map is fully zoomable and pannable using both the mouse and the tools in the right toolbar. The toolbar includes several buttons, the functions of which are described in Table 1.1. Each button is activated when it is highlighted in red and deactivated when its colour returns to white.

Other buttons are available at the top of the map. They allow the user to open tabs through which the user can enable/disable the layers related to exposure, hazard, and risk/scenario data. The platform also makes it possible to display earthquake/landslide damage scenarios and to calculate alternative routes that rescuers can follow after an earthquake, avoiding infrastructures (in this particular case, bridges) damaged by the event. All the above tabs will be described in detail in the following paragraphs.

Lastly, the user can exit the platform by clicking the “Logout” button under the user icon at the top right of the web tool, as shown in Figure 1.3. Under the user icon, there is also the “Settings” button (see Figure 1.4) with which the user can:

- define the language of the platform. Currently, the available language is English.
- switch between two different behaviours when selecting items by clicking on the map. In particular, when “Selected layer” is flagged, to get information about a particular item, it is necessary to select the corresponding layer and then click on the item itself. Instead, when “First layer” is flagged, in the case of overlapping layers the information the user gets by clicking on the map corresponds to the most prominent one.

Table 1.1: Toolbar features.

Icon	Name	Function
	Layers	It opens the layers panel that collects activated layers and allows them to be deactivated/reactivated or completely deleted.
	Legend	It opens the panel showing the legend of active layers.
	Info	When activated, a layer can be selected to have the related information in a pop-up window. This button is active by default.
	Zoom extent	It allows returning to the default zoom condition.
	Zoom in	It allows the zoom level to be increased.
	Zoom out	It allows the zoom level to be decreased.
	Distance measure	It allows drawing a route by clicking on two or more points on the map. After defining the route, a double-click will bring up a pop-up window containing the length of the route in kilometres.
	Search	It opens the search panel. Two different search options are available: either by municipality or coordinates. The latter have to be inserted according to the WGS84 – EPSG 4326 system.

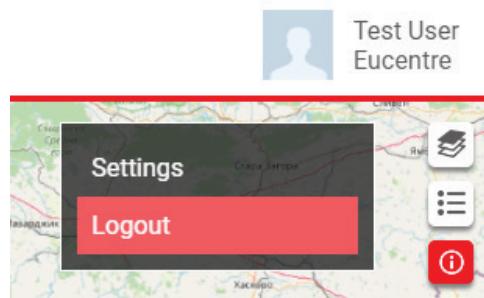


Figure 1.3: “Logout” button.

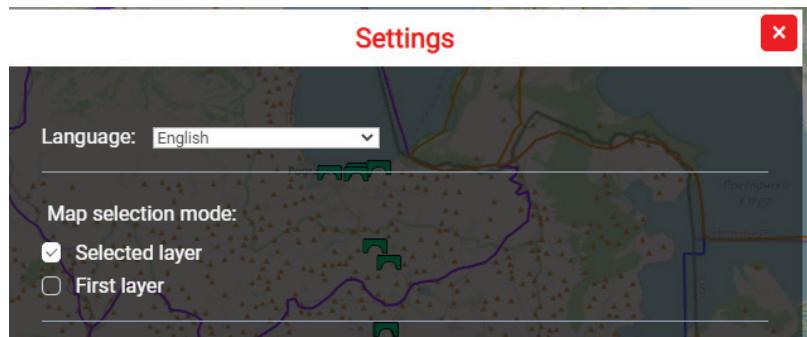


Figure 1.4: “Settings” button.

## 2 The platform functions

All platform functions are accessible through tab icons located at the top of the page, a brief description of which is provided in Table 2.1.

In the following paragraphs, instead, we define the functionality of each tab in Table 2.1, except for the “Home” tab.

Table 2.1: Tab icons.

Icon	Name	Function
	Home	It opens a pop-up side tab with the platform description, a button to download the web tool navigation manual, and a section with the acronyms used in the platform.
	Exposure layers	It allows enabling/disabling the exposure database layers of hospitals, schools, and bridges located in the area of the project interest.
	Seismic hazard	It allows enabling/disabling the layers of the seismic hazard maps and the VS30 map.
	Landslide hazard	It allows enabling/disabling the layers of the maps related to the landslide hazard.
	Earthquake scenario	It allows to perform a real-time damage scenario and/or to display the results of calculated damage scenarios for eleven historical events that affected the project's cross-border region.
	Landslide scenario	It allows enabling/disabling the layers of the landslide risk maps.
	Routing	It allows defining routes to take in case of emergency to avoid potentially unusable infrastructures (in this particular case, bridges) due to a seismic event.

### 2.1 Exposure layers

Once the user clicks on the corresponding icon (see Table 2.1), a pop-up tab opens on the left side of the web tool collecting the exposure database layers of hospitals, schools, and bridges in the cross-border region of Greece, North Macedonia, and Albania (see Figure 2.1). Herein, the user can enable/disable one or more layers simultaneously, thus displaying/not displaying on the map the elements of the exposure database related to the activated layer(s), as shown in Figure 2.2.

The layers activated in this tab also appear in the “Layers” panel (see Figure 2.3), from where they can be disabled by deselecting or deleting them. When they are deleted, the same layers are also disabled in the "Exposure layers" tab.

Lastly, once one or more layers are activated, with the info button enabled (see Table 1.1), the user can click on an item of his interest and read the related information available in the database, as shown in Figure 2.4.

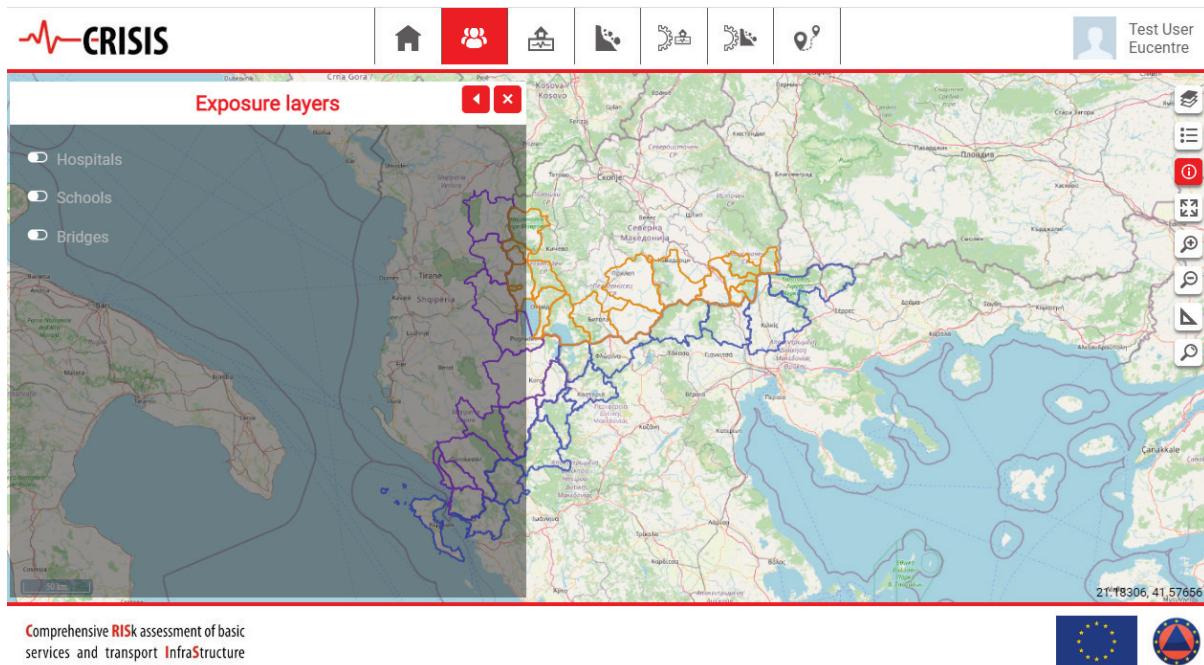


Figure 2.1: “Exposure layers” tab.

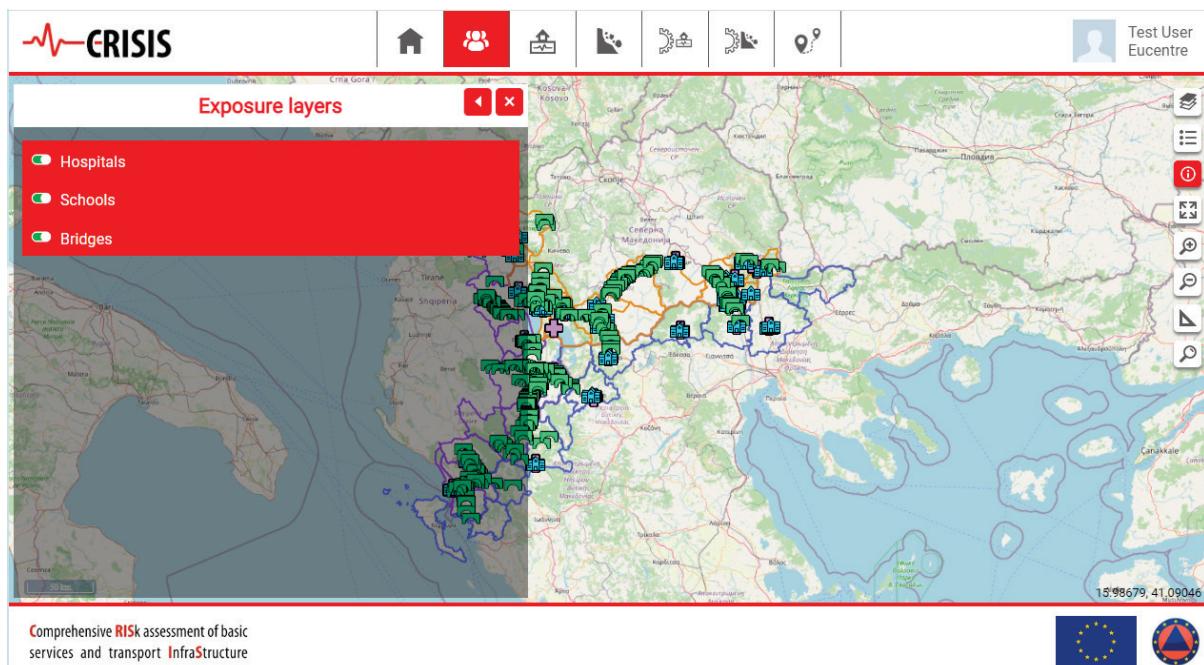


Figure 2.2: Layers’ activation.

