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Discussions

Perception of flood and landslide risk in Italy: a preliminary analysis

P. Salvati, C. Bianchi, F. Fiorucci, P. Giostrella, I. Marchesini, and F. Guzzetti

CNR IRPI, via Madonna Alta 126, 06128 Perugia, Italy

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Correspondence to: P. Salvati (p.salvati@irpi.cnr.it)

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Abstract

Inundations and landslides are widespread phenomena in Italy, where they cause severe damage and pose a threat to the population. Little is known on the perception of the population of landslides and floods. This is surprising, as an accurate perception is important for the successful implementation of many risk reduction or adaptation strategies. In an attempt to fill this gap, we have conducted two national surveys to measure the perception of landslide and flood risk of the population of Italy. The surveys were executed in 2012 and 2013, performing for each survey approximately 3100 computer assisted telephone interviews. The samples of the interviewees were statistically representative for a national scale quantitative assessment. The interviewees were asked questions designed to obtain information on their: (i) perception of natural, environmental, and technological risks, (ii) direct experience or general knowledge on the occurrence of landslides and floods in their municipality, (iii) perception of the possible threat posed by landslides and floods to their safety, (iv) general knowledge on the number of victims caused by landslides or floods, and on (v) the factors that they considered important to control landslide and flood risks in Italy. The surveys revealed that the population of Italy fears technological risks more than natural risks. Of the natural risks, earthquakes were considered more dangerous than floods, landslides, and volcanic eruptions. Examination of the temporal and geographical distribution of the responses revealed that the occurrence of recent damaging events influenced risk perception locally, and that the perception persisted longer for earthquakes and decreased more rapidly for landslides and floods. We justify the differentiation with the diverse consequences of the risks. The interviewees considered inappropriate land management the main cause of landslide and flood risk, followed by illegal construction, abandonment of the territory, and climate change. Comparison of the risk perception with actual measures of landslide and flood risk, including the number of fatal events, the number of fatalities, and the mortality rates, revealed that in most of the Italian regions the perception of the threat did not match the long-term risk posed by landslides and floods to

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the population. This outcome points to the need to fostering the understanding of the population of landslide and flood hazards and risks in Italy.

1 Introduction

Landslide and floods are recurrent and abundant phenomena in Italy, where they cause damage and pose a threat to the population (Guzzetti et al., 1994; Guzzetti and Tonelli, 2004). Landslide and flood hazards, and the associated risk, have been determined at various geographical scales in Italy, from the site specific (local) to the synoptic (national) scale. At the local scale, detailed investigations have produced zonations of landslide and flood hazards and risks ("Piani di Assetto Idrogeologico"), which are used to design defensive structures, and to implement mitigation strategies. At the synoptic scale, investigators have estimated the individual and the collective risk posed by landslides and floods to the population (Guzzetti et al., 2005a; Salvati et al., 2010, 2011). Despite these efforts, little is known on the perception of the population of Italy of the risk posed by landslides and floods. This is surprising, because an appropriate perception of the risk is important for the successful implementation of risk reduction or adaptation strategies.

In an attempt to fill this gap, in 2012 and 2013, we executed two national surveys to probe the perception of the population of Italy of landslide and flood risk. The two surveys were executed performing more than 3000 telephone interviews, and they provided sufficient information to perform a preliminary evaluation of the perception that the population has of landslide and flood risk, and its geographical variations, in Italy. In this paper, following a brief overview of concepts related to risk perception (Sect. 2), we describe the content of the two national surveys (Sect. 3). This is followed (Sect. 4) by a discussion of the results of the surveys, and (Sect. 5) by a comparative analysis of the perception of landslide and flood risk with known levels of the two risks to the population. We conclude (Sect. 6) summarizing the lessons learnt.

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2 Backround on risk perception

Kasperson et al. (1988) have argued that the investigation of risk is at the same time a science and an expression of culture. During his/her life, an individual is exposed to various risks, some of which are voluntarily (e.g., driving) and others are involuntary (Starr, 1969; Sunstein, 1997), or are not the direct result of a conscious choice made by the individual. Involuntary risks are associated typically to natural hazards, and others are generated, or intensified, by human actions or the lack of actions. Perception of risk depends to the subjective judgment and the evaluation of an individual of a specific risk (Renn, 1992, 2004; Rohrmann and Renn, 2000). However, what a person perceives as potentially dangerous (i.e., risky), another person may consider safe (i.e., free of risk). The mental models and the psychological mechanisms that people use to judge, evaluate, tolerate, and react to risks are complex, modulated by culture and the social environments, and are conditioned and constantly revised by information obtained from multiple sources, including the media, and by the influence of peers and others (Morgan et al., 2001).

Research on risk perception attempts to understand the choices made by an individual, or a group of individuals, to judge, evaluate, tolerate, and react to risk (Fromm, 2005). However, the criteria adopted by individuals to judge and evaluate different risks, and to decide to accept (or not accept) a risk, vary largely depending on multiple, general and local conditions and situations. Risk can be measured quantitatively, in terms of annual mortality (e.g., individual risk, Latter, 1969; Morgan, 1997; Cruden and Fell, 1997; WBGU, 1998; Jonkman et al., 2002), or defining the probability that a damaging event may occur (e.g., societal risk, Fell and Hartford, 1997). Quantitative risk assessment is typical of the natural sciences. In Italy, Guzzetti (2000) and Guzzetti et al. (2004) were first to obtain quantitative estimates of landslide and flood risk to the population, and Salvati et al. (2010, 2012) updated the estimates.

