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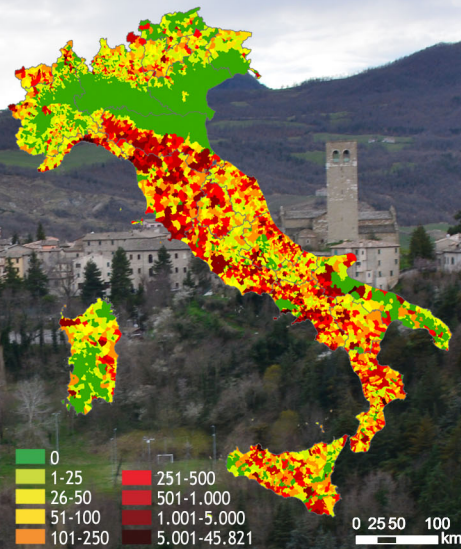


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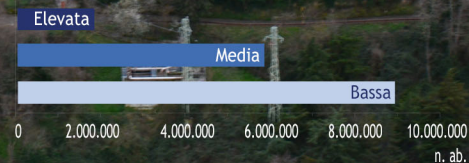
Landslides and floods in Italy: hazard and risk indicators

Summary Report 2018

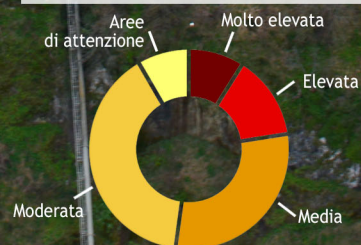
Popolazione a rischio frane
residente in aree a pericolosità da frana
elevata P3 e molto elevata P4 PAI (n. ab.)



Popolazione residente in aree a pericolosità idraulica



Popolazione residente in aree a pericolosità da frana PAI





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Landslides and floods in Italy: hazard and risk indicators

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INTRODUCTION

This document is a summary of the Report *Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio*. Ed. 2018. ISPRA, Rapporti 287/2018, in Italian (Trigila et al., 2018).

The 2018 edition of the Report, the second dedicated to this topic, provides an updated overview on landslide and flood hazard over the Italian territory. It contains risk indicators related to population, families, buildings, industry and services, and cultural heritage.

1. LANDSLIDES

Italy is one of the European countries most affected by landslides (Herrera et al., 2018; Spizzichino et al., 2013; Van Den Eeckhaut & Hervás, 2012), with **620,808 landslides**¹ affecting an area of **23,700 km²**, equal to **7.9%** of the national territory. These data derive from the **Italian Landslide Inventory**² (IFFI Project) realized by ISPRA and the Regions and Autonomous Provinces according to standardized and shared methods (Trigila & Iadanza, 2008; Trigila et al., 2010). The IFFI Inventory is the most complete and detailed landslide database in Italy, for the number of parameters and the 1:10,000 map scale. An overview on the landslide distribution in Italy can be obtained from the landslide density, equal to the ratio between the landslide area and the total area, calculated over a 1×1 km grid (Figure 1.1).

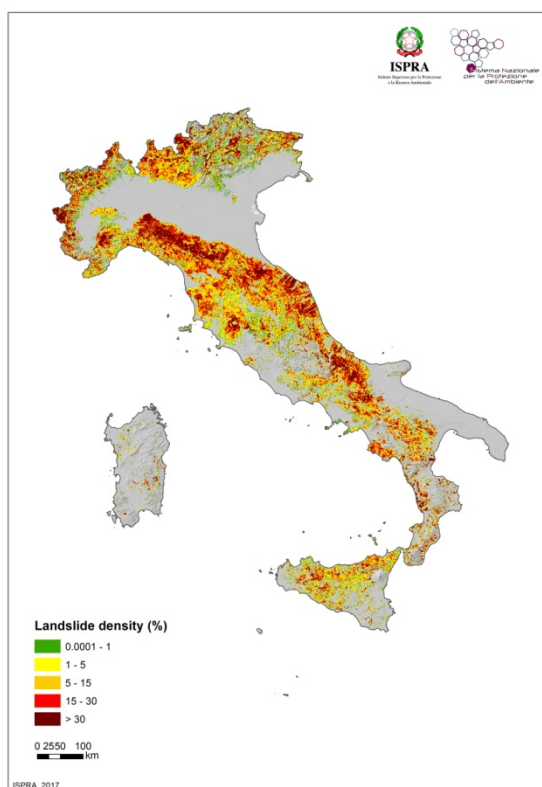


Figure 1.1 - Landslide density (ratio between landslide area and total area) calculated over a 1×1 km grid

About a third of Italian landslides are rapid phenomena (e.g. rockfall, mud and debris flows), characterized by high velocity, up to a few meters per second, and by high destructive power, often with serious consequences in terms of loss of human lives (Trigila et al., 2015a). Other types of movement (e.g. slow earth flows, complex landslides), characterized by moderate or slow velocity, can cause extensive damage to residential areas and transportation network. The most important triggering factors are short period intense rainfall, persistent precipitation and earthquakes.

Collecting information on landslides is a strategic activity considering that most landslides can be reactivated even after long periods of multi-year or multi-century inactivity (e.g. Corniglio landslide,

¹ Temporal coverage: 1116-2017

² <http://www.progettoiffi.isprambiente.it>

Emilia-Romagna Region: 1902, 1994-2000). The IFFI Inventory is an important tool for landslide hazard³ assessment of River Basin Plans (PAI), preliminary design of mitigation measures, infrastructures and civil protection emergency plans.

Every year a few thousand of landslides occur on the national territory and a few hundred of these cause victims, injured, evacuated people and damage to buildings, cultural heritage and primary transportation infrastructures (172 events in 2017, 146 events in 2016, etc.; ISPRA, *in press*).

1.1 National mosaic of landslide hazard zones

The landslide hazard zones of the River Basin Plans (PAI) include areas of possible evolution of existing landslides and areas where new landslides potentially may occur, in addition to occurred landslides. River Basin Plans⁴ represent a fundamental tool for a correct land use planning through the application of land use restrictions and regulations (e.g. prohibition of building construction in high and very high hazard zones). River Basin Plans are dynamic instruments that may be subject to change over time by the River Basin Authorities (now River Basin District Authorities), following new studies and surveys, new landslide and flood events, completion of mitigation measures or requests of local authorities.

In order to update the landslide hazard map on the entire national territory, in 2017 ISPRA realised the new National Mosaic⁵ of the hazard zones provided by the River Basin District Authorities. Similarly with the 2015 national mosaic⁶ (Trigila et al., 2015c), ISPRA harmonized the PAI legends in 5 classes: Very high hazard H4, High H3, Medium H2, Moderate H1 and Attention zones AA⁷.

The total area of landslide hazard zones and attention zones in Italy is **59,981 km²** (19.9% of the national territory) (Table 1.1). If we take into account the most hazardous classes (high H3 and very high H4), the area amounts to **25,410 km²**, equal to **8.4%** of the Italian territory (Table 1.2).

Table 1.1 – National mosaic of landslide hazard zones (River Basin Plans PAI)

Landslide hazard zones			
		km ²	% of national territory
H4	Very high	9,153	3.0%
H3	High	16,257	5.4%
H2	Medium	13,836	4.6%
H1	Moderate	13,953	4.6%
AA	Attention zones	6,782	2.2%
Total		59,981	19.9%

As you can see from Figure 1.2, there are significant mapping inhomogeneities, mainly due to the different methods used by the River Basin District Authorities for landslide hazard assessment (e.g. qualitative matrix method, geomorphologic method, statistical quantitative method or mixed-type approaches). The main differences are between hazard zone mapping that classified only the landslide polygons (e.g. Upper Adriatic Basins, Autonomous Province of Bolzano) and those that classified the entire territory (e.g. Valle d'Aosta Region, Autonomous Province of Trento, Arno Basin).

In order to overcome the inhomogeneities currently contained in the national mosaic of landslide hazard zones, it is necessary that the competent authorities adopt in the next future a shared methodology to update/revise the existing hazard maps.

³ Landslide hazard is the probability of occurrence of a potentially damaging phenomenon within a given area and in a given period of time (Varnes, 1984).

⁴ Law 183/89, Law Decree 180/98, Act of address 29th September 1998, Law 267/98, Law 365/00, and Legislative Decree 152/06.

⁵ Version 3.0 - December 2017

⁶ 2015 Report *Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio* (233/2015) (in Italian).

⁷ Attention zones: areas where the level of hazard is not yet defined.

The comparison between the 2017 and the 2015 national mosaics shows an increase of 2.9% of the total classified area (classes H4, H3, H2, H1 and AA), an increase of 6.2% of the high and very high hazard classes (H3 and H4) and a reduction of 19.5% of the attention zones, mainly reclassified as hazardous areas. The most significant increases of the high and very high hazard classes concerned the Tiber River Basin, the Sardegna Region, the Arno Basin, the Calabria, Marche and Abruzzo Regional Basins, the Po Basin in Lombardia Region, the Autonomous Province of Bolzano. These changes are mainly related to more detailed studies and mapping of new landslides.

The national mosaic of landslide hazard zones has been used together with data on exposed elements for the production of national risk indicators (Chapter 4).