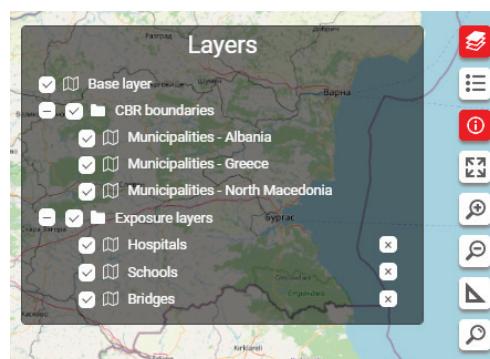


Figure 2.3: List of activated layers in the “Layers” panel.

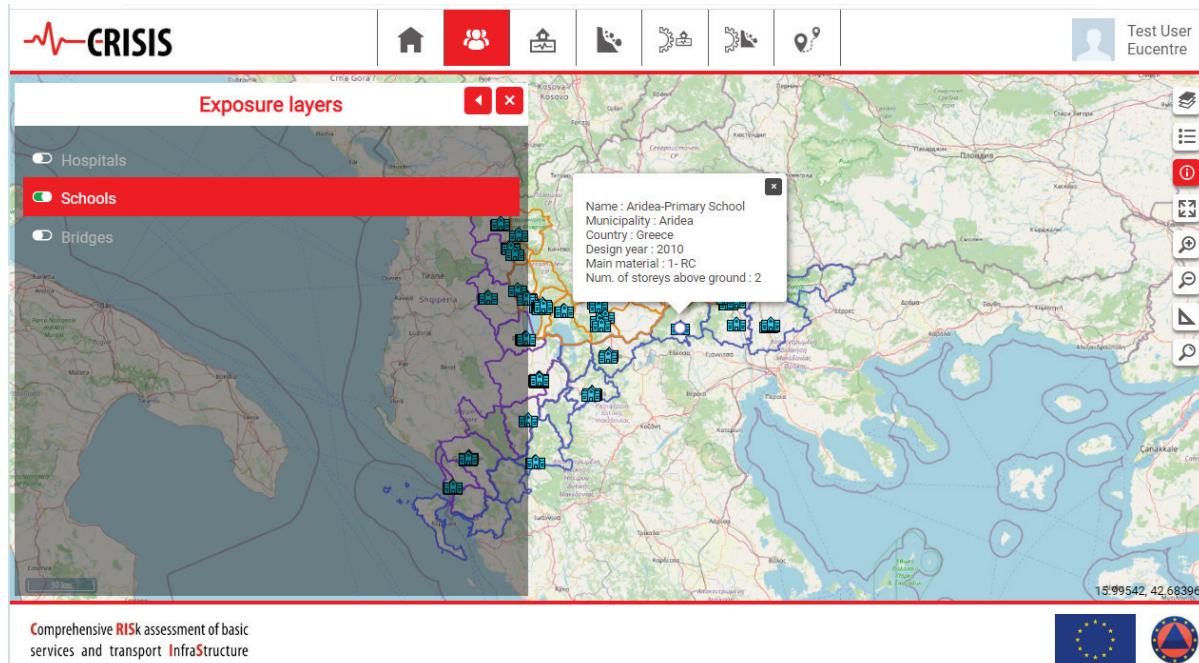


Figure 2.4: Selection of an item and display of the corresponding information available in the database.

## 2.2 Seismic hazard

After clicking on the corresponding icon (see Table 2.1), a pop-up tab opens on the left side of the web tool collecting the following layers (Figure 2.5):

- PGA-RT=102 years;
- PGA-RT=475 years;
- PGA-RT=975 years;
- Vs30.

In the platform, the seismic hazard maps for Peak Ground Acceleration (PGA) refer to three return periods (RT), i.e., 102 years, 475 years, and 975 years, and are derived from the *European Seismic Hazard Model* (ESHM13; [www.share-eu.org](http://www.share-eu.org); Giardini et al., 2014). Instead, Vs30 is the *Shear wave velocity in the top 30 m of soil* and is expressed in m/s. It allows for site effects to be considered and is derived from the VS30 map proposed by the *United States Geological Survey* (USGS, [earthquake.usgs.gov/data/vs30](http://earthquake.usgs.gov/data/vs30)).

Figure 2.6-a and Figure 2.6-b show the layers' activation of the seismic hazard map for a return period equal to 475 years and the VS30 map, respectively. Both figures have corresponding legends as an example.

Once a layer is activated, the user can click on the map and get information about the value of PGA or VS30 (depending on the displayed map) around the clicked point, as reported in Figure 2.7.

Lastly, when one or more layers are activated in this tab, they also appear in the "Layers" panel, from where they can be disabled by deselecting or deleting them. When they are deleted, the same layers are also disabled in the "Seismic Hazard" tab.

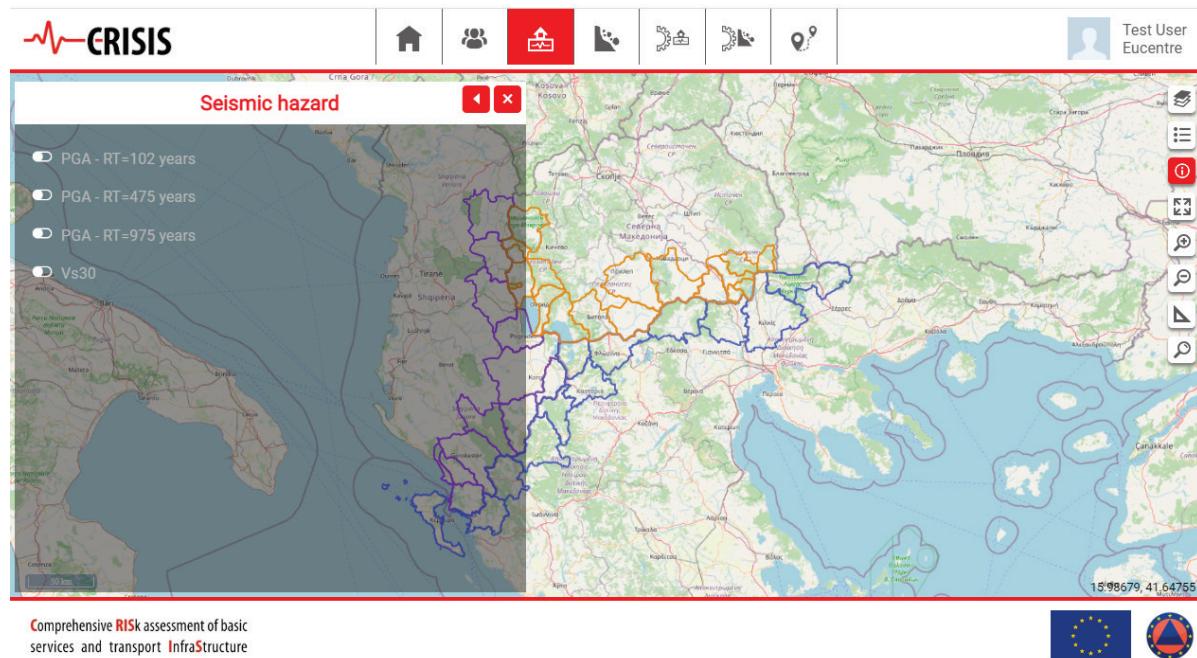
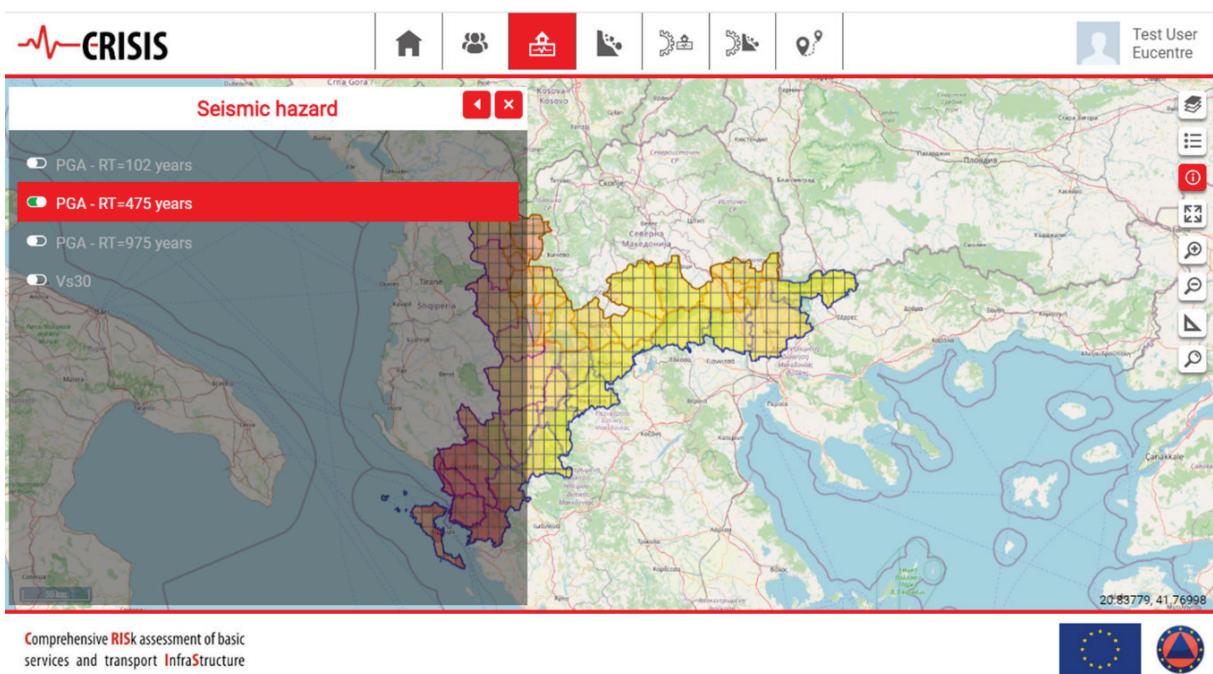
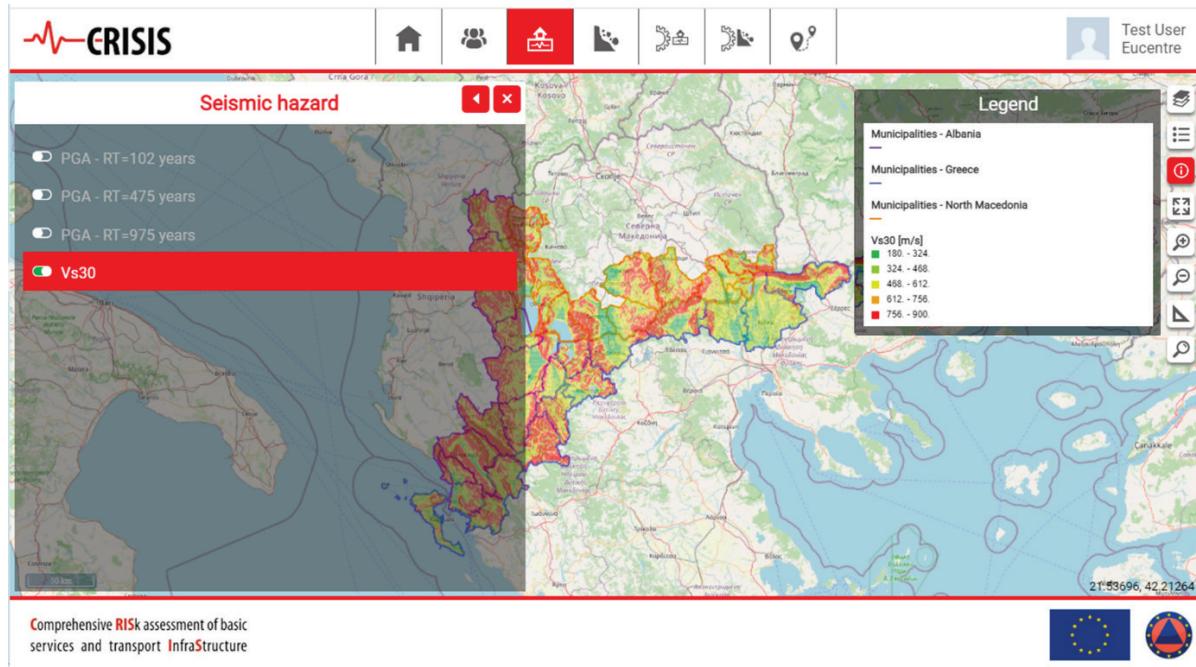


Figure 2.5: “Seismic hazard” tab.