The social sciences typically investigate risk adopting a framework that incorporates technical, psychological, societal, and cultural aspects (Schmidt, 2004). In this frame-

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work, multiple individual and social characteristics mold the perception of risk of an individual, or a group of individuals, and influence the way individuals and groups judge, evaluate, tolerate, and react to a risk. The individuals may add other factors in their understanding of a risk, including the known or perceived catastrophic potential of the risk, the impartiality and the controllability of the risk, the apparent or real voluntariness or involuntariness of the risk, and the known, inferred, or perceived short and long term effects and consequences of the risk (Slovic, 1987).

Risk scientists have proposed two general approaches to investigate risk perception. A first approach is based on the cultural theory developed in sociology and social anthropology (Douglas and Wildavsky, 1982; Wildavsky and Dake, 1990; Rippl, 2002). A second approach adopts the psychometric model developed in psychology and decision research (Fischhoff et al., 1978; Slovic, 1987). Cultural theory focuses on the concept that risk is a social construct, and that each social group has its own set of risks and of criteria to judge, tolerated, and react to the risks. Based on these concepts, the theory categorizes individuals in groups based on broad cultural biases that can affect the perception of the risk. The groups include egalitarians, individualists, hierarchists, and fatalists (Marris et al., 1998; Tansey and O'Riordan, 1999). Conversely, the psychometric model, introduced in the 1970s (Fischhoff et al., 1978; Fromm, 2005), attempts to obtain cognitive maps of risk attitudes and perceptions (Slovic, 1987; Slovic et al., 1982) i.e., quantitative representations of the perception of the risk, using metrics, scalings, and statistics. In this context, the factors controlling risk perception are numerous, but the most relevant factors include: (i) the fear of a risk, (ii) the number of people affected by a risk, and (iii) the fact that risk is known or unknown. The psychometric paradigm can be used to explain how people judge a risk, and what are the factors that modulate the perception of the risk (Schmidt, 2004).

Multiple qualitative characteristics influence the perception of risk of an individual, or a group of individuals (Oltedal et al., 2004). These characteristics include voluntariness, controllability, distribution of risk and benefits, confidence in risk management, familiarity, personal experience, and the natural vs. human source of the risk. Percep-

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tion of a risk is reduced when the risk is voluntary (chosen), and it is increased when the risk is imposed (Renn, 1992; Jungermann and Slovic, 1993). For risks that have the same or similar consequences, or similar probabilities of occurrence, a voluntary (chosen) risk is generally more acceptable than an involuntary (imposed) risk. This is because individuals associate a voluntary risk to an expected benefit that balances the consequences of the risk. Further, an individual beliefs (or is convinced) to be able to control (and reduce) a voluntary risk and its consequences, regardless of the fact that this is possible or not, and risks perceived to be controllable are more acceptable that those perceived to be non-controllable. However, socio-psychological studies have shown that individuals tend to overestimate their ability to control a situation (a risk) (Sjoberg, 2000), resulting in an unrealistic optimism and the tendency to deny a risk (Weistein, 1980).

A risk perceived to be distributed fairly (impartially) in a group is more easily accepted than a risk perceived to be distributed unfairly (unequally) (Davy, 1996; Linnerooth-Bayer and Fitzgerald, 1996). In general, the least acceptable risks are those for which the consequences are sustained by a group of people, and a different group benefits from the (real or perceived) advantages. Also, risks perceived associated to a benefit are more easily accepted than risks perceived to have little or no benefit. In this perspective, the benefits serve as compensation for the risk.

Familiarity and habituation are additional factors that modulate risk perception. Familiarity indicates that an individual affected by a risk knows about the risk and its consequences. Habituation means that an individual is used to a risk. A risk present for a long period is attenuated (i.e., perceived as more acceptable) due to habituation, even if the risk remains unchanged (Slovic et al., 1986). Familiarity and habituation explain why a known risk is better accepted than an unknown risk. Familiarity is influenced by time and uncertainty. Delayed effects tend to reduce familiarity, whereas immediate effects intensify familiarity. Familiarity is further affected by the uncertainty of being exposed, or not exposed, to a risk. Individuals that know to be exposed to

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a risk become familiar with the risk more rapidly. Also, familiarity is more important for known than for unknown risks (Hazard and Seidel, 1993).

A difference exists in the perception of natural vs. human induced (e.g., technological) risks (Renn and Rohrmann, 2000). Human induced risks are usually more accepted than natural risks. In general, individuals are convinced that a risk posed by human actions (or the lack of actions) can be avoided or mitigated e.g., by a prudent behavior, appropriate actions, or by an improved knowledge about the risk. Conversely, risks posed by natural hazards (including landslides and floods considered in this work) are less accepted. Individuals, tend to perceive natural hazards as unavoidable, and believe that the consequences are largely independent on their abilities to cope with or to mitigate the risk.

3 The surveys

To evaluate the perception of natural risks in Italy, including landslide and flood risk, in collaboration with DOXA (www.doxa.it), a leading Italian company operating in the field of statistical research and opinion polls, we designed two surveys. For the surveys, we prepared two questionnaires designed to help the interviewees to consider first their general feelings about environmental and natural risks, and next their specific understanding of landslide and flood risk. The number of questions in the questionnaires, and the number of interviews in out two surveys, were conditioned by the resources available to execute the polls.