Table 1.2 – High and very high landslide hazard zones on regional basis

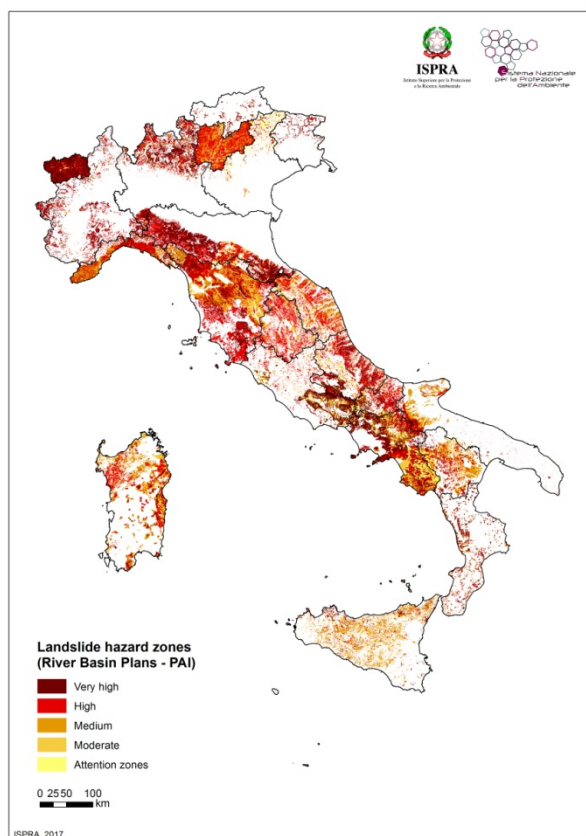


Figure 1.2 – Landslide hazard zones (River Basin Plans)

Region	Region area <i>km²</i>	High and very high landslide hazard zones	
		H4 + H3	
	<i>km²</i>	<i>km²</i>	%
Piemonte	25,387	1,230.8	4.8%
Valle D'Aosta	3,261	2,671.7	81.9%
Lombardia	23,863	1,538.2	6.4%
Trentino-Alto Adige	13,605	1,476.7	10.9%
<i>Bolzano</i>	7,398	131.7	1.8%
<i>Trento</i>	6,207	1,345.0	21.7%
Veneto	18,407	105.6	0.6%
Friuli Venezia Giulia	7,862	190.5	2.4%
Liguria	5,416	751.9	13.9%
Emilia-Romagna	22,452	3,277.7	14.6%
Toscana	22,987	3,367.6	14.7%
Umbria	8,464	492.9	5.8%
Marche	9,401	735.5	7.8%
Lazio	17,232	953.3	5.5%
Abruzzo	10,831	1,678.2	15.5%
Molise	4,460	716.9	16.1%
Campania	13,671	2,678.2	19.6%
Puglia	19,541	594.8	3.0%
Basilicata	10,073	511.6	5.1%
Calabria	15,222	545.6	3.6%
Sicilia	25,832	394.6	1.5%
Sardegna	24,100	1,497.6	6.2%
Total	302,066	25,410	8.4%

2. FLOODS

Flood is the temporary covering by water of land not normally covered by water. It includes floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas (Flood Directive 2007/60/EC).

The Floods Directive 2007/60/EC established a framework on the assessment and management of flood risk, aiming at the reduction of the potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity. It was implemented in Italy with Legislative Decree 49/2010 (Barbano et al., 2012).

Flood risk management plans address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event.

The first cycle of implementation of the Floods Directive has now been completed, and the Member States are moving into the second cycle, to be completed in 2021.

2.1 National mosaic of flood hazard zones

In order to update the flood hazard map on the entire national territory, in 2017 ISPRA realised the new National Mosaic⁸ of the hazard zones provided by the River Basin District Authorities. The mosaic has been realized according to the three hazard scenarios of Legislative Decree 49/2010: High probability scenario with return period of 20-50 years (frequent floods), Medium probability scenario with return period of 100-200 years and Low probability or extreme event scenario. The high flood hazard zones in Italy amount to **12,405 km²**, the medium flood hazard zones to **25,398 km²** and the low hazard zones to **32,961 km²**.

Table 2.1 - National mosaic of flood hazard zones⁹ (Legislative Decree 49/2010)

Flood hazard zones		
	km ²	% of national territory
High probability scenario	12,405.3	4.1%
Medium probability scenario	25,397.6	8.4%
Low probability scenario	32,960.9	10.9%

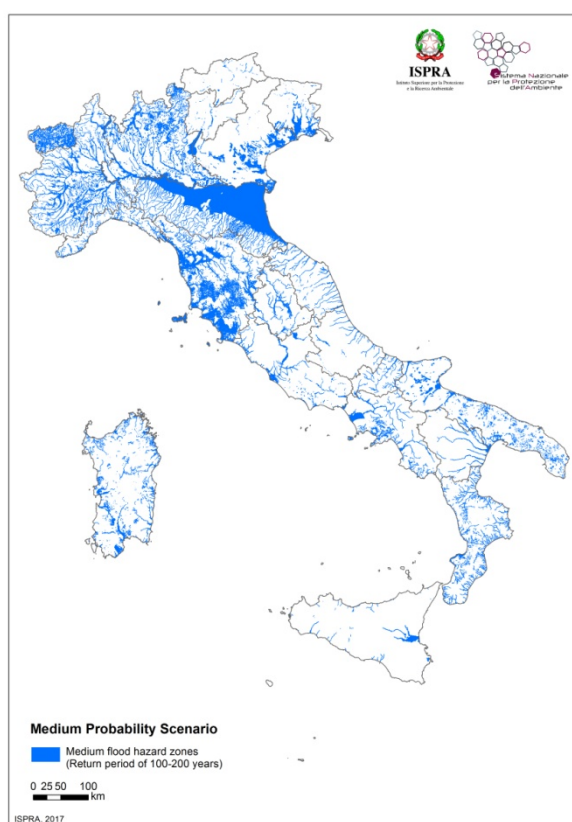


Figure 2.1 – Medium flood hazard zones

Table 2.2 - Medium flood hazard zones on regional basis

Region	Medium flood hazard zones		
	Region area km ²	km ²	%
Piemonte	25,387	2,066.0	8.1%
Valle D'Aosta	3,261	239.2	7.3%
Lombardia	23,863	2,405.7	10.1%
Trentino-Alto Adige	13,605	78.9	0.6%
<i>Bolzano</i>	7,398	33.2	0.4%
<i>Trento</i>	6,207	45.7	0.7%
Veneto	18,407	1,713.4	9.3%
Friuli Venezia Giulia	7,862	610.3	7.8%
Liguria	5,416	153.5	2.8%
Emilia-Romagna	22,452	10,252.5	45.7%
Toscana	22,987	2,790.8	12.1%
Umbria	8,464	336.7	4.0%
Marche	9,401	241.0	2.6%
Lazio	17,232	572.3	3.3%
Abruzzo	10,831	149.9	1.4%
Molise	4,460	139.4	3.1%
Campania	13,671	699.6	5.1%
Puglia	19,541	884.5	4.5%
Basilicata	10,073	276.7	2.7%
Calabria	15,222	576.7	3.8%
Sicilia	25,832	353.0	1.4%
Sardegna	24,100	857.3	3.6%
Total	302,066	25,398	8.4%

At the date of processing (December 2017) the high probability scenario and the low probability scenario were not available for the territory of the Marche Regional Basins. The low probability scenario was also not available for the territory of the Conca-Marecchia Basin and the Romagnoli Regional Basins (with the exception of the coastal marine areas) and for the drainage and irrigation channel network of the Po basin within the Emilia-Romagna Region. Because of this lack of

⁸ Version 4.0 - December 2017

⁹ A hazard zone can be flooded according to one or more of the three probability scenarios. The low probability scenario which represents the maximum extent of areas which could be flooded (maximum expected scenario) contains therefore the high and medium scenarios. Data referring to the three scenarios should not be added together.

information, the low probability scenario has a smaller area than the medium one in Emilia-Romagna and Marche Regions.

A certain lack of homogeneity can be seen in Figure 2.1, due to the drainage network which has been investigated in hazard maps. In some portions of the national territory only the primary drainage network has been modelled, in others also the minor drainage network in hilly or mountainous territories (e.g. Valle d'Aosta Region) or the artificial drainage network in alluvial-plain areas (e.g. Emilia-Romagna Region) has been well investigated.

The comparison between the 2015 and 2017 national mosaics shows an increase of 1.5% of the high probability scenario, 4% of the medium probability scenario and 2.5% of the low probability one. These increases are related to the integration/revision of the mapping, to the updating of the hydraulic modelling studies and to the inclusion of recent flood events. The most significant increases in medium hazard zones concerned the Sardegna Region, the Po Basin in Lombardia Region, the Marche Basins, the Tiber Basin in Lazio Region, the Arno Basin and the Toscana and Puglia Basins.

3. ITALIAN SYNOPTIC FRAMEWORK OF LANDSLIDES AND FLOODS

Figure 3.1 shows landslide hazard zones (Very high H4, High H3, Medium H2, Moderate H1 and Attention zones AA) and flood hazard zones (High, Medium, Low) on national territory (Tables 1.1 e 2.1).

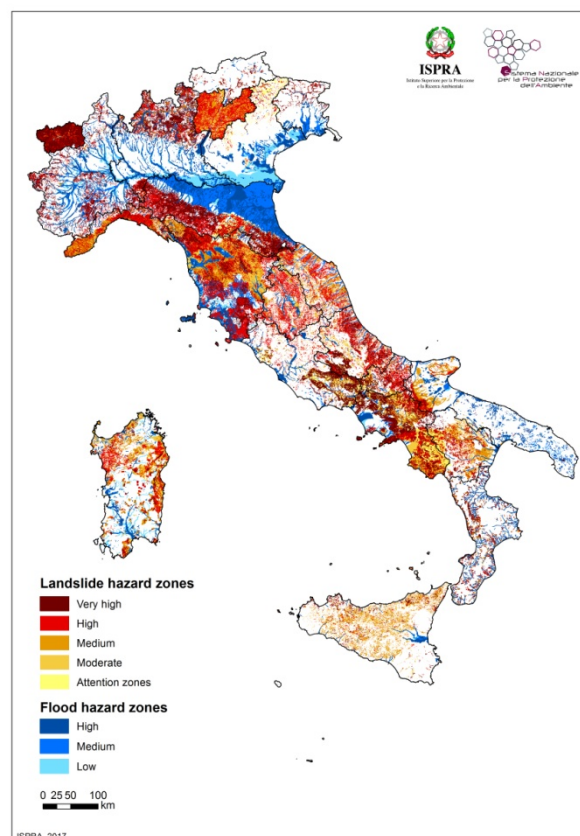


Figure 3.1 – National mosaics of landslide hazard zones and flood hazard zones

The new national mosaics of landslide hazard zones and flood hazard zones are published online¹⁰ (Figure 3.2).