(a)



(b)

Figure 2.6: Layers' activation of the (a) Seismic hazard map for RT=475 years and (b) the VS30 map.

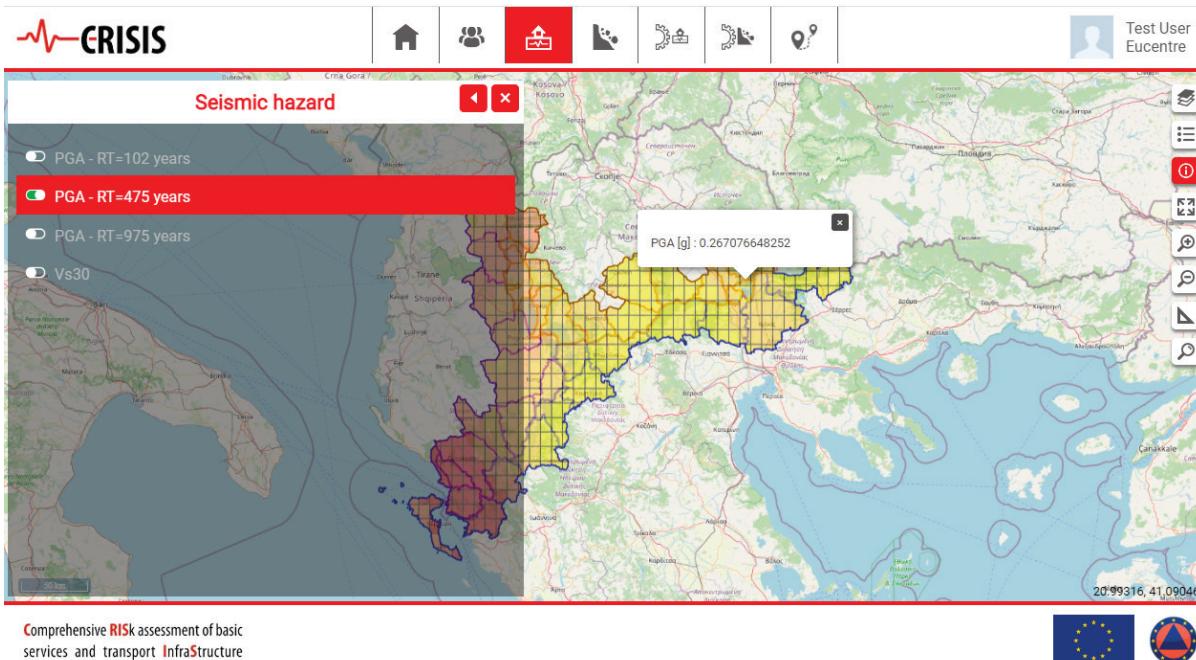


Figure 2.7: Value of PGA in the surroundings of the clicked point in the seismic hazard map for RT=475 years.

## 2.3 Landslide hazard

After clicking on the corresponding icon (see Table 2.1), a pop-up tab opens on the left side of the web tool collecting the layers of the following maps related to the landslide hazard of the cross-border region (see Figure 2.8):

- Lithology;
- Landslides susceptibility;
- Landslide critical acceleration;

- PGA at surface - RT=475 years;
- PGA at surface - RT=975 years;
- PGD - RT=475 years;
- PGD - RT =975 years.

The lithology and the landslide susceptibility maps of the cross-border region of Greece, North Macedonia, and Albania is based on the *Pan-European Landslide Susceptibility Map version 2* (ELSUS v2, Wilde et al., 2018).

The landslide critical acceleration values are based on ELSUS v2 (Wilde et al., 2018) and are the result of engineering judgement. The suggested critical acceleration values are in line with the ones proposed in the HAZUS methodology for landslide hazard evaluation (NIBS, 2004; Pitilakis et al., 2009).

The Peak Ground Acceleration (PGA) surface maps for RT=475 years and RT=975 years are derived from the ESHM13 hazard maps (Giardini et al, 2014), considering the soil factor based on the V30 map proposed by USGS (<https://earthquake.usgs.gov/data/vs30/>).

The Permanent Ground Displacement (PGD) maps for RT=475 years and RT=975 years are, instead, derived from an analytical relationship proposed by Fotopoulou& Pitilakis (2015):

$$\ln(\text{PGD}) = -2.965 + 20217 \times \ln(\text{PGA}) - 6.583 \times k_y + 0.535 \times M \pm \varepsilon \times 0.72$$

where:

- PGA is the peak ground acceleration at the ground surface in g;
- $k_y$  is the yield or critical acceleration ratio/g;
- M is the earthquake magnitude, i.e.: M=6 (RT=475 years) and M=7 (RT=975 years);
- $\varepsilon$  is the standard normal variant with zero mean and unit standard deviation.

Figure 2.9 shows the landslides susceptibility map and the PGD map for RT=475 years with the corresponding "Legend" panel as an example.

Once a layer is activated, the user can click on the map and get information about the surrounding of the clicked point, as reported in Figure 2.10.

Lastly, when one or more layers are activated in this tab, they also appear in the "Layers" panel, from where they can be disabled by deselecting or deleting them. When they are deleted, the same layers are also disabled in the "Landslide Hazard" tab.

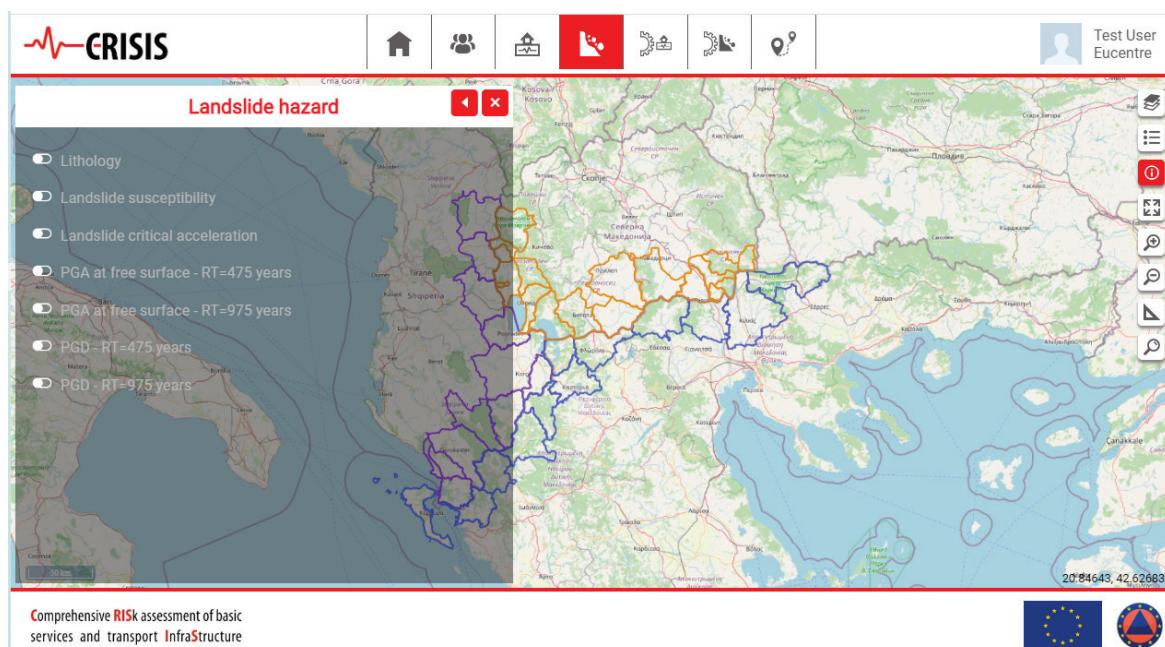
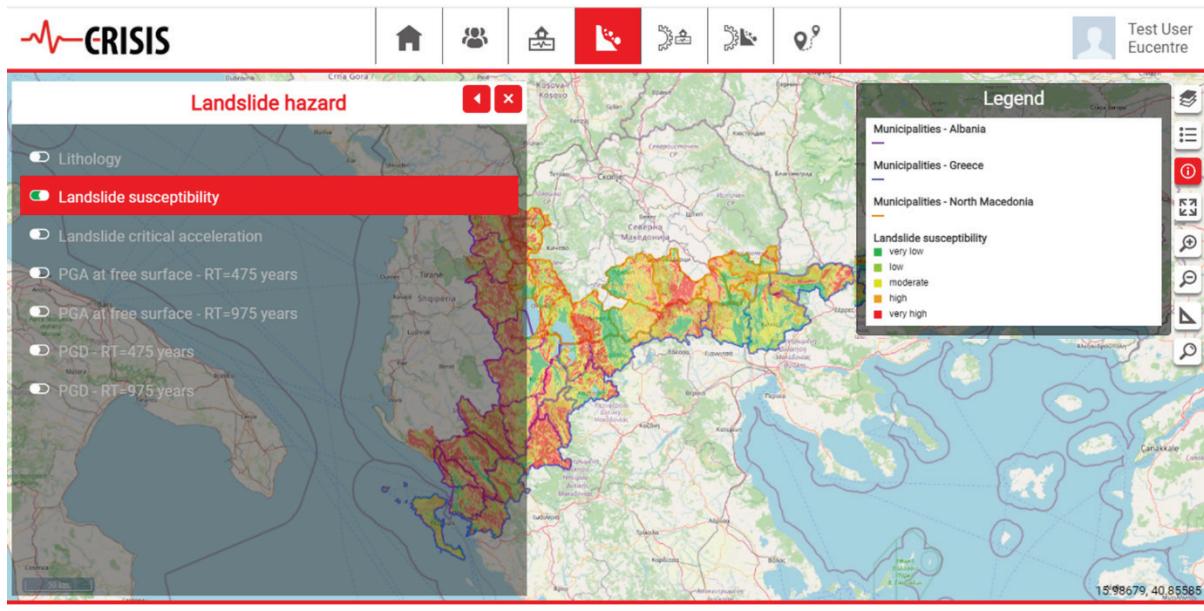