The questionnaires consisted of five questions (Table 1), and were designed to obtain information on: (i) the perception of natural, environmental, and technological risks, (ii) the direct experience or general knowledge of the interviewees on the occurrence of landslides and floods in the areas where they lived (i.e., the municipality of residence, or the surrounding areas), (iii) the perception of the possible threat posed by landslides and floods to the personal safety of the interviewees, (iv) the general knowledge of the interviewees on the number of victims caused by landslides or floods in the recent past,

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and (v) information on the natural and human-induced causes that control landslide and flood hazards and risks in Italy. We modified slightly the questionnaire used for the second survey (in 2013) based on the results of the first survey (in 2012). More specifically, in the 2013 questionnaire the question on the knowledge of the number of victims occurred in the previous five years was replaced by a new question on the causes influencing landslide and flood occurrence (Table 1).

DOXA executed the two surveys using their Computer Assisted Telephone Interview (CATI) system. This is an interactive front-end computer system designed to help interviewers to ask questions over the phone, and to record and organize the responses (Ketola and Klockars, 1999). The system is capable of adjusting a pre-defined questionnaire based on the answers obtained, and on information on the individual interviewees. To execute the two surveys, DOXA adopted their general-purpose "omnibus" sampling tool that selects statistically representative samples for quantitative research at the national scale (http://www.doxa.it/strumenti/doxabus/). The sampling strategy used a classification based on demographic variables, including: (i) the size and distribution of the population in each Italian region (Table 2), (ii) gender by age, (iii) education, and (iv) occupation. The sampling strategy exploited a national database to select the interviewees randomly from a pool of 15 000 Italian families. The pool of the families was different for the two surveys.

The first survey was conducted in the 19 day period between 12 and 30 January 2012, and consisted in 3122 telephone interviews of individual adults, 15 years old or older. The second survey was executed in the 18 day period from 17 January to 3 February 2013, and consisted in 3126 telephone interviews of adults, 15 years old or older. The size of the samples (approx. 3100 interviews) allowed for the segmentation of the analysis at the regional scale. For the purpose, in each region the number of interviews was proportional to the number of residents in the region (Table 2). For the Valle d'Aosta and the Trentino-Alto Adige regions, a specific oversampling strategy was adopted to guarantee statistically significant results. For the Basilicata, Molise, and Umbria regions the size of the samples was insufficient to obtain statistically significant

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results at the regional scale. DOXA estimated a sampling error of the results of ±2 %, with a confidence level of 95 %.

4 Results of the surveys

The first question (Q1 in Table 1) was formulated to rank the perception of the risks posed by natural hazards, including landslides, floods, earthquakes, and volcanic eruptions, against the perception of risk posed by road accidents and environmental pollution, two human induced (technological) risks. Results are summarized in Fig. 1. In 2013, people in Italy felt more exposed to technological than to natural risks, and specifically to environmental pollution (67 %, including 31 % of interviewees that felt "considerably" exposed and 36 % that felt "somewhat" exposed), followed by road accidents (55 %, 19 % "considerably" and 36 % "somewhat" exposed). The ranking was the same in 2012, with the interviewees that felt slightly less exposed to environmental pollution (65 %, of which 29 % "considerably" and 36 % "somewhat" exposed), and significantly more exposed to road accidents (65 %, of which 21 % "considerably" and 44 % "somewhat" exposed). For natural hazards, in 2013 the interviewees felt most exposed to earthquakes (45 %, 15 % "considerably" and 30 % "somewhat" exposed), followed by flooding (24 %, 7 % "considerably" and 17 % "somewhat" exposed), landslides (17 %, 5 % "considerably" and 12 % "somewhat" exposed), and volcanic eruptions (12 %, 5 % "considerably" and 7 % "somewhat" exposed).

The ranking for the natural hazards was the same in 2012, with slightly different percentages. A general increase in the number of interviewees that felt "considerably" exposed to the natural hazards (+3 % for earthquakes, +1 % for landslides, +1 % for floods), was paired by a decrease in the total number of interviewees that felt exposed to landslide or flood risk (i.e., the sum of the responses with "considerably" and "somewhat" exposed). Compared to 2013, in 2012 the interviewees felt slightly less exposed to earthquakes (42 %, 12 % "considerably" and 30 % "somewhat" exposed), slightly more exposed to flooding (27 %, 6 % "considerably" and 21 % "somewhat" exposed)

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and landslides (18 %, 4 % "considerably" and 14 % "somewhat" exposed), and equally exposed to volcanic eruptions (12 %, 4 % "considerably" and 8 % "somewhat" exposed). Considering the 2 % sampling error, we conclude that the 2013 survey revealed a slight decrease in the perception of landslide and flood risk, and a slight increase in the perception of earthquake risk. The perception of volcanic risk remained the same.

In 2013, the interviewees felt most exposed to landslides in Valle d'Aosta (39 % "considerably" and 17 % "somewhat" exposed) and in Calabria (16 % "considerably" and 26 % "somewhat" exposed), and most exposed to flooding in Liguria (21 % "considerably" and 28 % "somewhat" exposed) and in Calabria (18 % "considerably" and 28 % "somewhat" exposed). The regions with the smallest proportion of interviewees that felt exposed to landslides were Puglia and Lombardia, and to floods were Trentino-Alto Adige and Lombardia (Fig. 2). The regions where the number of interviewees that felt "considerably" exposed to landslide risk increased in 2013 compared to 2012 were Valle d'Aosta (+33 %), Sardegna (+6 %), Piemonte (+5 %), and Marche (+3 %). Similarly, the regions where the number of interviewees that felt "considerably" exposed to flood risk increased in 2013 were Valle d'Aosta (+9 %), Abruzzo (+7 %), Calabria (+7 %), Sardegna (+7 %), and Lazio (+3 %).