¹⁰ <http://www.geoviewer.isprambiente.it>; <http://sgi2.isprambiente.it/mapviewer/>

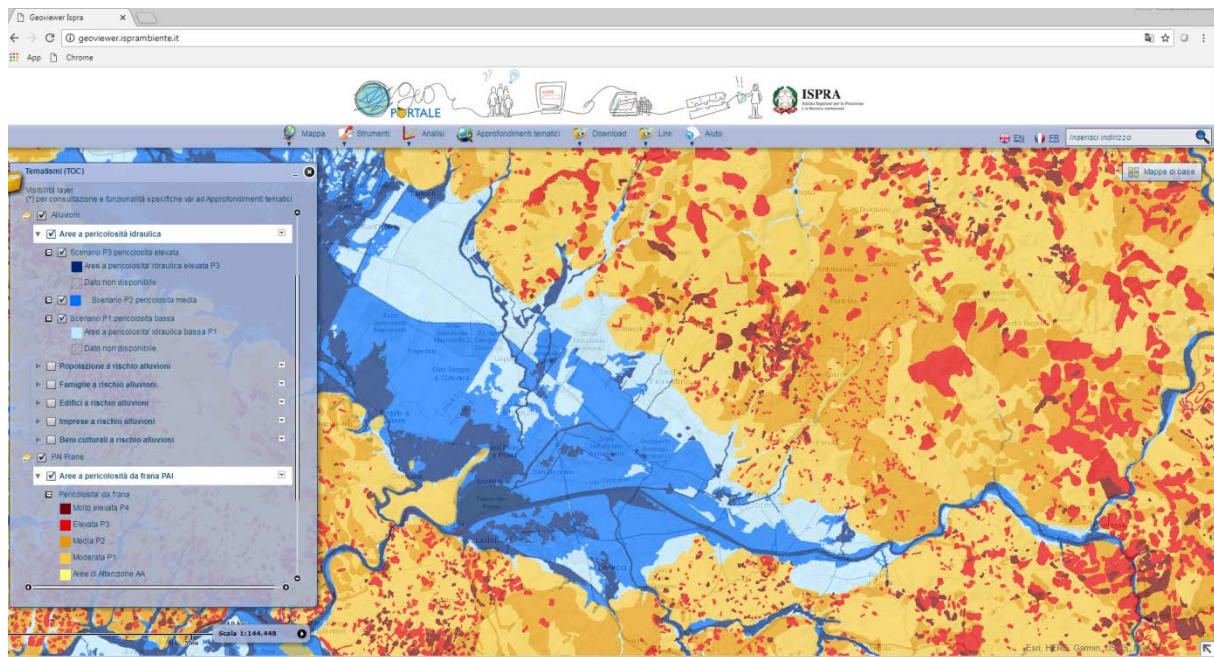


Figure 3.2 – National mosaics of landslide and flood hazard zones published online

The municipalities affected by landslide hazard zones (high and very high hazard) and/or flood hazard zones (medium probability scenario, return period of 100-200 years) are **7,275** equal to **91.1%** of Italian municipalities. The area classified as high and very high landslide hazard and/or medium flood hazard in Italy amounted to **50,117 km²**, equal to **16.6%** of the national territory.

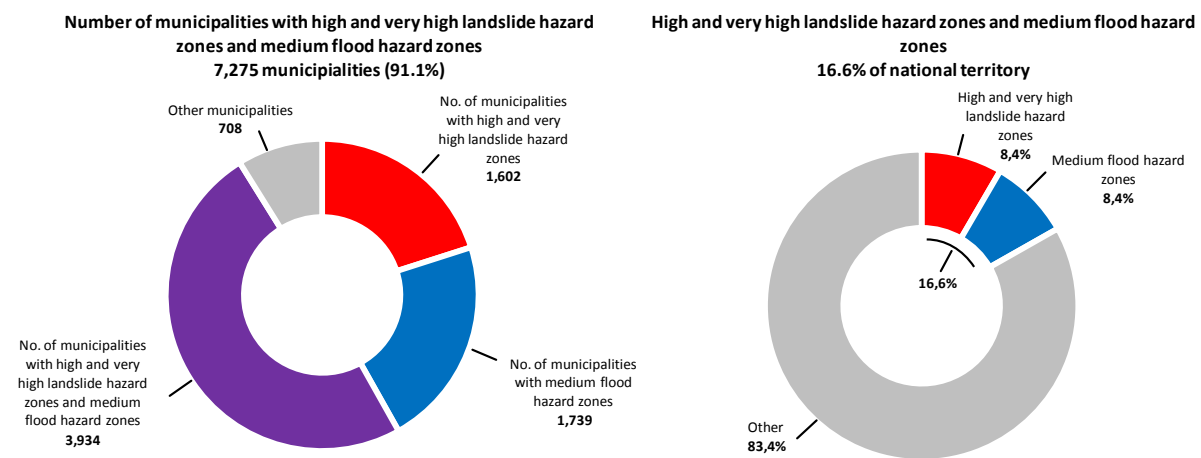


Figure 3.3 – Number of municipalities¹¹ and area¹² of high and very high landslide hazard zones and/or medium flood hazard zones

If we take into account the **number of municipalities**, 9 Regions (Valle d'Aosta, Liguria, Emilia-Romagna, Toscana, Umbria, Marche, Molise, Basilicata and Calabria) have 100% of municipalities affected by high and very high landslide hazard and/or medium flood hazard zones; in addition, the Province of Trento, Abruzzo, Lazio, Piemonte, Campania and Sicilia Regions have percentages greater than 90%.

¹¹ The total number of Italian municipalities refers to ISTAT 2017 administrative limits.

¹² The overall area classified as high and very high landslide hazard and/or medium flood hazard is lower than the sum of the areas considered separately (Par. 1.1 and 2.1) as 1.4% of the total area is classified hazardous for both landslides and floods.

Table 3.1 - Number of municipalities and area of high and very high landslide hazard zones and/or medium flood hazard zones

Region	No. of municipalities	Number of municipalities with high and very high landslide hazard zones and/or medium flood hazard zones		Region area <i>km</i> ²	High and very high landslide hazard zones and/or medium flood hazard zones	
		No.	%		<i>km</i> ²	%
Piemonte	1,201	1,133	94.3%	25,387	3,217.8	12.7%
Valle D'Aosta	74	74	100.0%	3,261	2,713.2	83.2%
Lombardia	1,524	1,287	84.4%	23,863	3,815.6	16.0%
Trentino-Alto Adige	293	268	91.5%	13,605	1,547.7	11.4%
<i>Bolzano</i>	116	92	79.3%	7,398	164.9	2.2%
<i>Trento</i>	177	176	99.4%	6,207	1,382.8	22.3%
Veneto	576	372	64.6%	18,407	1,818.9	9.9%
Friuli Venezia Giulia	216	183	84.7%	7,862	800.6	10.2%
Liguria	235	235	100.0%	5,416	902.8	16.7%
Emilia-Romagna	333	333	100.0%	22,452	13,496.4	60.1%
Toscana	276	276	100.0%	22,987	5,985.9	26.0%
Umbria	92	92	100.0%	8,464	829.2	9.8%
Marche	229	229	100.0%	9,401	975.6	10.4%
Lazio	378	373	98.7%	17,232	1,523.6	8.8%
Abruzzo	305	304	99.7%	10,831	1,826.9	16.9%
Molise	136	136	100.0%	4,460	851.9	19.1%
Campania	550	512	93.1%	13,671	3,351.4	24.5%
Puglia	258	230	89.1%	19,541	1,475.6	7.6%
Basilicata	131	131	100.0%	10,073	786.4	7.8%
Calabria	409	409	100.0%	15,222	1,106.3	7.3%
Sicilia	390	360	92.3%	25,832	747.5	2.9%
Sardegna	377	338	89.7%	24,100	2,343.4	9.7%
Total	7,983	7,275	91.1%	302,066	50,117	16.6%

4. RISK INDICATORS

The goal of the risk indicators is to provide an official reference framework for landslide and flood risk in Italy and an important tool to support national mitigation policies by identifying intervention priorities, allocation of funds, programming mitigation measures and planning civil protection measures.

4.1 Methodology

The methodology adopted for the production of risk indicators responds to transparency and repeatability criteria and uses official data available across the national territory. It refers to the equation $R = H \times E \times V$ where R is the Risk, H the Hazard, E the exposed Elements and V the Vulnerability. The ISPRA national mosaics of landslide and flood hazard zones, the 15th ISTAT Population Census 2011, the 9th ISTAT Census of Industry and Services 2011 and the ISCR Database of Cultural Heritage¹³ have been used as input data.

The estimate of the population exposed to landslide risk has been processed using the 402,678 ISTAT 2011 census sections as mapping unit. The number of exposed people has been calculated with a proportional method, multiplying the percentage of landslide hazard zones inside each census section for the resident population of the section (Trigila et al., 2015b). The data has been then aggregated on a municipal, provincial, regional and national basis. The population at risk represents the population living in landslide hazard zones exposed to the risk of damage (dead, missing, injured, evacuated people).

Vulnerability, which represents the degree of loss of the element at risk that can be damaged during an event, has been assigned as 1, as its assessment would require knowledge of the landslide magnitude (velocity and volume) as well as knowledge of the behaviour/resilience of the population categories (e.g. elderly, children, non-self-sufficient). Vulnerability may also vary based on the time of the year (summer/winter), the week (weekdays/holidays) and the time (day/night) in which the event occurs.

Similarly, the population exposed to flood risk has been estimated. In this case, the vulnerability is also set equal to 1, as the information on water level and flow velocity it is not available for the entire national territory.

Families, buildings and industry and services local units at risk have been estimated with a similar methodology. Instead for the evaluation of cultural heritage at risk the georeferenced features of cultural sites have been intersected with the national mosaics of landslide and flood hazard.

4.2 Use of risk indicators

Data have been used at national level for identification of intervention priorities, allocation of funds among the Regions and planning of mitigation measures (*Plan for urban and metropolitan areas against floods* - CIPE Resolution No. 32/2015; *National plan for mitigation measures* - Prime Minister Decree of 5th December 2016). In Europe, the indicators have been selected for the evaluation of the effectiveness of the Structural Fund measures 2014-2020 (Dipartimento per lo Sviluppo e la Coesione economica, 2014). Population exposed to landslide and flood risk indicators have been carried out within the framework of the project *Environmental statistics for cohesion policies 2014-2020 (PON Governance and Institutional Capacity 2014-2020)*.

¹³ Database of Cultural Heritage - VIR realized and managed by ISCR: <http://vincoliinrete.beniculturali.it/>

4.3 Population exposed to landslide risk

The population exposed to landslide risk in Italy living in high (H3) and very high (H4) landslide hazard zones (River Basin Plans – PAI) amounts to **1,281,970 inhabitants** (2.2% of the resident population in Italy: 59.433.744 inhab., ISTAT 2011 Census).

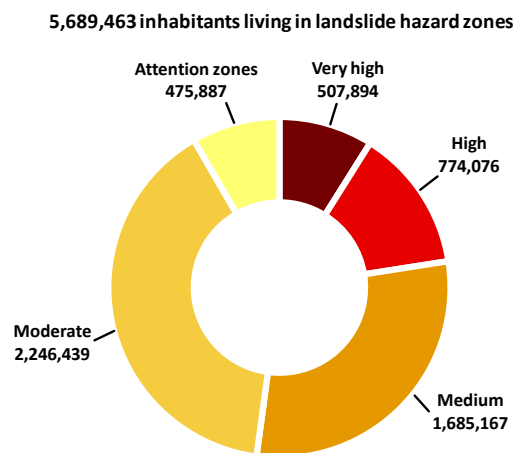


Figure 4.1 - Population exposed to landslide risk in Italy

Campania, Toscana, Emilia-Romagna and Liguria Regions have the highest values of population at risk living in H3 and H4 landslide hazard zones. The increase of 4.7% in population at risk compared to 2015 data¹⁴ is due to the integration/revision of the hazard zoning maps by the River Basin District Authorities (Par. 2.1).