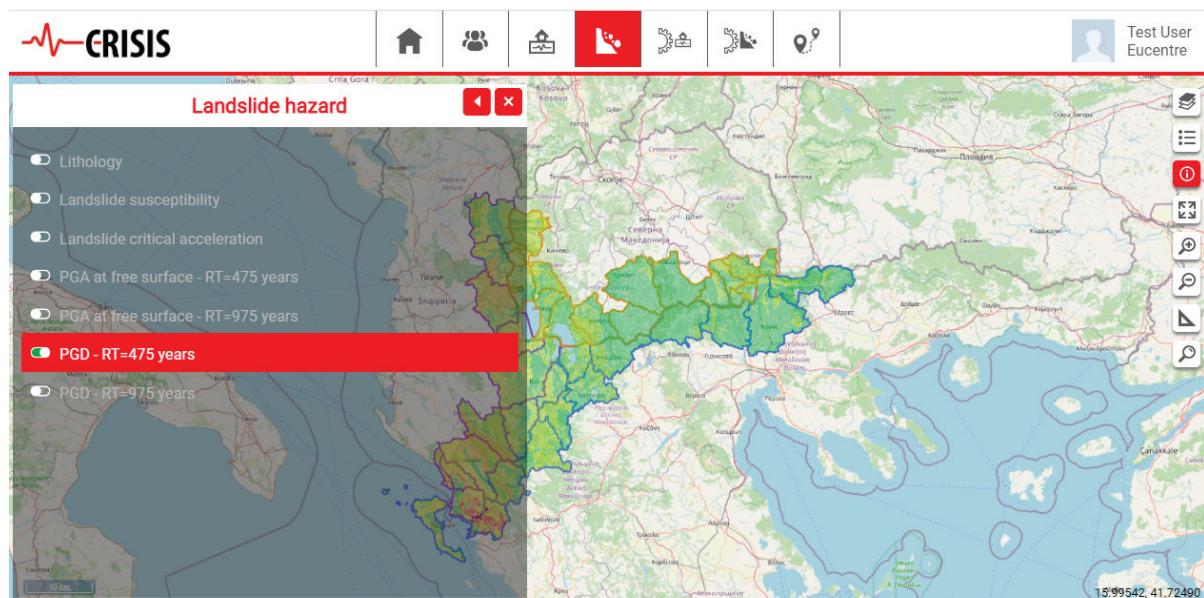
Figure 2.8: "Landslide hazard" tab.



Comprehensive RISK assessment of basic services and transport InfraStructure



(a)



Comprehensive RISK assessment of basic services and transport InfraStructure



(b)

Figure 2.9: Layers' activation of the (a) Landslide susceptibility map and (b) the Landslide hazard map for RT=475 years.

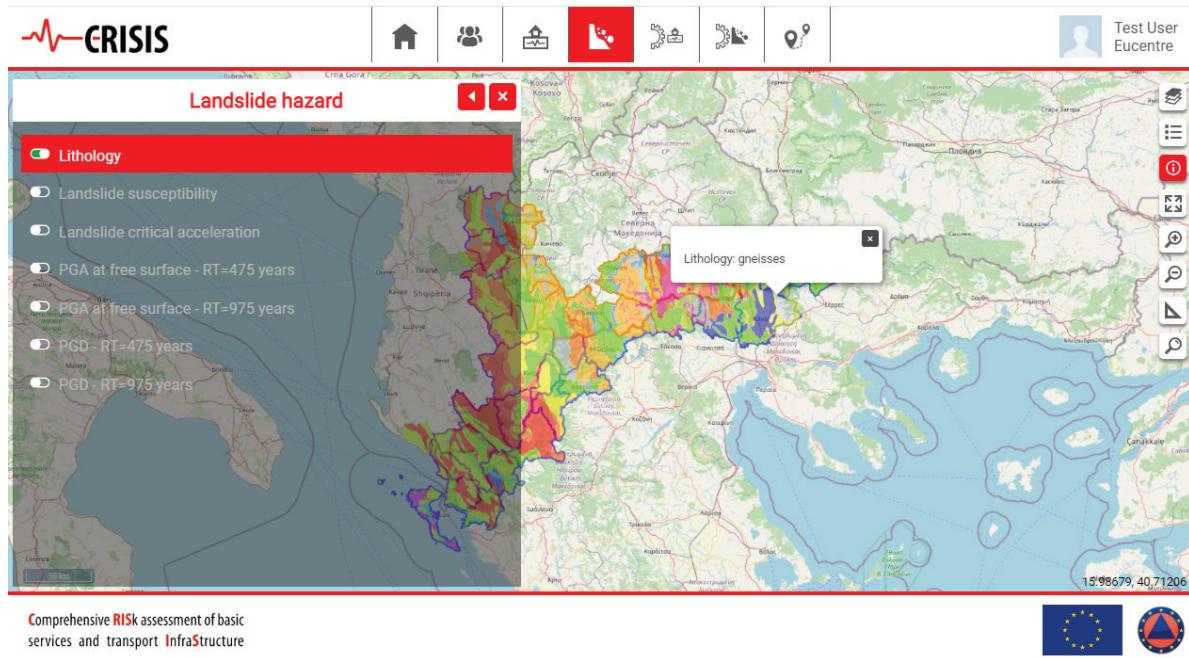


Figure 2.10: Type of soil in the surroundings of the clicked point.

## 2.4 Earthquake scenario

The "Earthquake scenario" tab (see Figure 2.11) consists of three different sections:

- Historical scenarios;
- Real-time scenarios – Event input data;
- Calculated real-time scenarios.

The “Historical scenario” section contains a table with the eleven most important historical events, and their respective characteristics (i.e. magnitude, epicentre depth/longitude/latitude, type of fault, and date), that affected the cross-border region.

For each of these events, the scenario damage assessment has been performed using the Scenario Damage Calculator of the OpenQuake Engine (Silva et al., 2014) and the ground motion prediction equation (GMPE) by Kotha et al. (2020). In this GMPE the site amplification follows the formulation established by Weatherill et al. (2020).

By selecting one of the events in the table, the layers corresponding to the five damage levels appear below the table while the epicentre is displayed on the map (see Figure 2.12). By activating one or more layers referring to the damage levels, the corresponding calculated damage scenario is uploaded on the map. As can be seen from Figure 2.13, all items considered in the cross-border region take on a different colouring, depending on the probability of reaching the selected damage level. The probability ranges associated with each colour are reported in the “Legend” tab (Figure 2.14-a). If the user wishes to know the probability of reaching the activated damage layer for a specific element, he needs to simply click on it and a label with the required information will appear on the map, as shown in Figure 2.14-b.

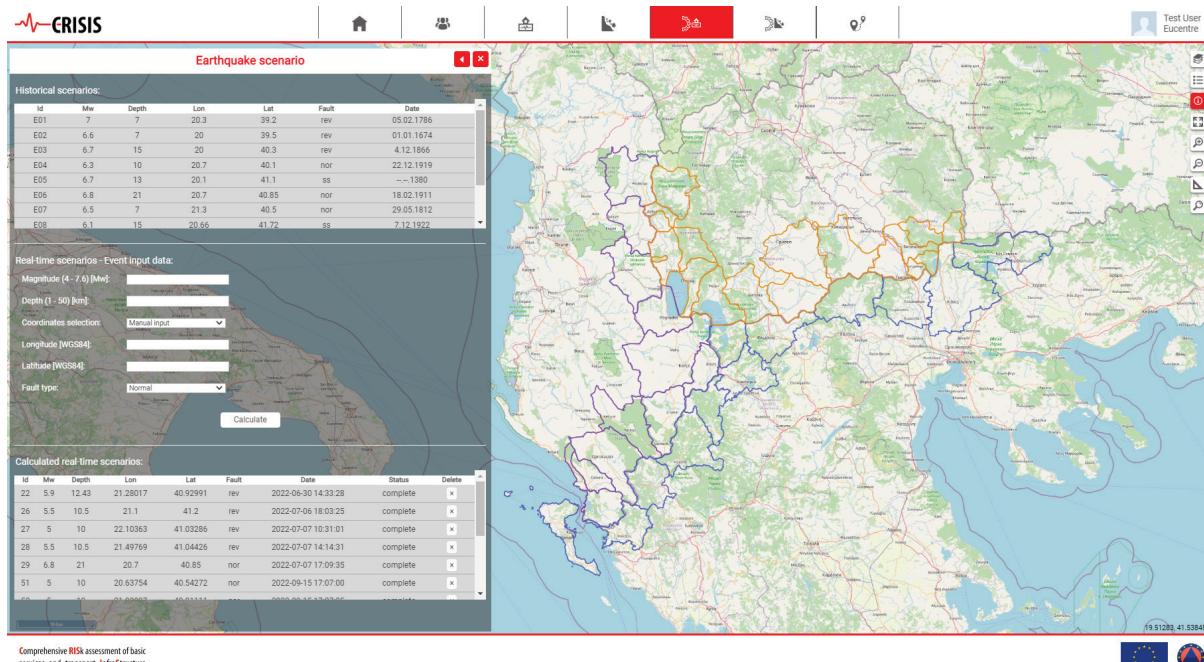


Figure 2.11: “Earthquake scenario” tab.