The trend was different for earthquakes. The destructive seismic sequence in Emilia-Romagna, with a first earthquake on 20 May 2012 (5.9 M_L), a second earthquake on 29 May 2012 (5.8 M_L), and aftershocks exceeding 5.0 M_L (Anzidei et al., 2012), conditioned the second (2013) survey. The earthquake caused 27 fatalities, at least 400 injured people, and up to 45 000 homeless, and raised significantly the perception of earthquake risk in Emilia-Romagna where 30 % of the interviewees felt "considerably" exposed to earthquake risk, an increase of 19 % compared to 2012. At the same time, the perception of landslide and flood risk decreased in the region. Interestingly, in 2013 the perception of earthquake risk increased in Abruzzo (26 % felt "considerably" exposed, +15 %), Calabria (33 %, +6 %), and Sicilia (26 %, +3 %). Campania and Sicilia were the regions where the interviewees felt more exposed to volcanic risk (25 % felt "considerably" and 26 % "somewhat" exposed in Campania, and 10 % "considerably"

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and 20 % "somewhat" exposed in Sicily). Campania and Sicilia host the most dangerous volcanic areas in Italy i.e., the Vesuvius Volcano and the Campi Flegrei, in the great Neapolitan area, in Campania, and the Etna Volcano and the Volcano Island, in Sicily.

The second question (Q2 in Table 1) attempted to determine the ability of the interviewees to evaluate the frequency or the likelihood of occurrence of the different natural hazards, including landslides, floods, earthquakes, and volcanic eruptions, in the general area where they lived. Results are summarized in Fig. 3, which shows the results of both surveys, for the 20 regions and for the whole of Italy. At the national scale, earthquake was the natural hazard that, in 2013, the interviewees felt was more likely in their area (41 %), followed by flooding (30 %), landslides (10 %), and volcanic eruptions (2 %). The ranking was the same and the percentages were only slightly different in 2012 (39 % earthquakes, 31 % floods, 9 % landslides, 4 % volcanic eruptions). For both surveys, 15 % of the interviewees felt that none of the listed hazards was likely of frequent in their area.

The interviewees considered earthquakes particularly likely in the Marche (69 % in 2013, 61 % in 2012), Umbria (60 %, 68 %), Basilicata (64 %, 63 %), Abruzzo (68 %, 57 %), Molise (62 %, 51 %), and Friuli-Venezia Giulia (59 %, 57 %) regions (Fig. 3). These are the regions that have experienced severe earthquakes in the last decades (between 1976 and 2009), and that are considered at high or very high seismic risk (Bertolaso and Borchi, 2007; Boncio et al., 2007; Cucci et al., 1996). In the Emilia-Romagna region, northern Italy, the percentage of interviewees that considered likely an earthquake increased from 48 % in 2012 – before the May–June 2012 seismic sequence (Anzidei et al., 2012) – to 73 % in 2013. Calabria and Sicilia, southern Italy, are areas where seismic risk is known to be high or very high (Slejko et al., 1998, http://zonesismiche.mi.ingv.it/), and where the proportion of interviewees that considered likely an earthquake was somewhat reduced (50 % in 2013 and 41 % in 2012 in Calabria, 51 % in 2013 and 47 % in 2012 in Sicilia). The reasons for this outcome can be manifold, including the relatively long period without a destructive earthquake in the two regions. The last destructive earthquakes in the area were the 28 December 1908,

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7.1 M_W Messina and Reggio Calabria earthquake and subsequent tsunamis, that have killed more than 120 000 people in NE Sicily and southern Calabria, and the 14–15 January 1968, 5.5 M_W Belice earthquake in W Sicily, that has caused more than 300 fatalities (Boschi et al., 1995). On 9 September 1998, a 5.5 M_W earthquake hit Basilicata and the northern part of Calabria, causing moderate damages, and no fatalities. The regions where the least number of interviewees considered an earthquake likely were Sardinia (1 %, 2 %) and Valle d'Aosta (9 %, 6 %). These regions are considered at low seismic risk in Italy (Slejko et al., 1998).

Inundations were considered frequent and likely by interviewees in Sardegna (65 % in 2013, 71 % in 2012) and Liguria (65 %, 65 %), followed by Valle d'Aosta (43 %, 48 %), Veneto (45 %, 42 %), and Toscana (41 %, 40 %). Conversely, only a small proportion of the interviewees in Molise (8 %, 2 %) considered an inundation likely. Landslides were deemed frequent and likely by interviewees in Valle d'Aosta (39 %, 35 %), Trentino-Alto Adige (27 %, 42 %), and Calabria (16 %, 19 %). Interestingly, in most of the regions inundations were considered (much) more frequent and likely than landslides (Fig. 3). This is despite the fact that landslide fatalities and landslide mortality are larger than flood fatalities and mortality (Table 3). Volcanic activity was considered likely only by interviewees in Campania (18 % in 2013, 23 % in 2012) and in Sicilia (10 %, 6 %). These are the two regions where volcanic risk is known to be high. Interestingly, a small number of interviewees considered a volcanic eruption likely even in municipalities located far away from any active volcano, and where volcanic risk is not present.