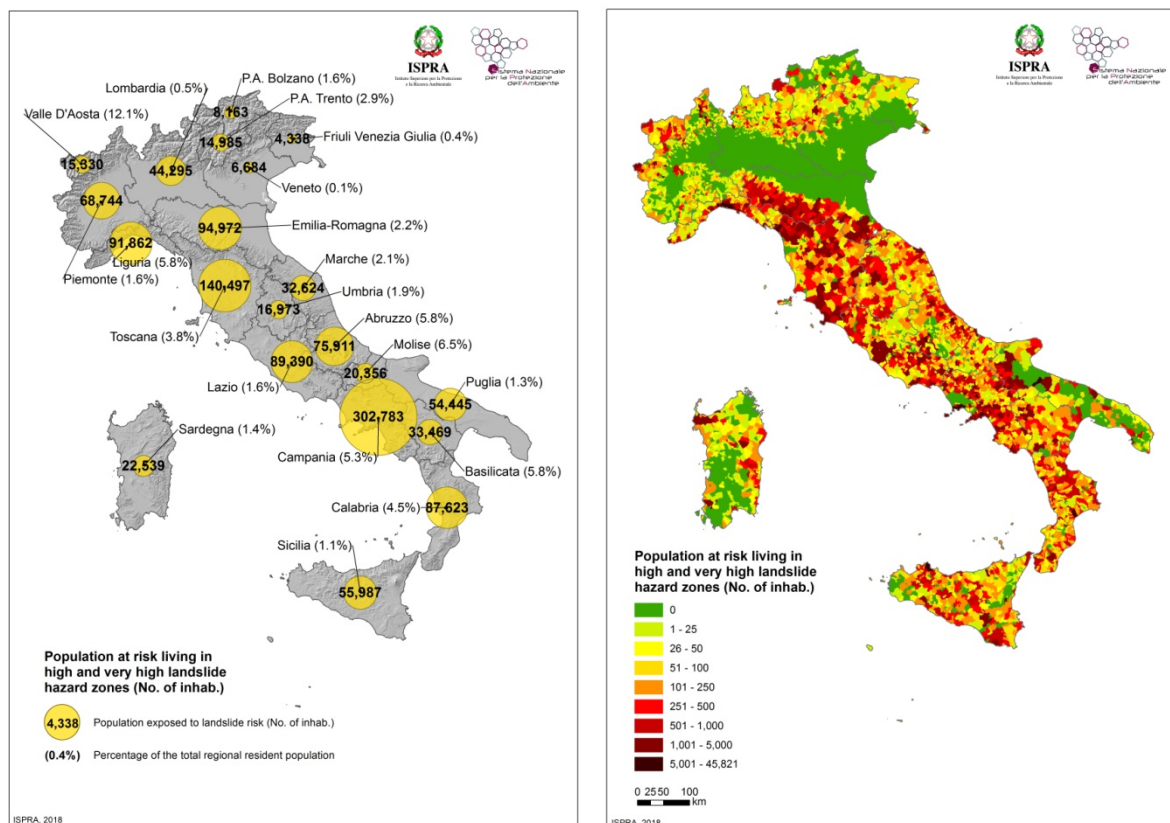


Figure 4.2 - Population at risk living in high and very high landslide hazard zones on regional and municipal basis

¹⁴ 2015 Report *Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio* (233/2015) (in Italian).

4.4 Families exposed to landslide risk

Families exposed to landslide risk in Italy living in high and very high landslide hazard zones are **538,034** equal to 2.2% of the total (24,611,766 families; ISTAT 2011 Census).

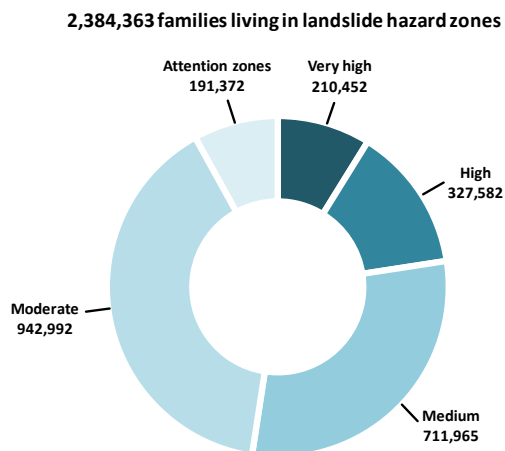


Figure 4.3 - Families exposed to landslide risk in Italy

The Regions with the highest values of families at risk are: Campania, Toscana, Liguria and Emilia-Romagna.

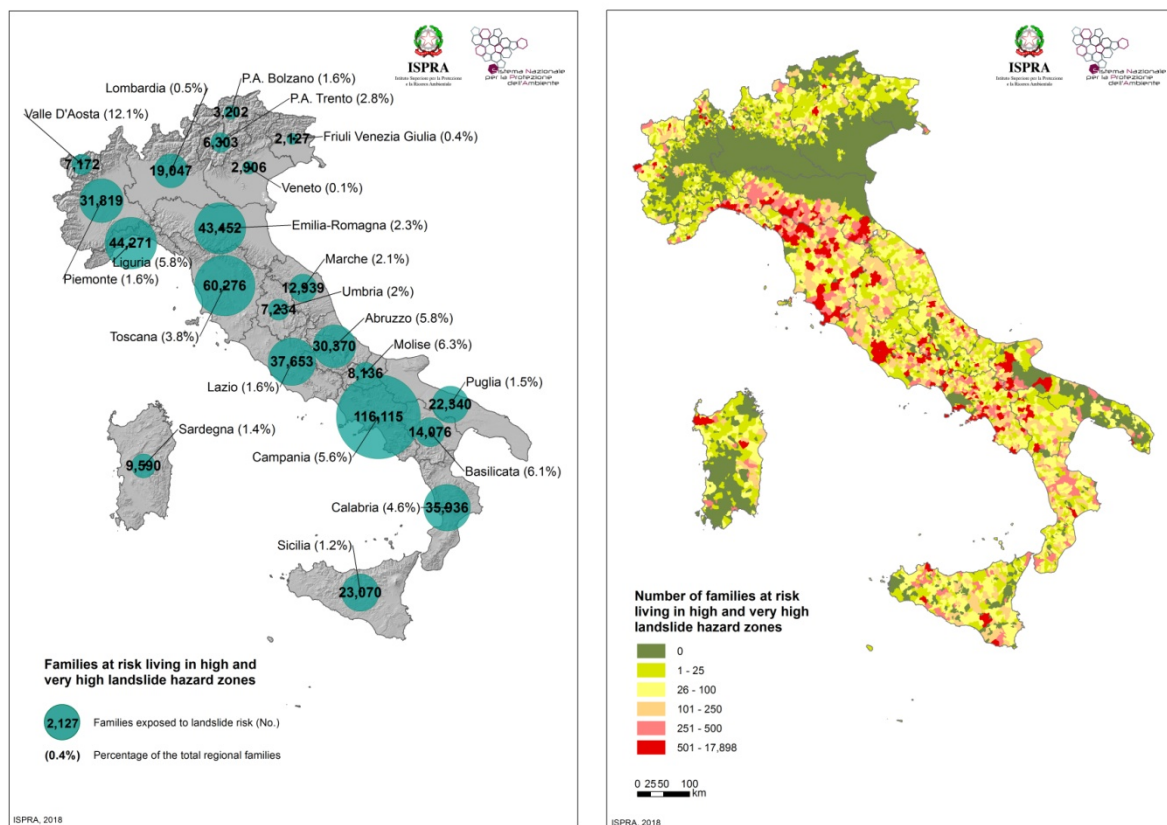


Figure 4.4 - Families at risk living in high and very high landslide hazard zones on regional and municipal basis

4.5 Buildings exposed to landslide risk

Buildings¹⁵ exposed to landslide risk in Italy located in high and very high landslide hazard zones are **550,723** equal to 3.8% of the total (14,515,795 buildings; ISTAT 2011 Census).

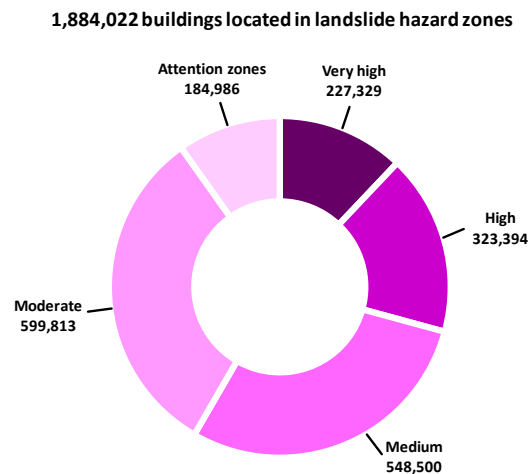


Figure 4.5 - Buildings exposed to landslide risk in Italy

Campania, Toscana, Emilia-Romagna and Calabria are the Regions with the highest number of buildings at risk located in high and very high landslide hazard zones.

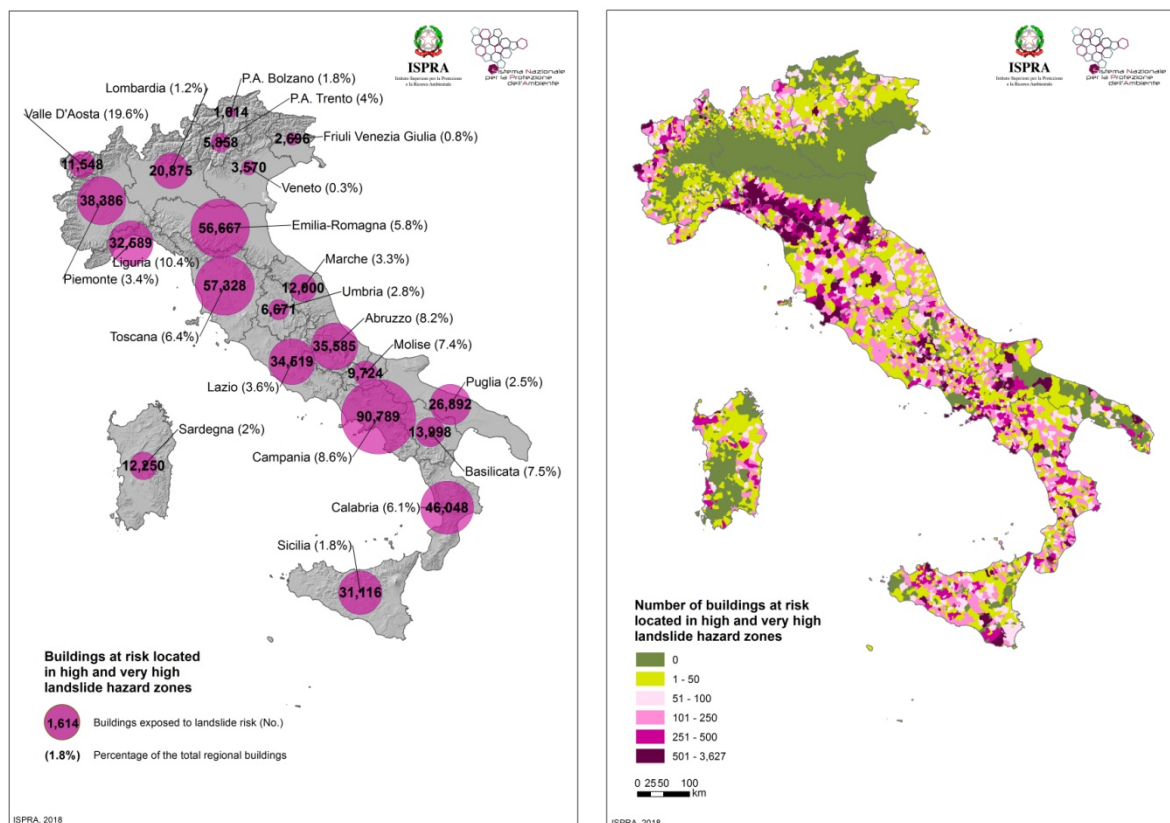


Figure 4.6 - Buildings at risk located in high and very high landslide hazard zones on regional and municipal basis