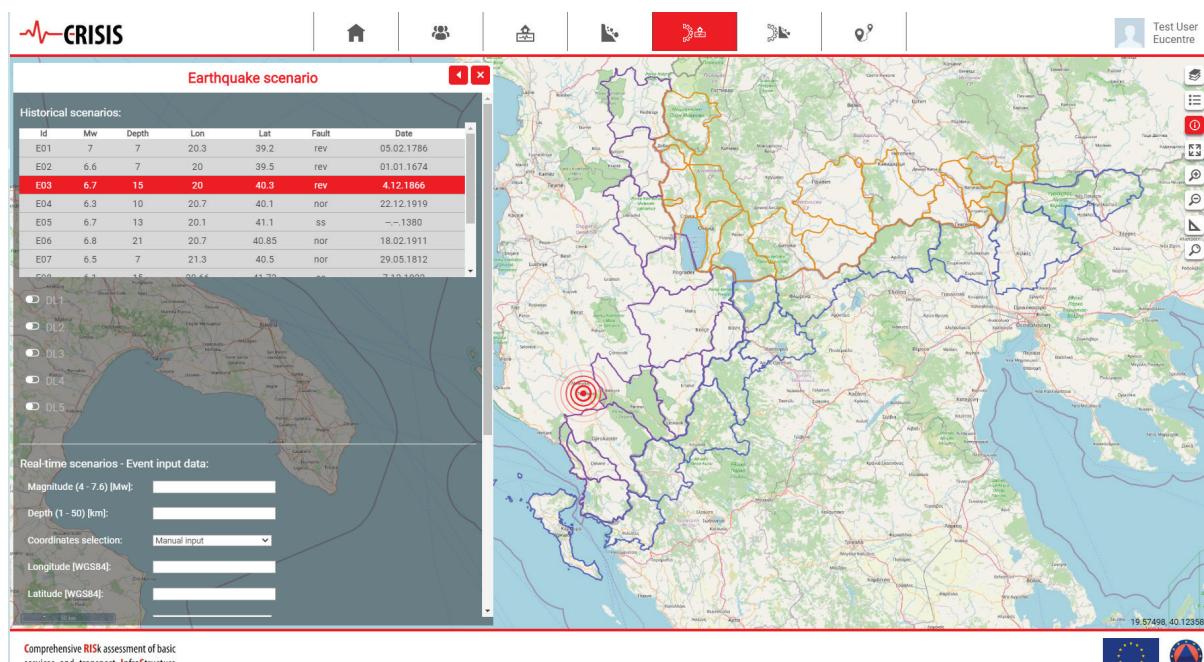


Figure 2.12: “Historical scenarios” section: event selection and consequent display of activatable layers.

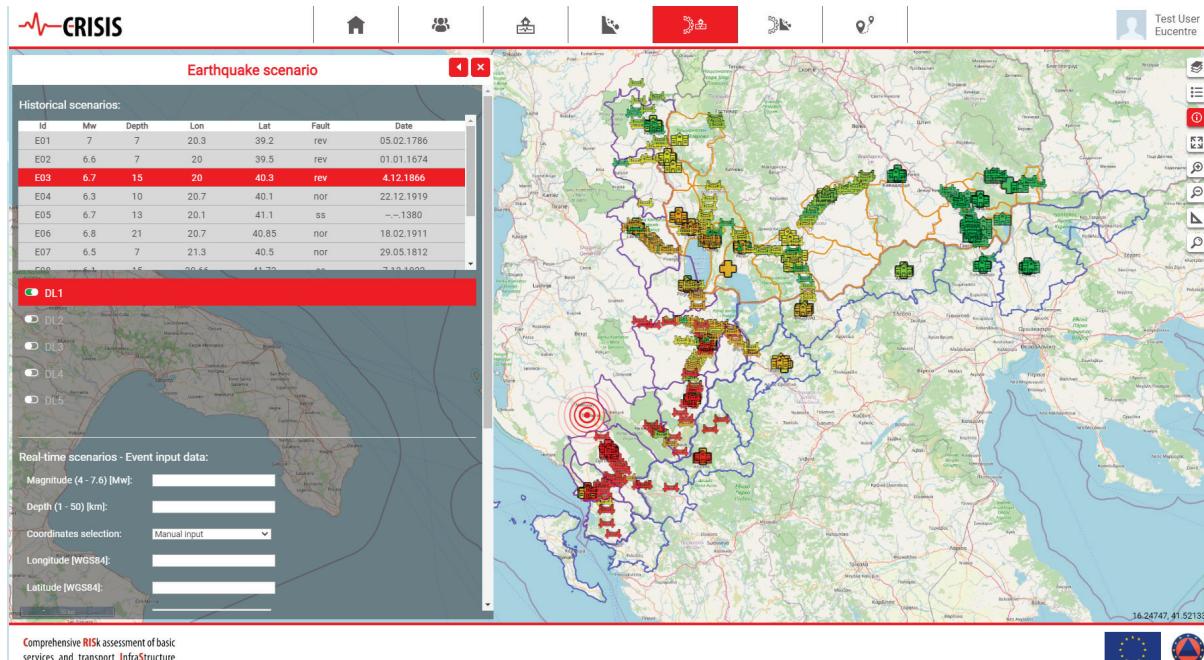
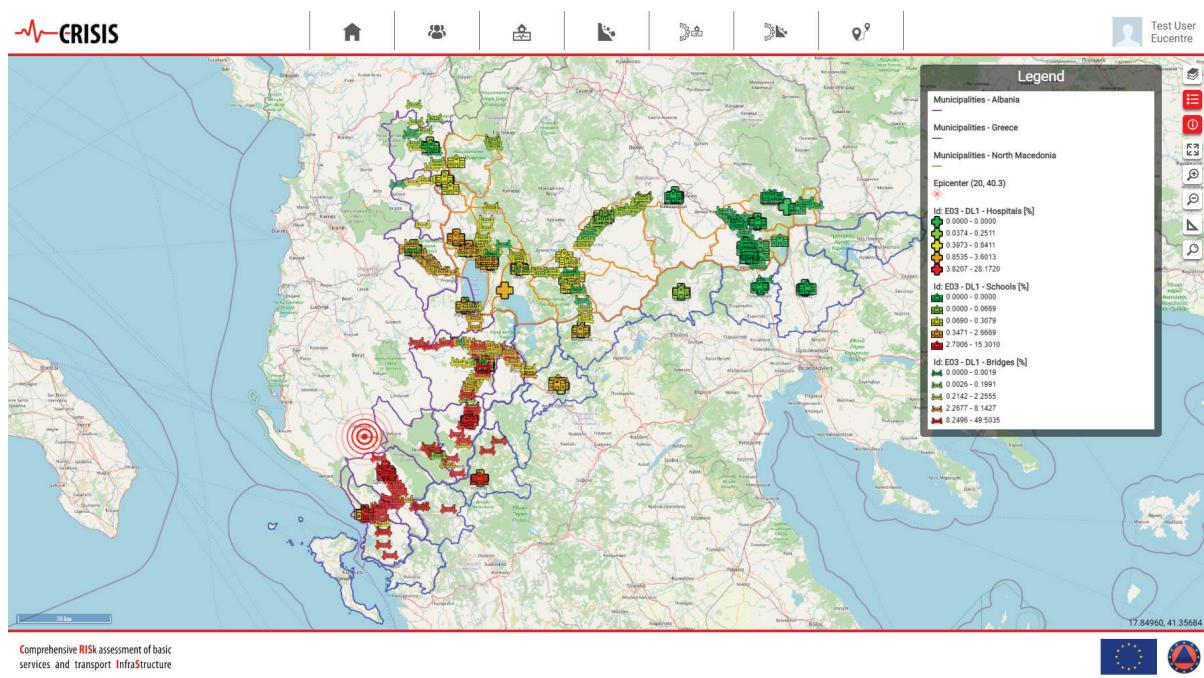
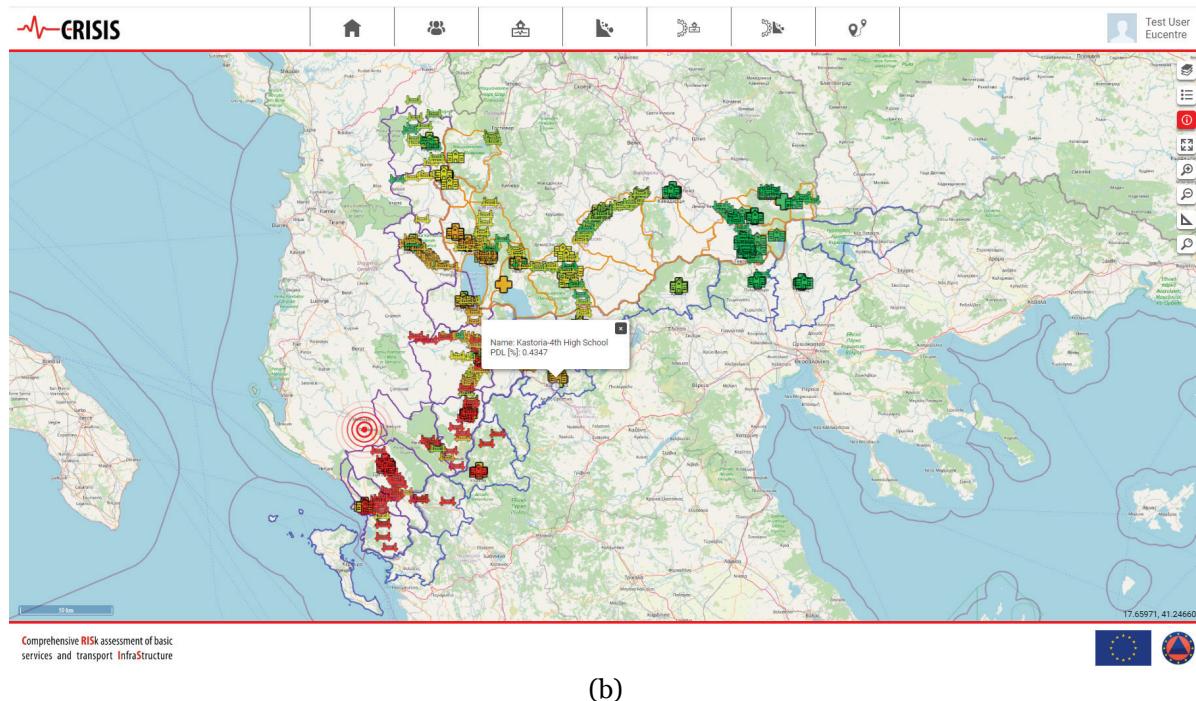


Figure 2.13: “Historical scenarios” section: selection of a damage level and related damage scenario.



(a)



(b)

Figure 2.14: “Historical scenarios” section: (a) legend associated with the damage scenario referring to the activated damage level and corresponding probability ranges associated with each colour and (b) probability of a specific element to reach the considered damage level.

In the “Real-time scenarios – Event input data” section the user can perform a real-time damage scenario, once provided the following information (see Figure 2.15-a):

- Magnitude (Mw). The damage scenario calculation works for  $4 \leq Mw \leq 7.6$ .
- Depth of the epicentre (D). The damage scenario calculation works for  $1 \text{ km} \leq D \leq 50 \text{ km}$ .
- Coordinates of the epicentre. The epicentre can be located by entering its geographical coordinates, expressed according to the WGS84 system, or by positioning it directly on the map. In the first case, after selecting *Manual input* in the “Coordinates selection” field, the user has to fill in the “Longitude” and “Latitude” fields. Instead, to place the epicentre directly on the map, the user needs to choose *Select on map* in the “Coordinates selection” field and click on the “Select on map” button. Once the position of the epicentre is defined on the map, its longitude and latitude will appear in the corresponding fields below.
- Fault type. The fault type can be defined in the drop-down menu, by choosing among *Normal*, *Reverse*, and *Lateral Strike-Slip*.