The third question (Q3 in Table 1) was specific for landslide and flood risk, and attempted to determine if the interviewees had a direct experience or an indirect knowledge of the occurrence of landslides or floods in in the general area where they lived. Overall, in 2013, 27 % of the interviewees were aware of an inundation (24 % in 2012), and 13 % of a landslide (14 % in 2012) occurring in their municipality. Only 8 % (7 % in 2012) of the interviewees responded that they were aware of both flood and landslide events in their municipality, or in the vicinities (Fig. 3). The result indicates that the majority of the interviewees (52 % in 2013, 55 % in 2012) had no direct experience or

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indirect knowledge of landslide or flood events occurring in the area where they lived. This is in contrast with the large abundance and frequency of landslides and floods in Italy. Guzzetti et al. (1994) have identified more than 37 000 sites affected by more than 61 000 landslide or flood events in Italy in the 73-year period 1918–1990. All the Italian provinces have experienced recursively landslides or floods, and of the total number of 8103 municipalities (in 1998), 6475 (79.9 %, 91 % of the territory) have experienced at least once a landslide or a flood (Guzzetti and Tonelli, 2004). At the regional scale, the percentage of interviewees that were aware of an inundation in their municipality was largest in Valle d'Aosta (65 % in 2013, 43 % in 2012), followed by Liguria (50 %, 34 %), Veneto (48 %, 36 %), Toscana (42 %, 29 %), and Piemonte (40 %, 39 %). Similarly, the percentage of the interviewees aware of a landslide occurring in their municipality was largest in Basilicata (49 %, 16 %) and Molise (30 %, 40 %), and large in Calabria (29 %, 32 %), Marche (27 %, 13 %), Trentino-Alto Adige (20 %, 31 %), Umbria (20 %, 23 %), and Campania (20 %, 21 %).

Inspection of Fig. 3 reveals that for some of the regions where there was an increase in the awareness of floods, there was a corresponding decrease in the awareness of landslides (i.e., Valle d'Aosta, Liguria, Veneto, Abruzzo, Calabria). The increased percentages for Toscana, Lazio, and Umbria may be the result of the serious flooding in November 2012 in central Italy that caused six fatalities and damage exceeding €700 million. Similarly, the large increase for Liguria (+16 %) is probably a consequence of repeated flooding events in the autumn of 2012.

The fourth question (Q4 in Table 1) was designed to determine if the interviewees considered landslides and floods a threat to their personal safety. In 2012, the interviewees were given two possible choices i.e., "yes", I consider landslides or floods are threat to my personal safety, or "no", I do not consider landslides or floods are threat to my personal safety. In 2013, the question was modified, so that when the response was "yes", the interviewees were asked to specify if they felt threatened by landslides, floods, or both, one option did not exclude the other.

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In 2013, 41 % of the interviewees considered landslides and floods to be a threat to their personal safety (Fig. 3). The proportion was lower (35 %) in 2012. We explain the increase in the number of people that considered landslides and/or floods a personal threat in 2013 with the severe events occurred in the period 2011–2012, which caused a total of 58 fatalities, 48 injured people, and more than 5000 homeless people (http://polaris.irpi.cnr.it/), and the related coverage of the events by the media. At the regional scale, the percentage of the interviewees that considered landslides or floods a threat to their personal safety was largest in Liguria (66 % in 2013, 61 % in 2012), followed by Calabria (63 %, 40 %), Basilicata (79 %, 33 %), Campania (54 %, 41 %), Veneto (46 %, 31 %), Valle d'Aosta (48 %, 30 %), and Sicilia (45 %, 48 %). In 12 of the 20 Italian regions floods were perceived a greater threat than landslides. In some of these regions the difference between the fear of floods and of landslides exceeded 20 % e.g., 31 % in Liguria, 27 % in Veneto, and 25 % in Sardegna. Interviewees in southern Italy feared more landslides than floods, whereas in northern Italy interviewees perceived flooding more dangerous than landslides (Fig. 3). Overall, Lombardia was the region where the interviewees perceived the least to be threatened by landslides or floods. This is despite a history of damaging landslide and flood events in this region. In Lombardia, the last severe event occurred in November 2002, when landslides and floods caused severe damage to infrastructures and building, more than 7000 were the evacuees and three people died due to landslides. The lack of highly damaging events in the most recent years can explain the reduced perception of the threat. The geographical distribution of the population in the region, which concentrates in urban and sub-urban areas, also contributes to the reduced perception of the threat.

Sex and age modified the perception of being threatened by a landslide or a flood (Fig. 4). In 2013, the women (42 %) felt more threatened than the men (40 %). The percentages were different in 2012, when the women (33 %) felt less threatened than the men (38 %). In 2013, 45 % of the young interviewees (34 years old or younger) felt threatened by landslides or floods. The percentage reduced to 42 % for the adults (35 to 54 years old), and to 37 % for the seniors (55 years old or older). The percentages

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changed in 2012, but the relative proportions remained the same, with 41 % of the young interviewees, 40 % of the adults, and 27 % of the seniors that felt threatened by landslides or floods. The latter result may be conditioned by familiarity and habituation, and the knowledge of the risks (Slovic et al., 1986; Hazard and Seidel, 1993).

The fifth question was different in 2012 and 2013 (Table 1). In 2012, the interviewees were asked ($Q5_{2012}$) to evaluate the total number of casualties (dead, injured and missing people) caused by landslides and floods in Italy in the previous five years i.e., in the period from 2007 to 2011. Of all the interviewees, only 58 % responded to this question, the 42 % said that they did not know. Analysis of the responses revealed that the interviewees overestimated largely the total number of casualties caused by landslides and floods, which in the five-year period 2007–2011 totaled 140. The majority of the respondents estimated the number of casualties to exceed 400 (21 %), or to be in the range between 201 and 400 (12 %).