¹⁵ The term *Buildings* means buildings related to any type of use (residential, industrial, commercial, services, tourism, directional/tertiary, other).

4.6 Industries and services exposed to landslide risk

Industry and services local units¹⁶ located in high and very high landslide hazard zones are **82,948** equal to **1.7%** of the total (4,806,014 local units; ISTAT 2011 Census of Industry and Services), with **217,608 workers** at risk.

403,719 industry and services local units located in landslide hazard zones

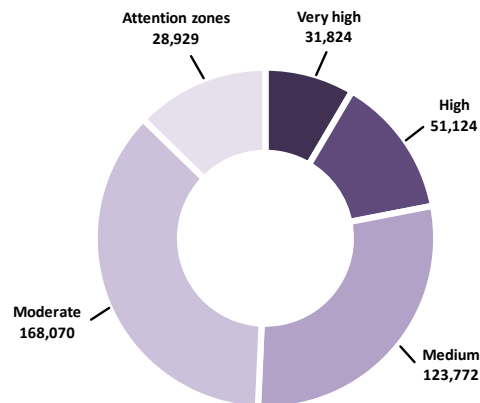


Figure 4.7 - Industry and services local units exposed to landslide risk in Italy

The Regions with the highest number of Industry and services local units located in high and very high landslide hazard zones are Campania, Toscana, Emilia-Romagna and Lazio.

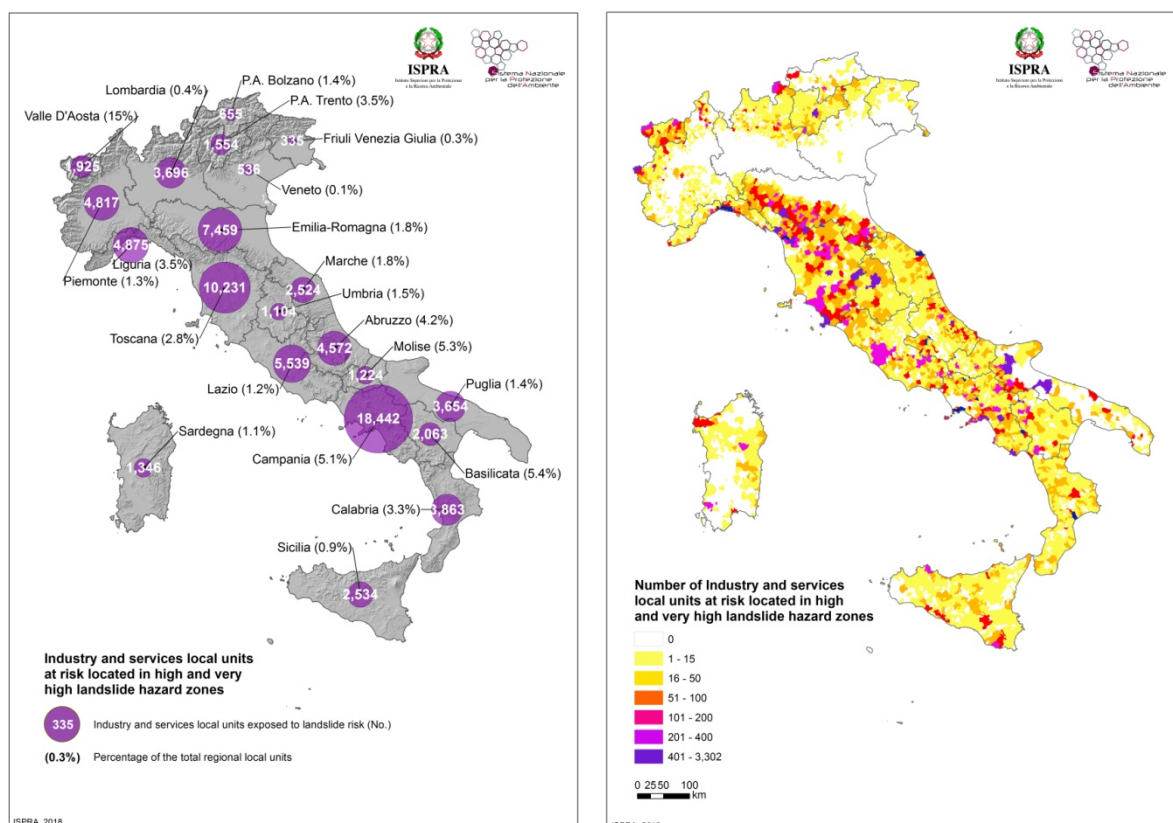


Figure 4.8 - Industry and services local units located in high and very high landslide hazard zones on regional and municipality basis

¹⁶ The Local Unit corresponds to a legal-economic unit or a part of it, located in a location that is topographically identified by an address and a street number.

4.7 Cultural heritage exposed to landslide risk

Cultural heritage exposed to landslide risk are **37,847** equal to **18.6%** of the total (203,665 cultural heritage; VIR Database – ISCR), of which **11,712 (5.8%)** are located in high and very high landslide hazard zones.

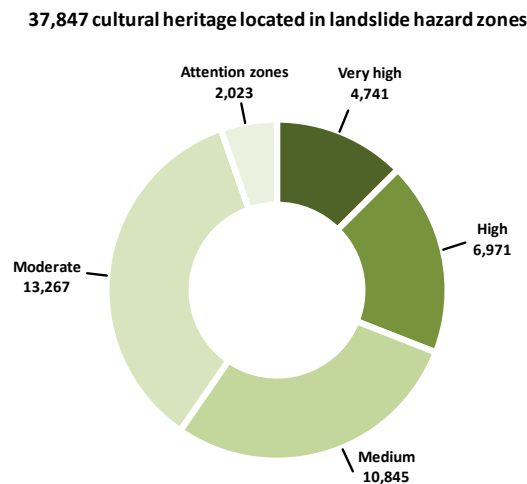


Figure 4.9 – Cultural heritage exposed to landslide risk in Italy

The highest number of cultural heritage located in high and very high landslide hazard zones is recorded in Toscana, Marche, Emilia-Romagna, Campania and Liguria Regions. There are numerous medieval villages affected by landslides that have been triggered or reactivated even in recent years, such as San Leo, Volterra and Civita di Bagnoregio. In recent decades, mitigation measures have been realised in several historic centres, as Certaldo, Todi and Orvieto.

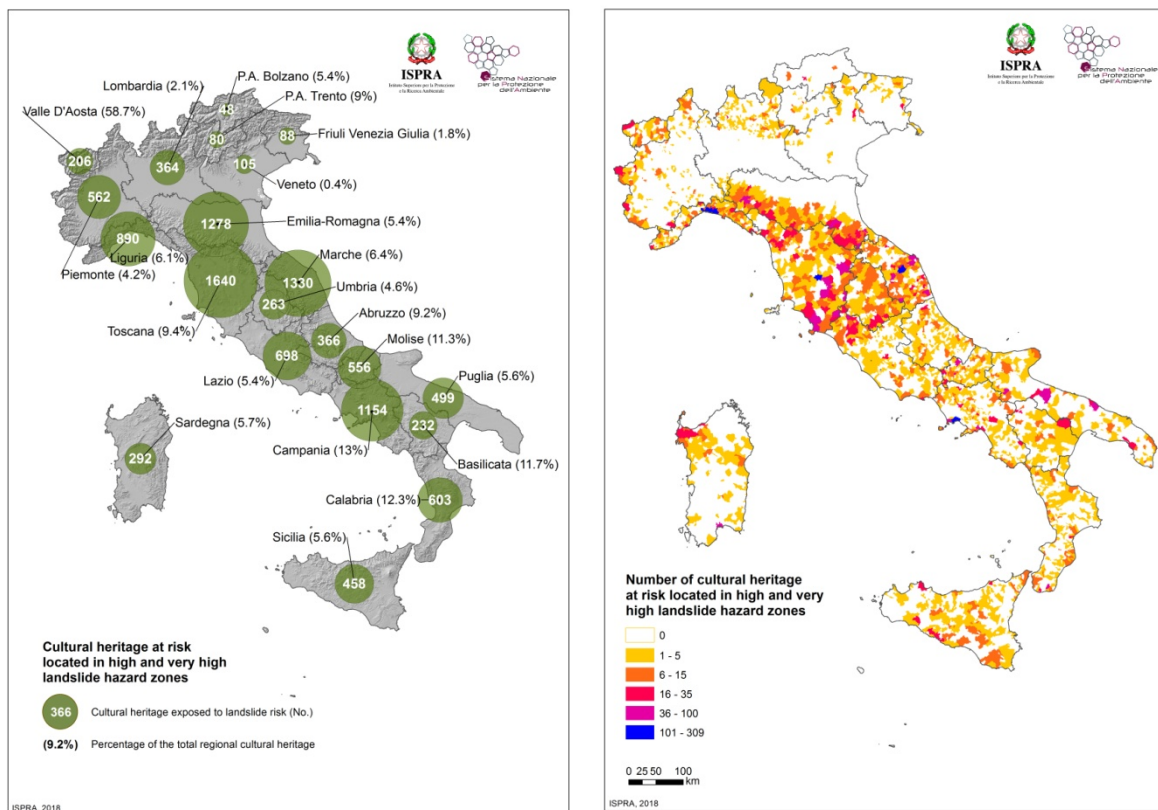


Figure 4.10 – Cultural heritage located in high and very high landslide hazard zones on regional and municipality basis