After clicking on the “Calculate” button, the calculation of the scenario is launched. Simultaneously the launched scenario is loaded into the “Calculated real-time scenarios” table, where it is also possible to check the status of the calculation (see Figure 2.15-b). Once the calculation is complete and the scenario has been selected, the damage level layers appear below the table. By activating one or more layers referring to the damage levels, the corresponding calculated damage scenario is uploaded on the map (see Figure 2.15-c).

The real-time damage scenarios are calculated by using the GMPE of Akkar et al. (2014) and site amplification according to the V30 map proposed by the USGS. (<https://earthquake.usgs.gov/data/vs30/>).

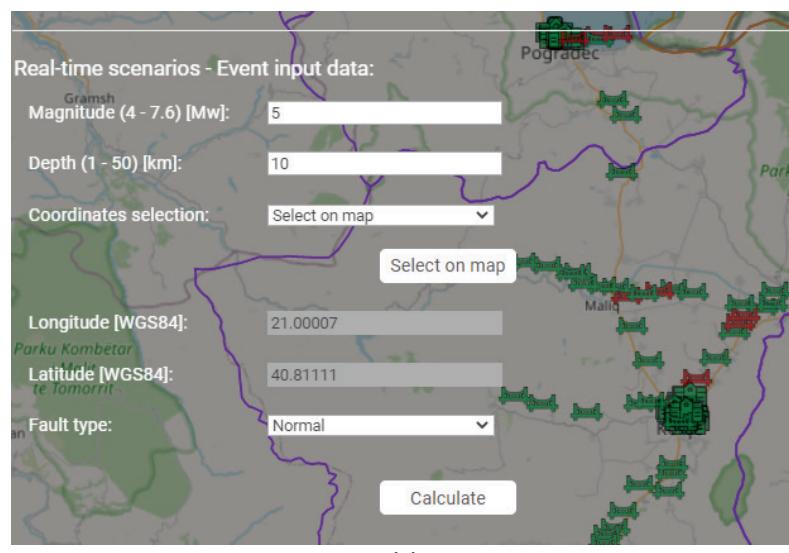
Whereas five damage levels have been considered for school and hospital buildings according to the EMS98 scale (Grüntal, 1998), for bridges we have only considered two damage levels, i.e. slight damage and collapse. For this reason, in both the historical damage scenarios and

those calculated in real-time, bridges are only displayed when the layers corresponding to damage levels DL1 and DL5 are activated.

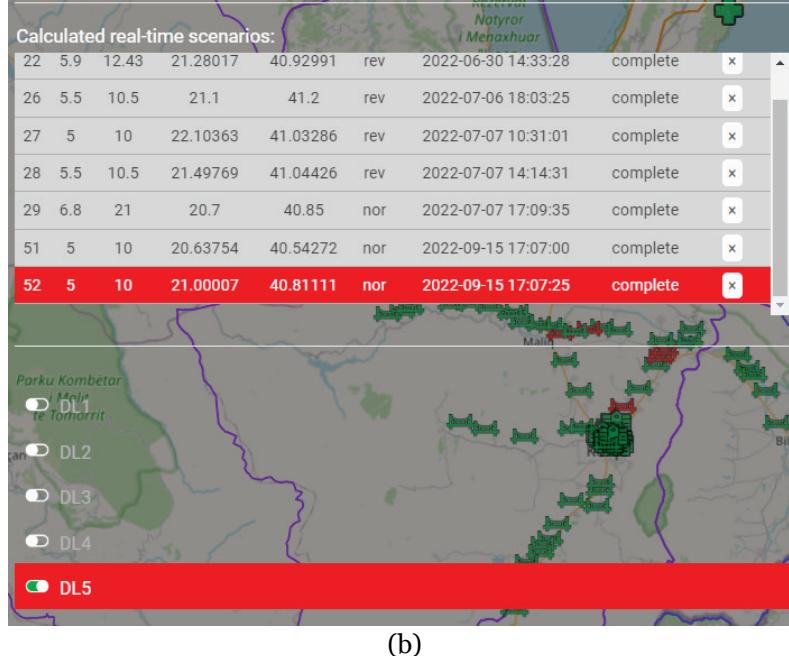
Furthermore, contrary to the damage scenarios of historical events, the damage scenarios calculated in real-time include only those elements in the exposure database for which the PGA takes a value greater than 1%g.

About the legend, the probability ranges with which it is defined for each damage scenario vary from time to time and are based on the minimum and maximum probability values of reaching a certain damage level resulting from the scenario calculation.

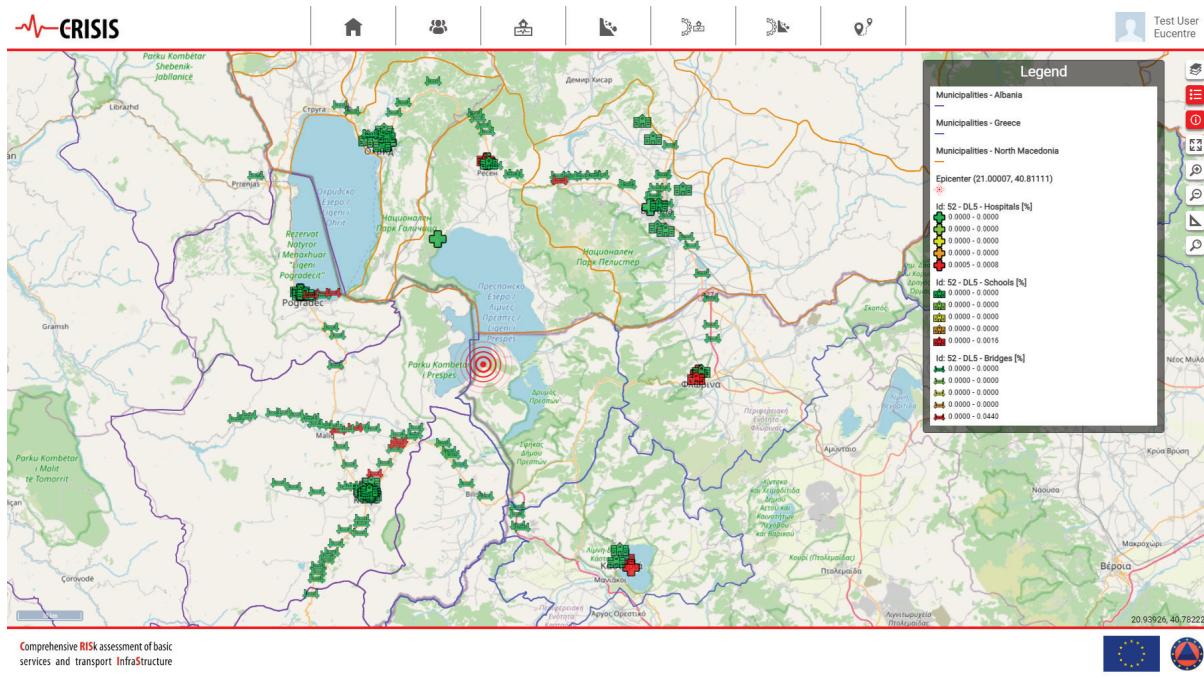
Lastly, when one or more layers are activated in this tab, they also appear in the "Layers" panel, from where they can be disabled by deselecting or deleting them. When they are deleted, the same layers are also disabled in the "Earthquake scenario" tab.



(a)



(b)



(c)

Figure 2.15: (a) Input data for the calculation of the real-time damage scenario, (b) selection of the real-time damage scenario in the “Real-time calculated scenario” and consequent activation of one or more layers of damage levels, and (c) real-time damage scenario associated with the selected damage level and its legend.

## 2.5 Landslide risk scenario

After clicking on the corresponding icon (see Table 2.1), a pop-up tab opens on the left side of the web tool collecting the layers of the landslide risk maps for (see Figure 2.16):

- Hospitals;
- Schools;
- Bridges – Slight damage (PGD – RT = 475 years);
- Bridges – Collapse (PGD – RT = 475 years);
- Bridges – Slight damage (PGD – RT = 975 years);
- Bridges – Collapse (PGD – RT = 975 years).

The landslide risk for buildings (schools and hospitals) has been defined according to a semi-quantitative procedure fully implemented in a GIS environment based on Arnaouti et al. (2013). Figure 2.17 shows the landslide risk scenario for hospitals and its legend.

Instead, the landslide risk for bridges has been defined using the fragility curves due to ground failure proposed by HAZUS (NIBS, 2004) and considering seismic events triggering landslides with return periods (RT) equal to 475 and 975 years, respectively. The landslide risk has not been calculated for all the bridges in the exposure database but for a part of them, selected based on their position and importance in terms of cross-border connection (see Table 2.2). In addition, the legend associated with each of the landslide risk scenario maps for bridges is defined based on the minimum and maximum values of the probability of reaching a given damage level resulting from the calculation.

Figure 2.18 shows the landslide risk scenario for bridges, considering collapse as the damage level and a seismic event triggering the landslide with a return period equal to 475 years. Figure 2.18 also reports the legend associated with the scenario.

Lastly, when one or more layers are activated in this tab, they also appear in the "Layers" panel, from where they can be disabled by deselecting or deleting them. When they are deleted, the same layers are also disabled in the "Landslide risk scenario" tab.