Given the poor quantitative understating of the impact of landslides and floods on the population, we changed this question, and in the 2013 survey ($Q5_{2013}$ in Table 1) the interviewees were asked to select the factor(s) that they considered important to control or condition landslide and flood risk in Italy. More specifically, the interviewees were asked to select from a list of five possible factors affecting landslide and flood risk, including (a) inappropriate land management, (b) landscape characteristics, (c) abandoning of the territory, (d) illegal construction ("abusiveness"), and (e) climate change. In addition, the "do not know" answer was listed. Of the 94 % of the interviewees that selected one or more of the proposed factors, 28 % considered inappropriate land management as the main cause for landslide and food risk in Italy. This was followed by illegal construction (25 %), the abandonment of the territory (16 %), and climate change (16 %). Interestingly, only 9 % of the interviewees considered landscape settings as a factor contributing to landslide and flood risk. Inspection of Fig. 5 reveals that the responses given by the interviewees varied geographically. Most of the respondents in northern and central Italy, considered the inappropriate land management the primary cause of landslide and flood risk. In southern Italy, with the exception of

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Basilicata, “abusiveness” (illegal constructions) was the single factor considered most important for landslide and food risk. Indeed, many houses and buildings were constructed illegally (i.e., without proper permits) in southern Italy, increasing significantly the geo-hydrological risk to the population. Later, most of these houses and buildings became legal through specific legislations. Interestingly, in Trentino-Alto Adige (45 %) and Valle d’Aosta (30 %) the respondents considered climate change (i.e., a largely natural cause) the main factor controlling landslide and flood risk. In these regions – and especially in Trentino-Alto Adige – land management is a priority, and efforts are made and resources are invested to mitigate geo-hydrological risks.

5 Comparison of perceived and actual flood and landslide risk

It is worth comparing the perception of flood and landslide risk in Italy probed by our two surveys, to quantitative assessments of flood and landslide risk available at the synoptic scale in Italy (Guzzetti et al., 2005a, b; Salvati et al., 2010, 2011) (Table 3). We perform the comparison using maps and specifically designed cartograms. Cartograms are maps in which the sizes of the geographic subdivisions, such as the administrative regions used in our study, appear in proportion to a numerical attribute e.g., the population (Dorling, 1996; Gastner and Newman, 2004). To deform the size of the regions, we adopted the diffusion-based method proposed by Gastner and Newman (2004). This method deforms the shape and size of a region using a numerical approach derived from the linear diffusion process of elementary physics. The individual regions are deformed (stretched, enlarged, reduced) in such a way that the density of the population (or the density of any other numerical attribute) is the same for all the regions. Using this method, a region with a larger population is expanded, and a region with a smaller population is shrunk. The method produces “density-equalizing maps” (cartograms) that maintain the geographical relationships between the regions, facilitating their visual interpretation (Gastner and Newman, 2004).

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For our comparison, we prepared two sets of maps and cartograms. Figure 6 shows the geographical distribution of the responses given to question 4 (Q4 in Table 1), in the 2013 survey. Maps A and B in Fig. 6 portray the (non-deformed) Italian regions colored based on the percentage of the interviewees that considered landslides (A) and floods (B) a threat to their safety. Cartograms C (for landslides) and D (for floods) show the same information using the same legend and color scheme used for maps A and B, but with the regions deformed based on the size of the population of each region (Table 2). As a result, the most populated regions (e.g., Lombardia, Lazio, Campania) are larger, and the least populated regions (e.g., Valle d'Aosta, Molise, Basilicata, Umbria) are reduced. Cartograms E (for landslides) and F (for floods) show the same information, but were obtained deforming the regions on the percentage of the respondents to Q4, and coloring each region based on the size of the population in the region. In Fig. 7 we show the geographical distribution of landslide and the flood risk in Italy measured by (i) the number of fatal landslide (A) and flood (B) events, (ii) the number of landslide (C) and flood (D) fatalities, and (iii) the average landslide (E) and flood (F) mortality in the 50 year period 1964–2013. Mortality is the yearly average number of deaths per 100 000 people (Guzzetti et al., 2004). The cartograms in Fig. 7 were obtained deforming the regions based on the size of the population. Collectively, the maps and the cartograms in Fig. 6 give a quantitative overview of the geographical distribution of the perception of landslide and flood risk in Italy, and the cartograms in Fig. 7 give the geographical distribution of different and complementary measures of landslide and flood risk to the population of Italy.

In Italy, landslide risk to the population is largest in Campania, Piemonte, and Trentino-Alto Adige (Fig. 7, Table 3). Due to the reduced size of the population (Table 2), landslide mortality is also large in Valle d'Aosta and significant in Basilicata. In Liguria landslide mortality is significant as a result of the number of fatalities compared to the size of the population. Visual inspection of Fig. 6 reveals that the perception of landslide risk, measured by the percentage of interviewees that considered landslides a threat to their safety (Q4 in Table 1), was largest in Campania, Basilicata and Cal-

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abria, and large in the Marche region. Thus, only in Campania landslide risk is high (in terms of mortality, number of fatalities, and number of fatal events, Fig. 7) and the perception of the risk was also high (Fig. 6). In Liguria, where landslide mortality is significant, the perception of the risk was also significant. In Piemonte and Trentino-Alto Adige, where landslide risk to the population is high (Fig. 7), the perception of the risk was moderate (Trentino-Alto Adige) or low (Piemonte). This can be a result of habituation and familiarity (Hazard and Seidel, 1993). Conversely, in Basilicata and Calabria where the perception of the risk was very high, landslide risk to the population was moderate. We attribute the result to the several landslide events – fortunately without severe fatal consequences – that have occurred in the two regions in the last few years. In the regions where landslide risk is low, in terms of mortality and the number of fatalities (e.g., Molise, Puglia, Lazio), the perception of the risk was intermediate, and not low. In Friuli-Venezia Giulia, where the proportion of the interviewees that considered landslides a personal threat was lowest (7 %, Fig. 7), landslide risk is moderately low.