Table 4.1 – *Landslide risk indicators related to population, families, buildings, industry and services, cultural heritage*

Region	Population at risk		Families at risk		Buildings at risk		Industry and services local units at risk		Industry and services workers at risk		Cultural heritage at risk	
	in high and very high landslide hazard zones											
	No. ab.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Piemonte	68,744	1.6%	31,819	1.6%	38,386	3.4%	4,817	1.3%	13,966	1.0%	562	4.2%
Valle D'Aosta	15,330	12.1%	7,172	12.1%	11,548	19.6%	1,925	15.0%	6,364	15.0%	206	58.7%
Lombardia	44,295	0.5%	19,047	0.5%	20,875	1.2%	3,696	0.4%	12,591	0.4%	364	2.1%
Trentino-Alto Adige	23,148	2.2%	9,505	2.2%	7,472	3.1%	2,209	2.4%	8,669	2.4%	128	7.2%
<i>Bolzano</i>	8,163	1.6%	3,202	1.6%	1,614	1.8%	655	1.4%	2,388	1.3%	48	5.4%
<i>Trento</i>	14,985	2.9%	6,303	2.8%	5,858	4.0%	1,554	3.5%	6,281	3.6%	80	9.0%
Veneto	6,684	0.1%	2,906	0.1%	3,570	0.3%	536	0.1%	1,431	0.1%	105	0.4%
Friuli Venezia Giulia	4,338	0.4%	2,127	0.4%	2,696	0.8%	335	0.3%	963	0.3%	88	1.8%
Liguria	91,862	5.8%	44,271	5.8%	32,589	10.4%	4,875	3.5%	12,892	2.8%	890	6.1%
Emilia-Romagna	94,972	2.2%	43,452	2.3%	56,667	5.8%	7,459	1.8%	20,006	1.3%	1,278	5.4%
Toscana	140,497	3.8%	60,276	3.8%	57,328	6.4%	10,231	2.8%	26,922	2.3%	1,640	9.4%
Umbria	16,973	1.9%	7,234	2.0%	6,671	2.8%	1,104	1.5%	2,977	1.2%	263	4.6%
Marche	32,624	2.1%	12,939	2.1%	12,000	3.3%	2,524	1.8%	9,919	2.0%	1,330	6.4%
Lazio	89,390	1.6%	37,653	1.6%	34,519	3.6%	5,539	1.2%	13,462	0.9%	698	5.4%
Abruzzo	75,911	5.8%	30,370	5.8%	35,585	8.2%	4,572	4.2%	11,792	3.5%	366	9.2%
Molise	20,356	6.5%	8,136	6.3%	9,724	7.4%	1,224	5.3%	3,262	5.2%	556	11.3%
Campania	302,783	5.3%	116,115	5.6%	90,789	8.6%	18,442	5.1%	43,165	4.2%	1,154	13.0%
Puglia	54,445	1.3%	22,340	1.5%	26,892	2.5%	3,654	1.4%	8,068	1.0%	499	5.6%
Basilicata	33,469	5.8%	14,076	6.1%	13,998	7.5%	2,063	5.4%	4,238	3.9%	232	11.7%
Calabria	87,623	4.5%	35,936	4.6%	46,048	6.1%	3,863	3.3%	7,920	2.6%	603	12.3%
Sicilia	55,987	1.1%	23,070	1.2%	31,116	1.8%	2,534	0.9%	5,683	0.7%	458	5.6%
Sardegna	22,539	1.4%	9,590	1.4%	12,250	2.0%	1,346	1.1%	3,318	1.0%	292	5.7%
Total	1,281,970	2.2%	538,034	2.2%	550,723	3.8%	82,948	1.7%	217,608	1.3%	11,712	5.8%

4.8 Population exposed to flood risk

The resident population exposed to flood risk in Italy is: 2,062,475 inhabitants (3.5%) in high probability scenario (return period of 20-50 years); **6,183,364 inhabitants (10.4%)** in medium probability scenario (return period of 100-200 years) and 9,341,533 inhabitants (15.7%) in low probability or extreme events scenario.

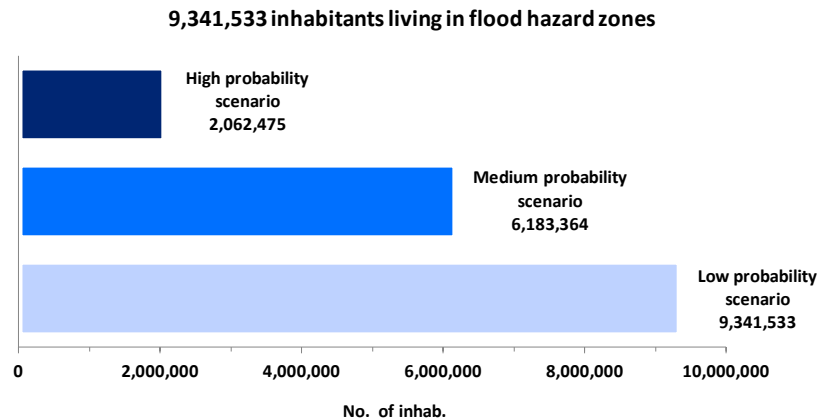


Figure 4.11 – Population exposed to flood risk in Italy¹⁷

The Regions with the highest values of population living in medium flood hazard zones are Emilia-Romagna, Toscana, Veneto, Lombardia and Liguria.

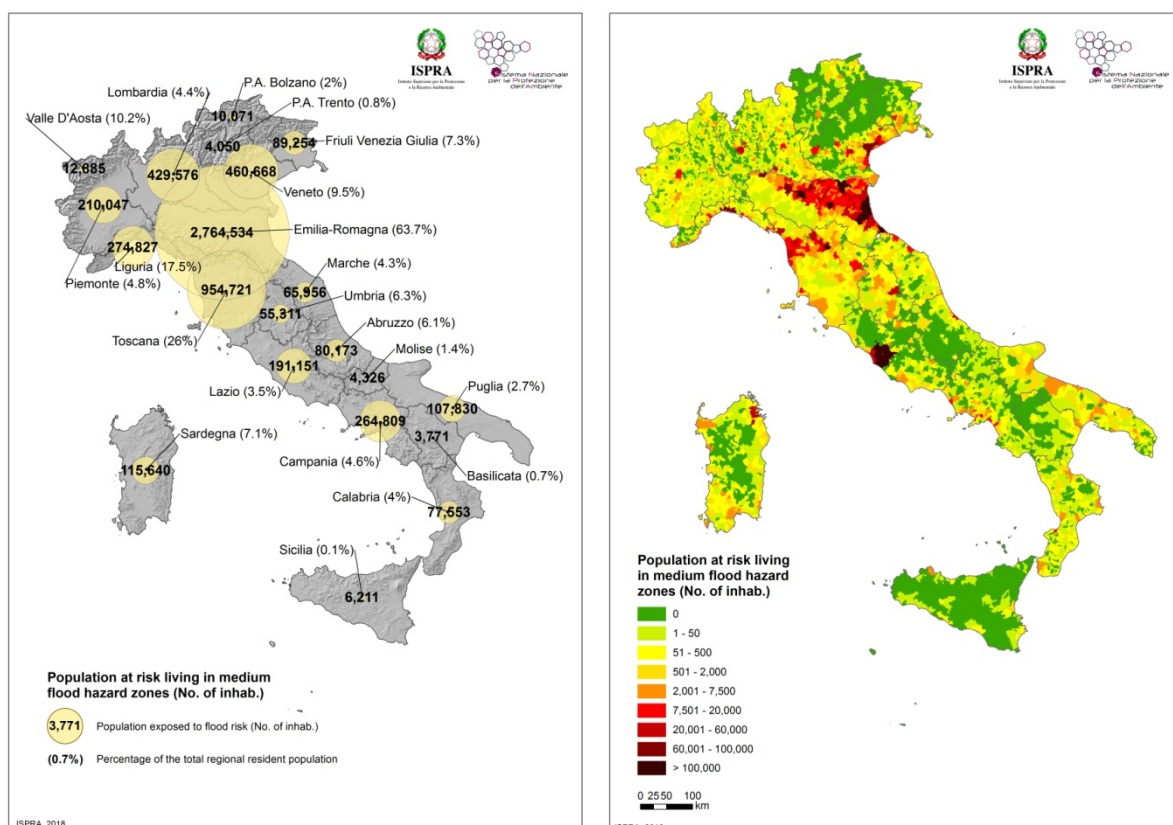


Figure 4.12 - Population at risk living in medium flood hazard zones on regional and municipal basis

¹⁷ The low probability scenario, which represents the maximum expected scenario or the maximum extent of areas which could be flooded, contains the high and medium scenarios. Therefore data of elements at risk (population, families, buildings, industry and services local units, cultural heritage) referring to the three scenarios should not be added together.

4.9 Families exposed to flood risk

Families exposed to flood risk in Italy are **2,648,499 (10.8%)** considering the medium probability scenario.

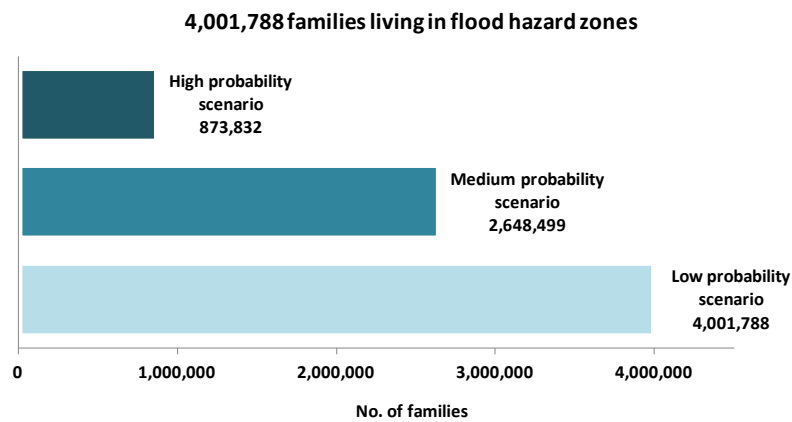


Figure 4.13 – Families exposed to flood risk in Italy¹⁸

Emilia-Romagna, Toscana, Veneto, Lombardia and Liguria Regions have the highest number of families exposed to flood risk in the medium probability scenario.