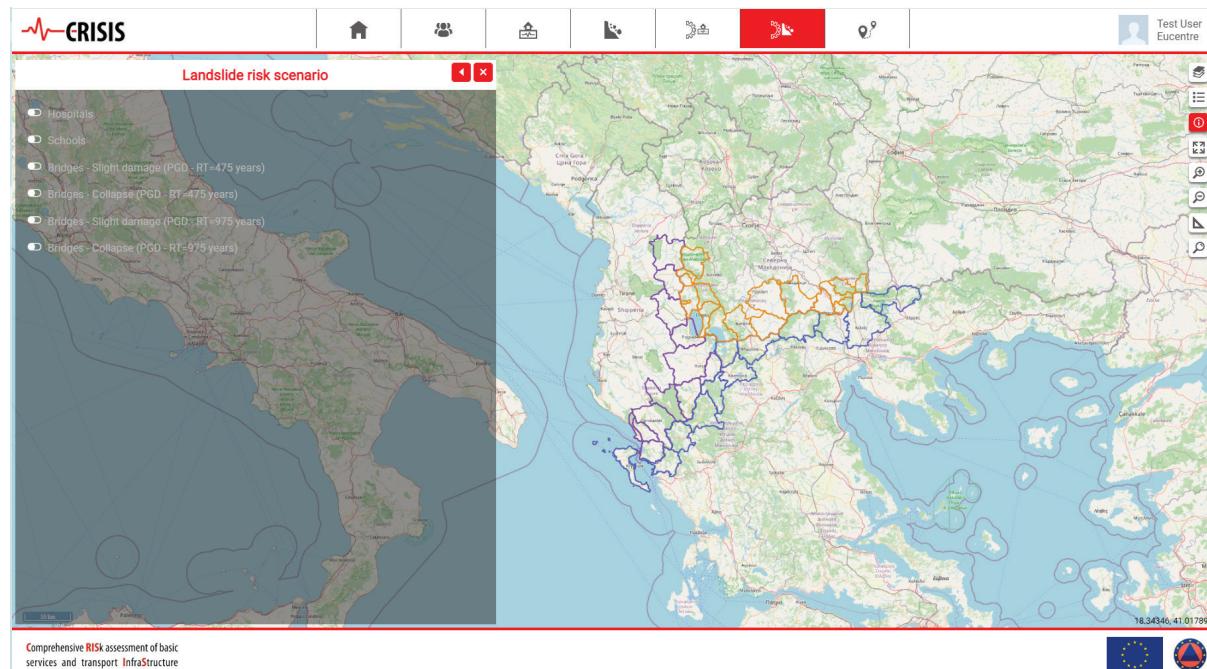


Figure 2.16: "Landslide risk scenario" tab.

Table 2.2: Selected bridges for the landslide risk scenario.

	Name	Bridge_id	middle_point_coor_lat	middle_point_coor_lon	hazus_c	Total len	Total Width	No. of spans
Greece	Telonio Kakavia -1	M1	39.910496	20.365309	HWB3	15	9	1
	Gefira Agion - Potamos Gormos	M3	39.896614	20.543840	HWB19	150	9	5
	Sarantaporos - Spiliotopoulou	M4	40.187189	20.800897	HWB2	210	9	6
	Aetomilitsa	M5	40.236049	20.872800	HWB19	100	7	3
	Telonio Evzoni -1	M6	41.101861	22.566405	HWB3	10	7	1
	Krystallopigi-1	M9	40.5933019	21.0656523	HWB3	12	8	1
Albania	Ura Kardhiqit	56	40.1499165	20.09437648	HWB7	265.2	13.5	5
	Ura e Librazhdit	152	41.1805822	20.31138717	HWB7	177	12.4	5
	Ura ne km96.160(Quksi Nr.2)	1088	41.0866608	20.4511677	HWB7	110	12.5	5
	Ura e re Gajdarit	1122	39.8798866	20.03356079	HBW14	105	11.9	3
	Ura e Bushtrices	1086	41.0992568	20.44275731	HWB7	104.4	12.5	5
	Ura Kserija	1100	39.9069196	20.34127546	HWB7	90	9	5
	Ura Murashi Nr.2	1075	41.1820179	20.2736929	HWB7	83.2	9.9	4
	Ura Hotolish(paralel me h/udhen)	1079	41.1361514	20.39424415	HWB7	82.1	9.5	7
	Ura e re e Bogazit	1121	39.7170602	20.12438563	HWB7	81.9	12.5	
	Ura e Trenit	1107	40.655051	20.95470935	HWB7	80	11.5	3
	Ura e Petranit	860	40.2080571	20.41515408	HWB6	76	4.5	4
	Ura e Libonikut 2	1109	40.7106919	20.71241959	HWB7	75	13.5	3
	Ura e Cerenecit	255	41.520873	20.4179533	HWB6	71.4	6	4
	Ure mbikalim Bulqize	253	41.4992077	20.21479712	HBW11	24.5	13	2
N. Macedonia	Struga	40776392	41.1835	20.6783	HWB3	30	10.6	1
	Bitola -Medjiti	188469300	40.9699	21.3958	HWB3	7.1	8.2	1
	Ohrid	194459404	41.1306	20.818	HWB9	24.3	8.2	2
	Bitola	225073520	41.07	21.1428	HWB10	81.1	13.6	4
	Gevgelija - Bogorodica -1	334632006	41.1486	22.5238	HWB2	235.8	13.6	10
	Gevgelija - Bogorodica -2	433067008	41.3405	22.3733	HWB2	504.9	13.6	12
	Mavrovo i Rostusha	900000044	41.72013	20.82931	HWB22	107.8	9.65	5
	Debar- Blato	900000202	41.52202	20.56653	HWB9	70	8.2	2

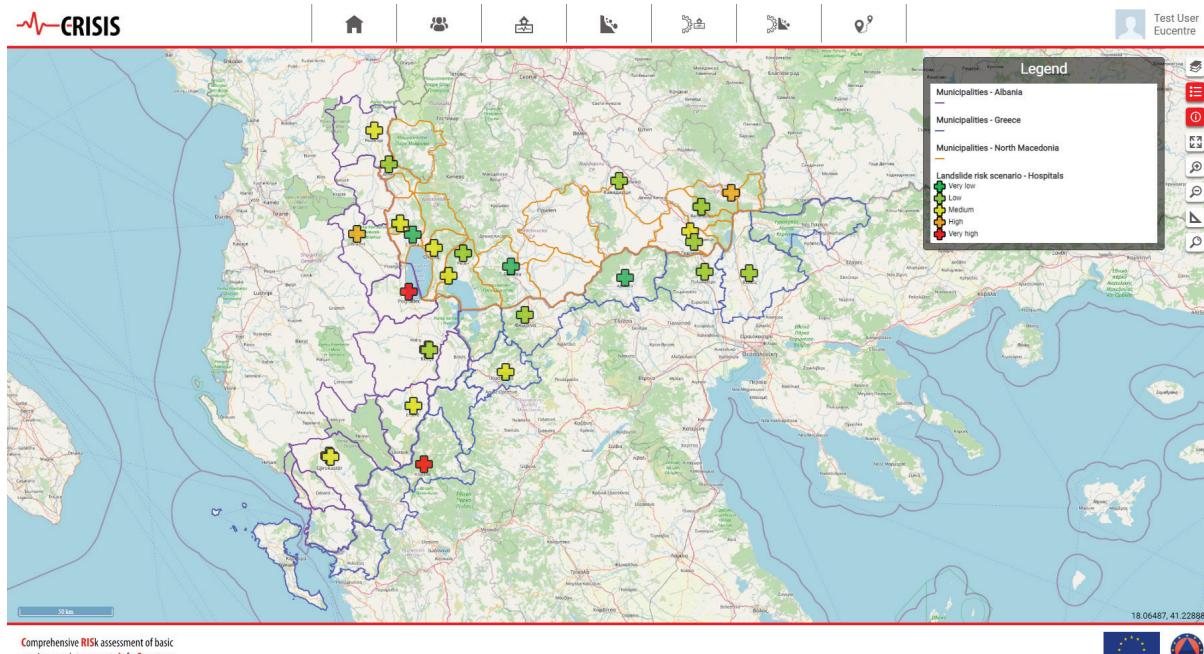


Figure 2.17: Landslide risk scenario for hospitals and its legend.

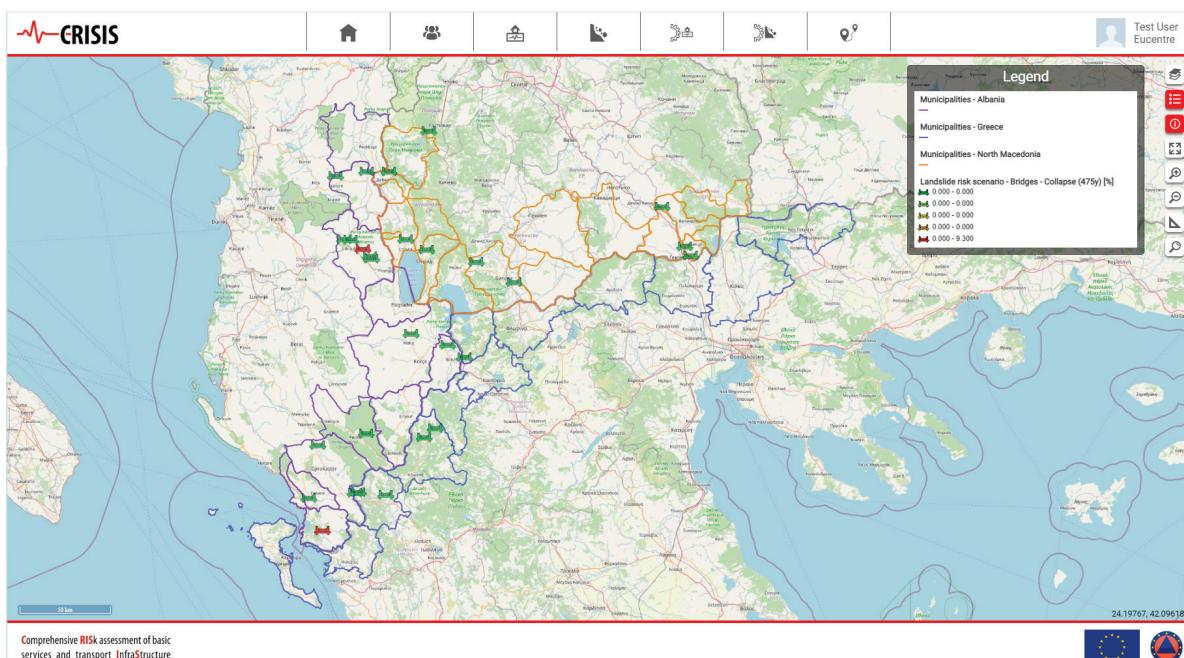


Figure 2.18: Landslide risk scenario for bridges, considering collapse as damage level and a seismic event triggering the landslide with RT= 475 years. The figure also shows the legend associated with the scenario.

## 2.6 Routing

The "Routing" tab (see Figure 2.19) provides information on possible routes to take in case of emergency to avoid potentially unusable infrastructures (in this particular case, bridges) due to a seismic event.

The route is identified by defining its start and end points on the map through the "Add start point" and "Add destination point" buttons, respectively (see Figure 2.20-a). To check whether the route has damaged infrastructures due to a seismic event, a scenario previously calculated in the "Earthquake Scenario" tab has to be loaded at the "Scenario ID" field. Then, the "Create

route" button needs to be clicked. If there are no damaged bridges in the defined route, the system will return the fastest route to follow by rescue teams (see Figure 2.20-b). Otherwise, it will provide the shortest alternative route (see Figure 2.20-c).

All the layers activated in this tab also appear in the "Layers" panel, from where they can be disabled by deselecting or deleting them.