Inspection of Fig. 7b, d and f and Table 3 reveals that the three metrics used to evaluate flood risk to the population of Italy are less consistent than for landslides (Fig. 7a, c and e). The number of fatal flood events is largest in Piemonte and Sicilia, is large in Toscana, and is smallest in Abruzzo and Molise (Fig. 7b). The number of flood fatalities is largest in Piemonte and Sicilia, large in Liguria and Toscana, and smallest in Marche, Abruzzo, and Molise (Fig. 7d). Flood mortality is largest in Piemonte, Liguria, Sardegna, Valle d'Aosta, and Trentino-Alto Adige, and smallest in Abruzzo, Emilia-Romagna, Lombardia, and Molise (Fig. 7f). In Valle d'Aosta and Trentino-Alto Adige flood mortality is very large due to the reduced size of the population in the two regions. The same occurs in Basilicata, where flood mortality is severe. High mortality in Liguria and Sardegna is due to the large number of fatalities compared to the size of the population. Inspection of Fig. 6 reveals that the perception of flood risk, measured by the percentage of the interviewees that considered floods a personal threat (Q4 in Table 1), was largest in Veneto, Liguria, Sardegna and Calabria, and large in Piemonte, Valle d'Aosta, Toscana and Puglia. Thus, only in Liguria and Molise the actual flood

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risk (large for Liguria and very low for Molise, Fig. 7) matches the perception of the risk (Fig. 6). In the other regions there exists – more or less significant – differences between the actual flood risk (Fig. 7) and the perception of the threats (Fig. 6). We note that some of the regions where the perception of flood risk was highest (Campania, Liguria, Veneto) were affected repeatedly by flood (and landslide) events in the recent years.

We conclude that, with a few exceptions (e.g., Campania for landslides and Liguria for floods) the perception of the threat posed by landslides and floods does not match necessarily the actual risk to the population of Italy, measured by landslide and flood mortality, and by the number of landslide and flood fatalities (Figs. 6 and 7, Table 3).

6 Conclusions

In 2012 and 2013, we executed two surveys to investigate the perception of landslide and flood risk in Italy. The surveys were performed interviewing through telephone calls approximately 3100 adults, using pre-defined questionnaires. Analysis of the responses showed that people in Italy feel more exposed to technological risks (environmental pollution and car accidents) than to natural risks. This was expected (Renn and Rohrmann, 2000). Of the natural risks, people in Italy feel more exposed to earthquakes, followed by floods, landslides, and volcanic eruptions. This is in general agreement with the societal risk levels posed by the different hazards (Guzzetti et al., 2005b; Salvati et al., 2012). Analysis of the temporal and the geographical variations of the responses indicated that the occurrence of recent events influences the perception of the risks, and that the perception of the risks decreased more rapidly for landslides and floods, and persisted longer for earthquakes. We attribute the difference to the different consequences and frequency of the risks (Slovic et al., 1986; Slovic, 1987; Hazard and Seidel, 1993).

Inappropriate land management was considered the main cause for landslide and food risk in Italy, followed by illegal construction, abandonment of the territory, and cli-

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mate change. However, the responses varied geographically. If in northern and central Italy, inappropriate land management was considered the primary cause of landslide and flood risk, in most of southern Italy "abusiveness" (illegal constructions) is the factor considered most important to control the risk.

Comparison of the perception of the risks with metrics of actual landslide and flood risk, including the number of fatal events, the number of fatalities, and mortality, revealed that the perception of the threat posed by geo-hydrological events does not match necessarily the risk posed by landslides and floods to the population of Italy. This points to the need for renewed actions to foster the knowledge and improve the understanding that the population of Italy has of the geo-hydrological hazards and their risks (Morgan et al., 2001).

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Table 1. Questions listed in the questionnaires used to determine the perception of flood and landslide risk in Italy, in 2012 and 2013. The original questions in Italian are in italic. The * symbol indicates the questions posed in 2012 and 2013.