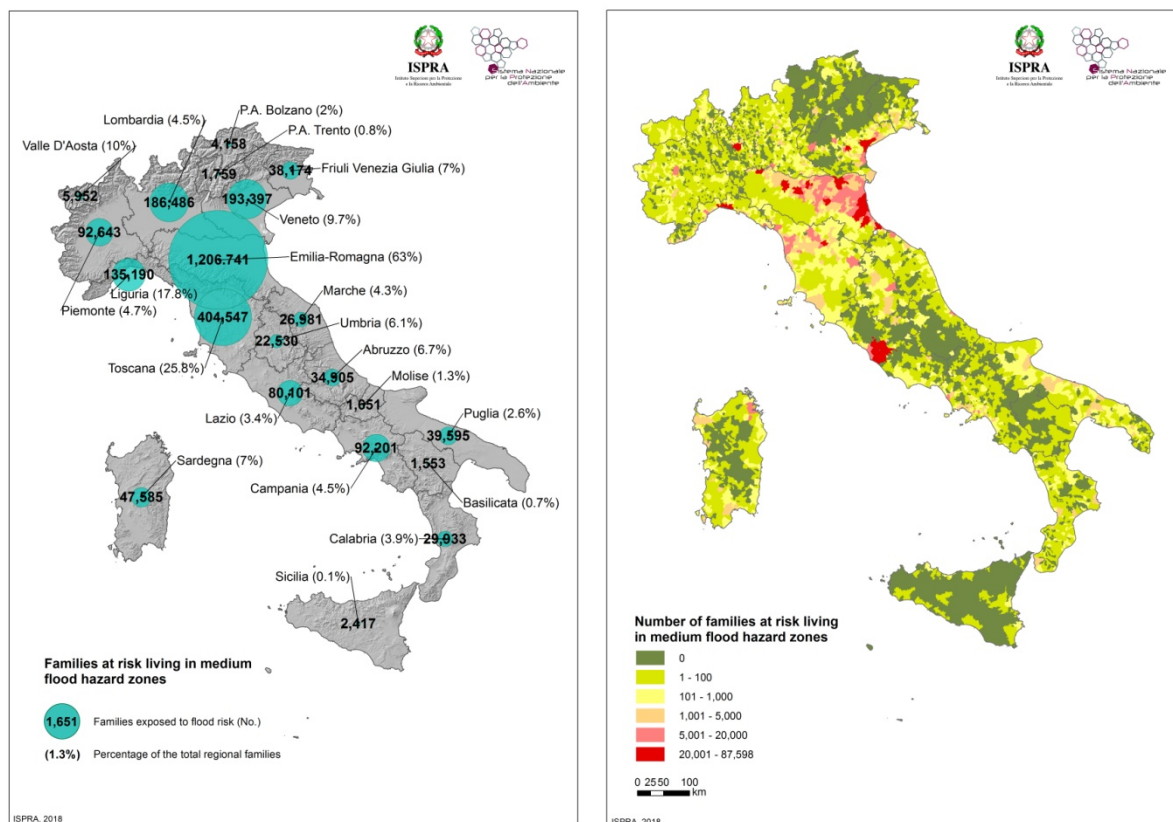


Figure 4.14 – Families at risk living in medium flood hazard zones on regional and municipal basis

¹⁸ See footnote 15

4.10 Buildings exposed to flood risk

Buildings exposed to flood risk in Italy are **1,351,578 (9.3%)** considering the medium probability scenario.

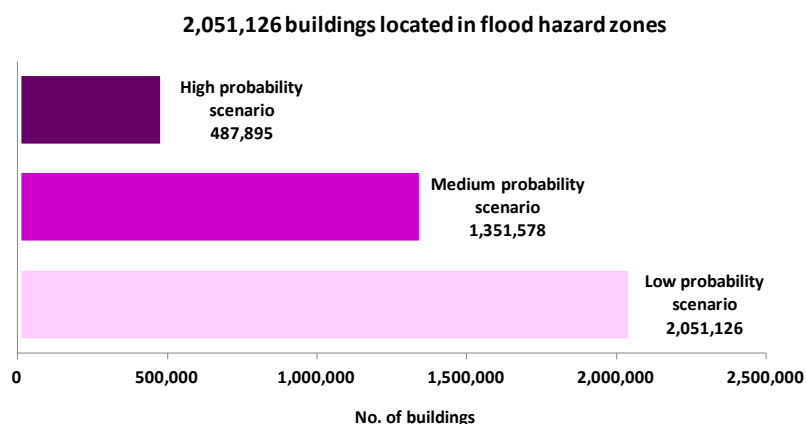


Figure 4.15 – Buildings exposed to flood risk in Italy¹⁹

Emilia-Romagna, Toscana, Veneto, Lombardia and Piemonte Regions have the highest number of buildings at risk in the medium probability scenario.

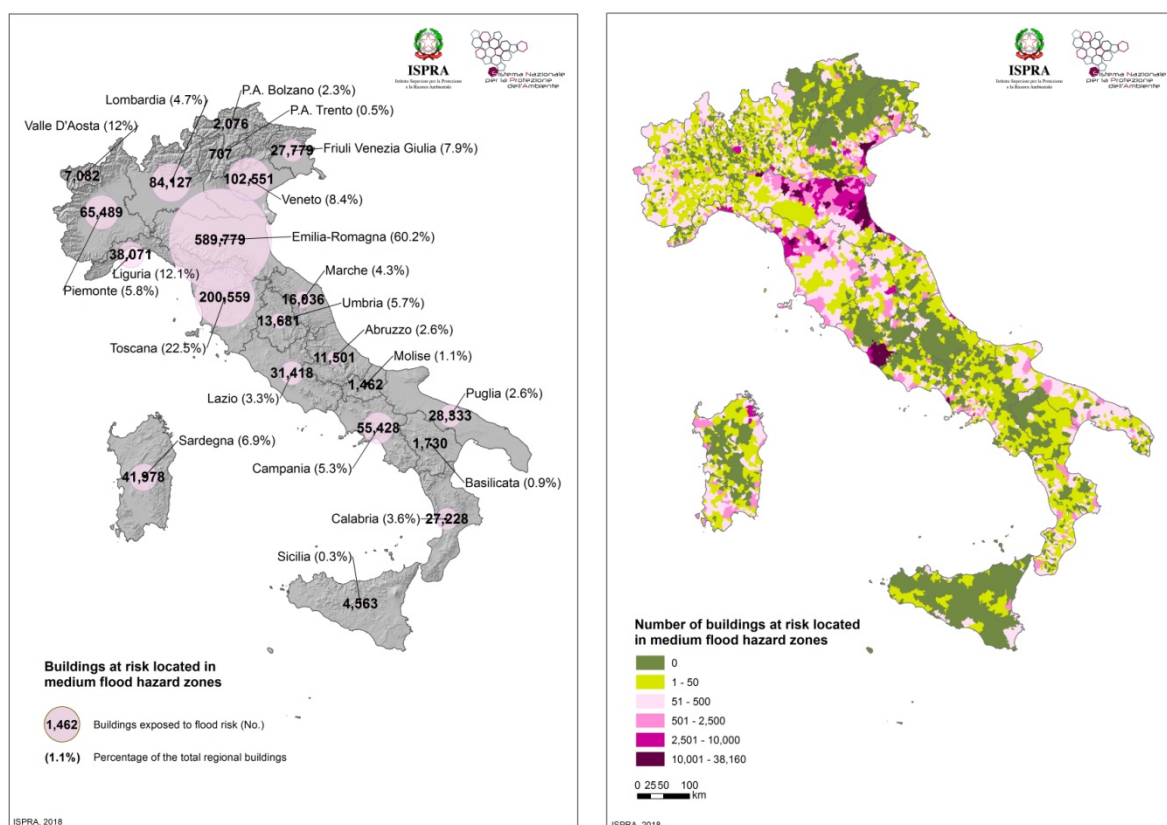


Figure 4.16 - Buildings at risk located in medium flood hazard zones on regional and municipal basis

¹⁹ See footnote 15

4.11 Industries and services exposed to flood risk

Industry and services local units exposed to flood risks are **596,254 (12.4%)** in the medium probability scenario with 2,306,229 workers at risk (14%).

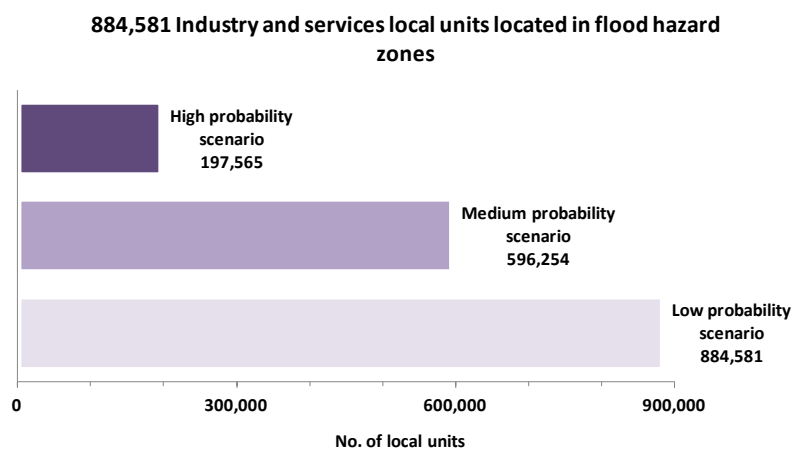


Figure 4.17 - Industry and services local units exposed to flood risk in Italy²⁰

Emilia-Romagna, Toscana, Veneto, Lombardia and Liguria Regions have the highest number of local units at risk in the medium probability scenario.