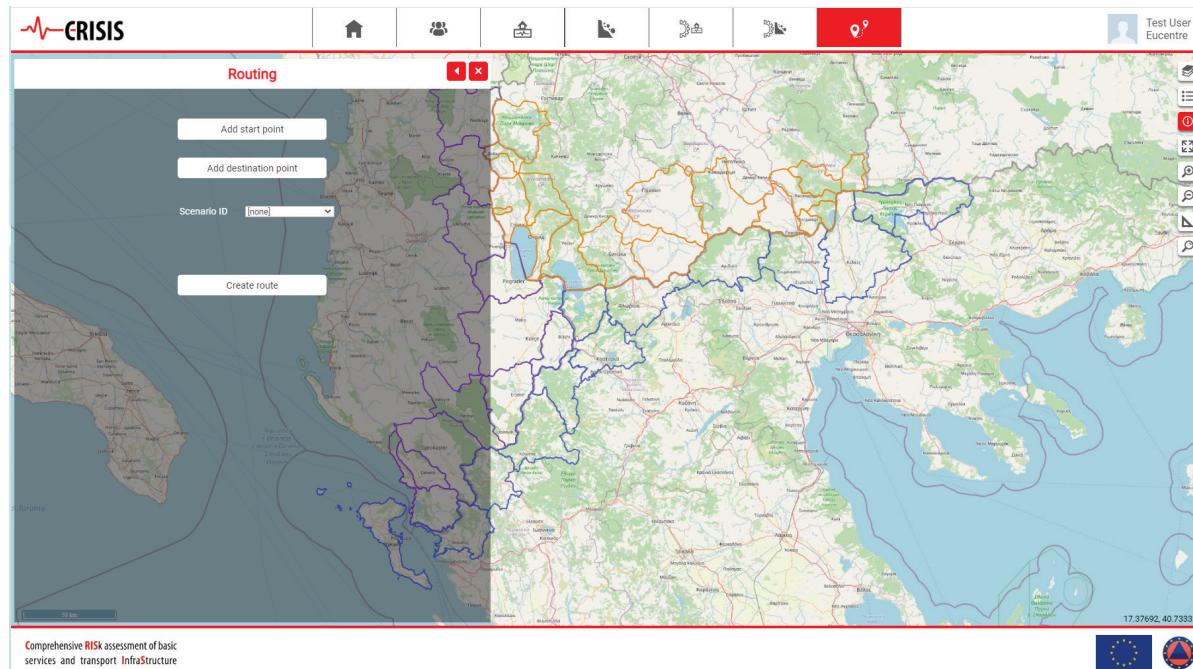
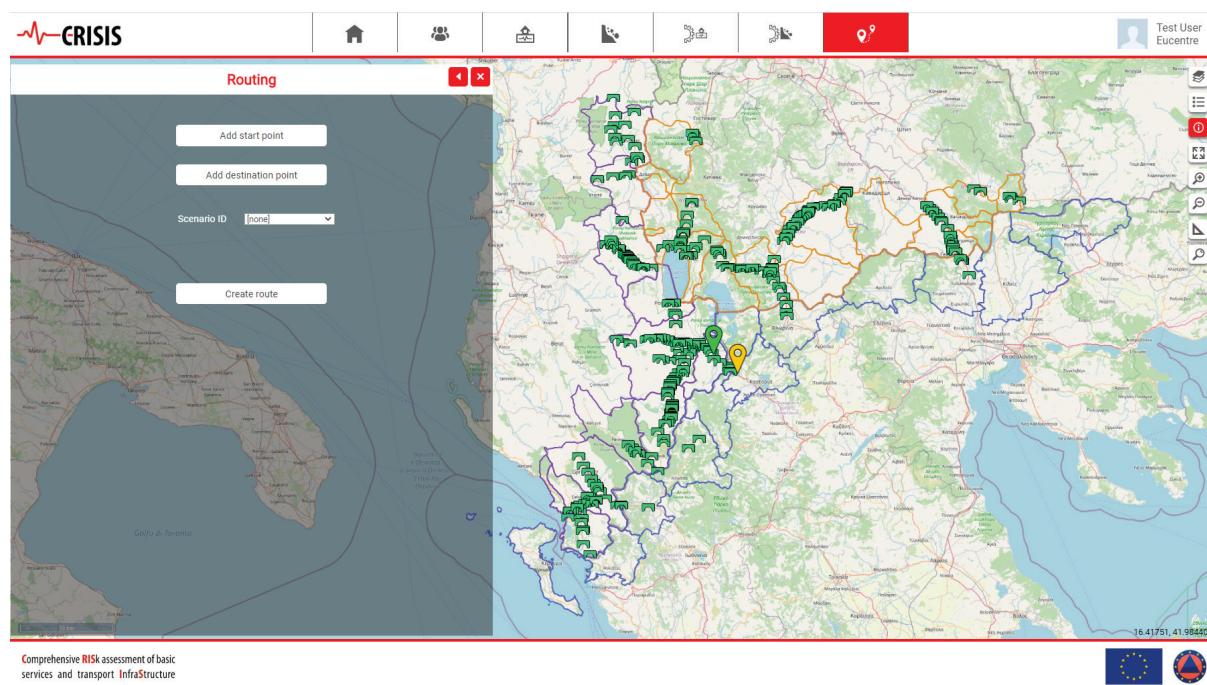


Figure 2.19: "Routing" tab.



(a)

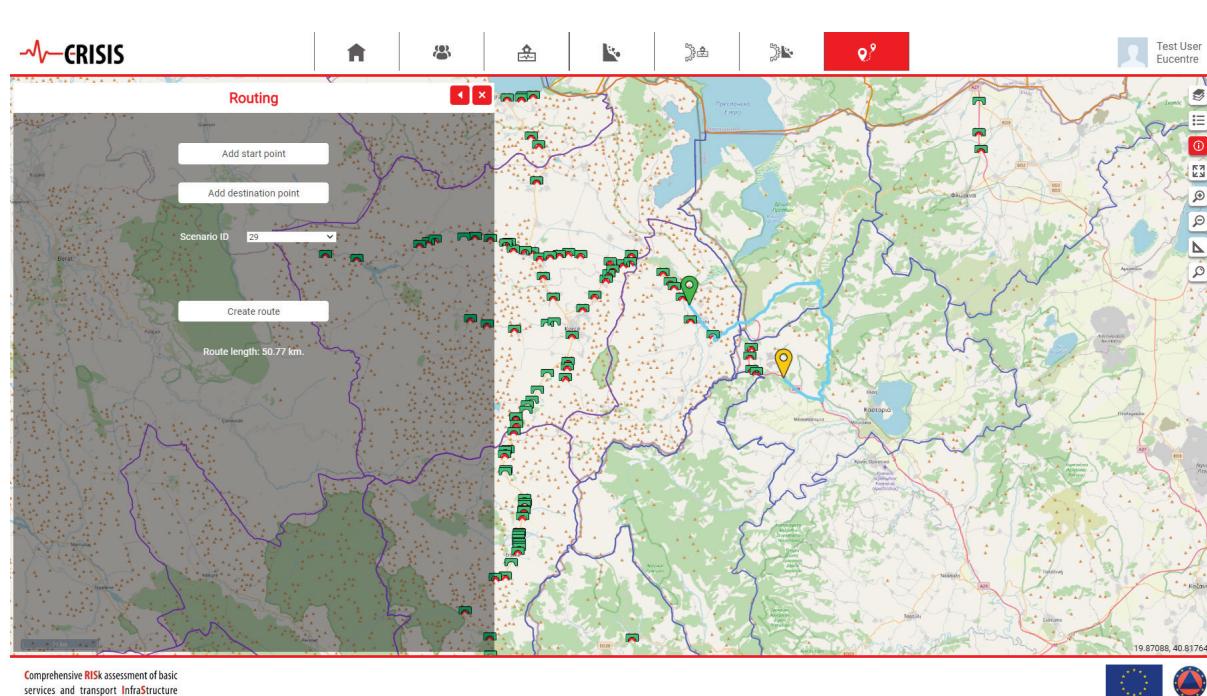
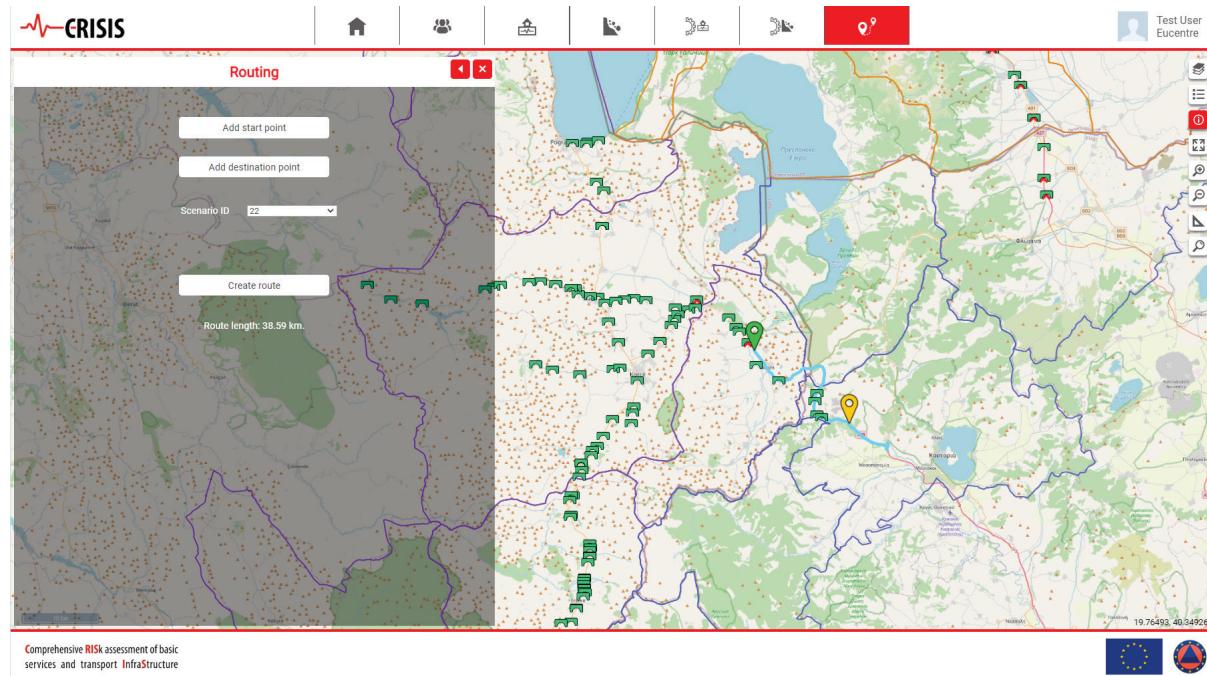


Figure 2.20: (a) Definition of the start and end points of a route on the map; (b) Identification of the shortest route between the start and end points identified on the map in case of no damaged bridges; (c) Identification of the shortest route between the start and end points identified on the map in case of damaged bridges due to a seismic event.

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