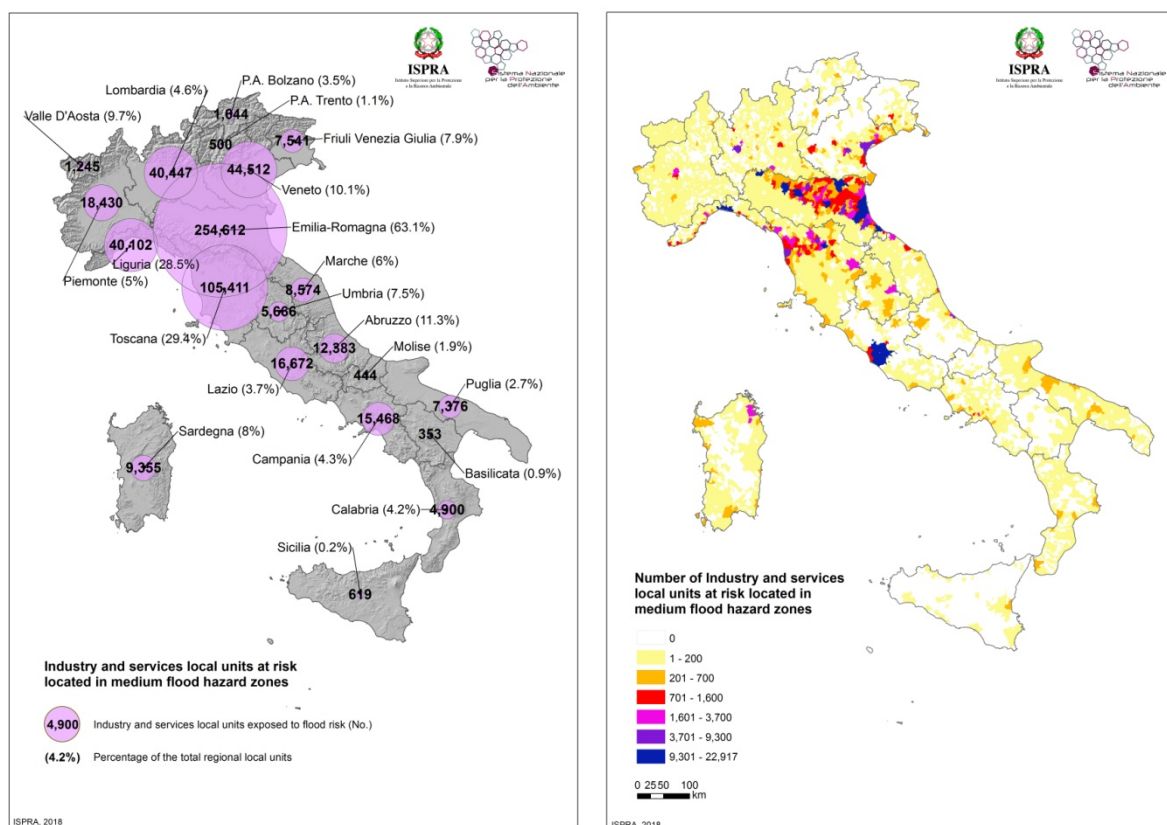


Figure 4.18 - Industry and services local units located in medium flood hazard zones on regional and municipality basis

²⁰ See footnote 15

4.12 Cultural heritage exposed to flood risk

Cultural heritage exposed to flood risk are **31,137 (15.3%)** in the medium probability scenario and reach **39,426 sites (19.4%)** in the low probability scenario²¹.

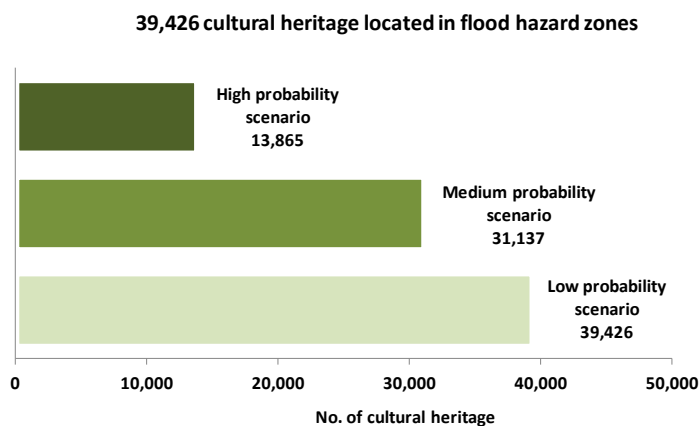


Figure 4.19 - Cultural heritage exposed to flood risk in Italy

The highest number of cultural heritage located in medium flood hazard zones is recorded in Emilia-Romagna, Veneto, Liguria and Toscana Regions. Venezia, Ferrara, Firenze, Genova, Piacenza, Ravenna and Pisa are the cities with the highest risk for cultural heritage. However, even the low probability scenario is particularly relevant for the assessment of cultural heritage at risk, considering that damage to cultural heritage would be priceless and irreversible.

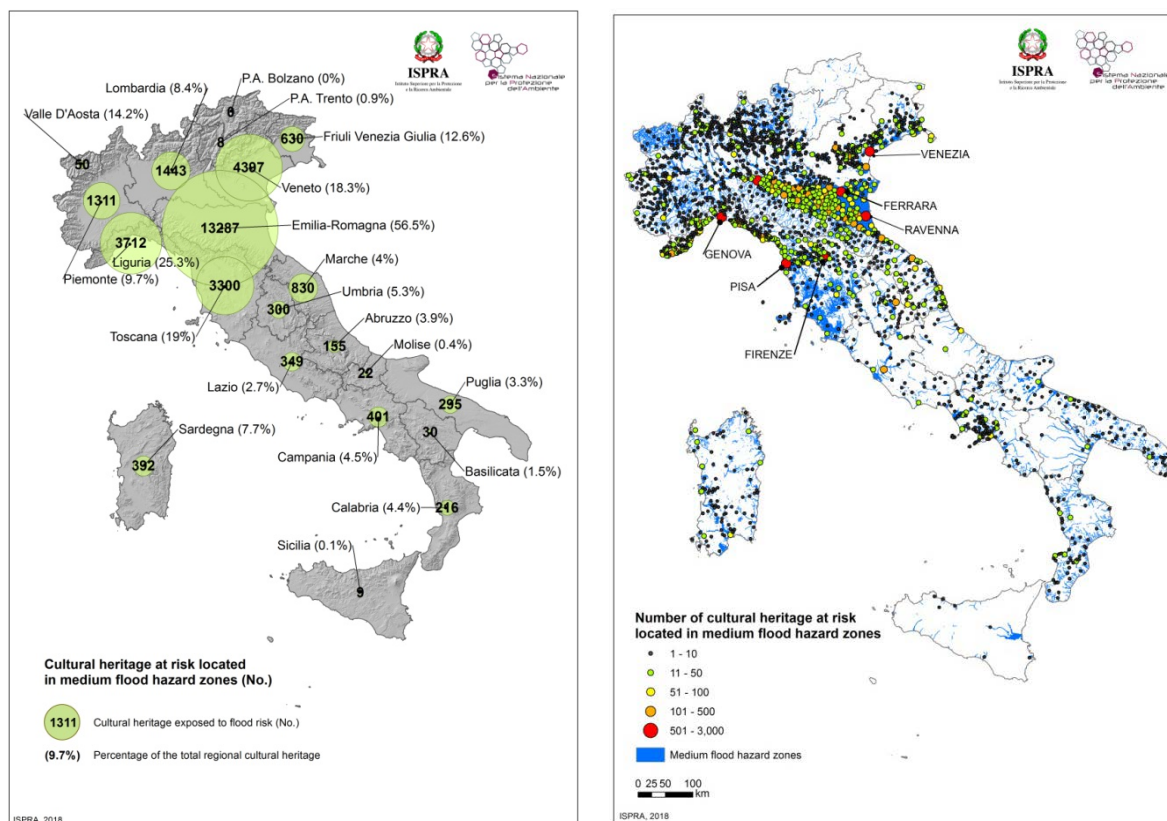


Figure 4.20 - Cultural heritage located in medium flood hazard zones on regional and municipality basis

²¹ See footnote 15

Table 4.2 – Flood risk indicators related to population, families, buildings, industry and services, cultural heritage

Region	Population at risk		Families at risk		Buildings at risk		Industry and services local units at risk		Industry and services workers at risk		Cultural heritage at risk	
	in medium flood hazard zones											
	No. ab.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Piemonte	210,047	4.8%	92,643	4.7%	65,489	5.8%	18,430	5.0%	79,984	5.9%	1,311	9.7%
Valle D'Aosta	12,885	10.2%	5,952	10.0%	7,082	12.0%	1,245	9.7%	4,489	10.6%	50	14.2%
Lombardia	429,576	4.4%	186,486	4.5%	84,127	4.7%	40,447	4.6%	177,031	5.1%	1,443	8.4%
Trentino-Alto Adige	14,121	1.4%	5,917	1.4%	2,783	1.2%	2,144	2.3%	13,935	3.8%	8	0.5%
<i>Bolzano</i>	10,071	2.0%	4,158	2.0%	2,076	2.3%	1,644	3.5%	10,364	5.5%	0	0.0%
<i>Trento</i>	4,050	0.8%	1,759	0.8%	707	0.5%	500	1.1%	3,571	2.1%	8	0.9%
Veneto	460,668	9.5%	193,397	9.7%	102,551	8.4%	44,512	10.1%	170,368	10.2%	4,397	18.3%
Friuli Venezia Giulia	89,254	7.3%	38,174	7.0%	27,779	7.9%	7,541	7.9%	30,995	8.2%	630	12.6%
Liguria	274,827	17.5%	135,190	17.8%	38,071	12.1%	40,102	28.5%	124,943	27.2%	3,712	25.3%
Emilia-Romagna	2,764,534	63.7%	1,206,741	63.0%	589,779	60.2%	254,612	63.1%	1,030,232	68.0%	13,287	56.5%
Toscana	954,721	26.0%	404,547	25.8%	200,559	22.5%	105,411	29.4%	382,627	33.2%	3,300	19.0%
Umbria	55,311	6.3%	22,530	6.1%	13,681	5.7%	5,666	7.5%	19,524	7.8%	300	5.3%
Marche	65,956	4.3%	26,981	4.3%	16,036	4.3%	8,574	6.0%	34,009	7.0%	830	4.0%
Lazio	191,151	3.5%	80,101	3.4%	31,418	3.3%	16,672	3.7%	81,214	5.3%	349	2.7%
Abruzzo	80,173	6.1%	34,905	6.7%	11,501	2.6%	12,383	11.3%	36,929	10.8%	155	3.9%
Molise	4,326	1.4%	1,651	1.3%	1,462	1.1%	444	1.9%	5,919	9.4%	22	0.4%
Campania	264,809	4.6%	92,201	4.5%	55,428	5.3%	15,468	4.3%	42,140	4.1%	401	4.5%
Puglia	107,830	2.7%	39,595	2.6%	28,333	2.6%	7,376	2.7%	23,971	3.1%	295	3.3%
Basilicata	3,771	0.7%	1,553	0.7%	1,730	0.9%	353	0.9%	1,550	1.4%	30	1.5%
Calabria	77,553	4.0%	29,933	3.9%	27,228	3.6%	4,900	4.2%	15,007	5.0%	216	4.4%
Sicilia	6,211	0.1%	2,417	0.1%	4,563	0.3%	619	0.2%	6,006	0.8%	9	0.1%
Sardegna	115,640	7.1%	47,585	7.0%	41,978	6.9%	9,355	8.0%	25,356	7.8%	392	7.7%
Total	6,183,364	10.4%	2,648,499	10.8%	1,351,578	9.3%	596,254	12.4%	2,306,229	14.0%	31,137	15.3%

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