2012	2013		Question
?	?	Q1	How much do you feel exposed to each of these risks: (a) landslide, (b) flood, (c) earthquake, (d) volcanic eruption, (e) road accident, (f) environmental pollution? Possible answers: (1) considerably exposed, (2) somewhat exposed, (3) little exposed, (4) not exposed. *Quanto pensa di essere esposto a ciascuno di questi rischi: (a) frana, (b) inondazione, (c) terremoto, (d) eruzione vulcanica, (e) incidente stradale, (f) inquinamento ambientale? Possibili risposte: (1) molto, (2) abbastanza, (3) poco, (4) per niente.*
?	?	Q2	Among these natural events (a) landslide, (b) flood, (c) earthquake, (d) volcanic eruption, which you believe to be most frequent or most likely to occur in the municipality where you live or nearby? Possible answers: (1) landslide, (2) flood, (3) earthquake, (4) volcanic eruption, (5) none of these, (6) I don't know. *Tra questi eventi naturali (a) frana, (b) inondazione, (c) terremoto, (d) eruzione vulcanica, quale crede essere il più frequente o il più probabile che avvenga nel comune dove lei vive o nelle vicinanze? Possibili risposte: (1) frana, (2) inondazione, (3) terremoto, (4) eruzione vulcanica, (5) nessuno di questi, (6) non so.*
?	?	Q3	Do you have direct knowledge, because involved, or indirect information of a landslide or a flood occurred in the municipality where you live or nearby? Possible answers: (1) yes, a landslide, (2) yes, a flood, (3) yes, both, (4) no. *Lei è venuto a conoscenza diretta, perché coinvolto, o indiretta, perché ne ha avuto notizia, di in una frana o di un'alluvione avvenuta nel territorio comunale dove lei risiede, o nelle vicinanze? Possibili risposte: (1) si frana, (2) si alluvione, (3) si, entrambe, (4) no, nessuna notiza.*
?	?	Q4	Do you think that geo-hydrological events such as landslides and floods can be a real threat to your personal safety? Possible answers: (1) yes, (2) no. If yes, (1a) yes, a landslide, (1b) yes, a flood (one option do not exclude the other). *Lei ritiene che eventi idrogeologici quali le frane e le alluvioni possano essere una minaccia reale alla sua incolumità personale? Possibili risposte: (1) si, (2) no. Se si, (1a) si, una frana, (1b) si, una alluvione (sono possibili entranbe le opzioni).*
?		$Q5_{2012}$	Do you think that in the last five years in Italy victims caused by geo-hydrological events, includind landslides and floods have been: (1) between 10 and 100, (2) between 100 and 200, (3) between 200 and 400, (4) more than 400, (5) I don't know. *Lei ritiene che negli ultimi cinque anni in Italia le vittime causate da eventi idrogeologici quali le frane e le alluvioni siano state: (1) tra 10 e 100, (2) tra 100 e 200, (3) tra 200 e 400, (4) oltre 400, (5) non so.*
	?	$Q5_{2013}$	In your opinion, which of the following factors have the most influence in the occurrence of landslides and floods: (a) inappropriate land management, (b) landscape characteristics, (c) abandoning the territory, (d) illegal construction ("abusiveness"), (e) climate change, (f) I don't know. *Secondo lei, quale tra i seguenti fattori influisce maggiormente nel verificarsi di frane ed alluvioni: (a) errata gestione del territorio, (b) caratteristiche del territorio, (c) abbandono del territorio, (d) abusivismo edilizio, (e) cambiamenti climatici, (f) non so.*

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Table 2. Total number and percentage of telephone interviews performed in each region, for the 2012 and the 2013 surveys. Right two columns give the total population (millions) and the percentage of the population in each Region (source: istituto Italiano di Statistica, ISTAT, http://www.istat.it). A cross (†) marks regions where oversampling was performed to obtain statistically significant results. An asterisk (∗) marks regions for which the number of interviews was insufficient to obtain statistically significant results.

Region		Interviewees (2012)		Interviewees (2013)		Population (2012)	
		[#]	[%]	[#]	[%]	[#]	%
Piemonte	PIE	230	7.4	200	6.4	4.358	7.3
Valle d'Aosta (†)	VDA	93	3.0	87	2.8	0.127	0.2
Lombardia	LOM	496	15.9	514	16.4	9.701	16.3
Trentino Alto Adige (†)	TAA	85	2.7	73	2.3	1.030	1.7
Veneto	VEN	249	8.0	255	8.2	4.854	8.2
Friuli Venezia Giulia	FVG	63	2.0	77	2.5	1.218	2.1
Liguria	LIG	77	2.5	86	2.8	1.567	2.6
Emilia Romagna	EMR	223	7.1	229	7.3	4.341	7.3
Toscana	TOS	220	7.0	202	6.5	3.668	6.2
Umbria (∗)	UMB	49	1.6	49	1.6	0.883	1.5
Mare	MAR	90	2.9	82	2.6	1.541	2.6
Lazio	LAZ	226	7.2	275	8.8	5.500	9.3
Abruzzo	ABR	60	1.9	68	2.2	1.306	2.2
Molise (∗)	MOL	25	0.8	21	0.7	0.313	0.5
Campania	CAM	242	7.8	279	8.8	5.764	9.7
Puglia	PUG	212	6.8	161	5.2	4.050	6.8
Basilicata (∗)	BAS	39	1.2	45	1.4	0.578	1.0
Calabria	CAL	113	3.6	115	3.7	1.958	3.3
Sicilia	SIC	259	8.3	236	7.5	5.000	8.4
Sardegna	SAR	71	2.3	72	2.3	1.638	2.8
Italy		3122	100	3126	100	59.394	100

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Table 3. Total number of fatal events and of fatalities caused by landslides and floods in the 20 Italian regions in the 50 year period 1964–2013. Average landslide and flood mortality rates in the period are also given.

Region		Landslides			Floods		
		Events	Fatalities	Mortality	Events	Fatalities	Mortality
Piemonte	PIE	50	134	0.062	64	130	0.060
Valle d'Aosta	VDA	12	25	0.423	4	5	0.085
Lombardia	LOM	39	118	0.027	26	35	0.008
Trentino Alto Adige	TAA	50	351	0.800	26	32	0.077
Veneto	VEN	24	71	0.034	21	25	0.012
Friuli Venezia Giulia	FVG	8	11	0.018	16	31	0.051
Liguria	LIG	16	37	0.043	34	88	0.101
Emilia Romagna	EMR	2	49	0.025	11	15	0.008
Toscana	TOS	28	64	0.039	49	88	0.051
Umbria	UMB	8	15	0.038	9	14	0.035
Mare	MAR	8	9	0.013	8	10	0.014
Lazio	LAZ	15	24	0.010	14	27	0.011
Abruzzo	ABR	6	8	0.013	3	5	0.008
Molise	MOL	0	0	0.000	1	1	0.006
Campania	CAM	87	293	0.106	22	29	0.011
Puglia	PUG	6	12	0.006	15	30	0.016
Basilicata	BAS	5	15	0.049	7	13	0.043
Calabria	CAL	18	37	0.037	10	28	0.028
Sicilia	SIC	20	67	0.027	66	130	0.054
Sardegna	SAR	10	14	0.021	31	45	0.061
Italy		412	1354	0.089	437	781	0.037

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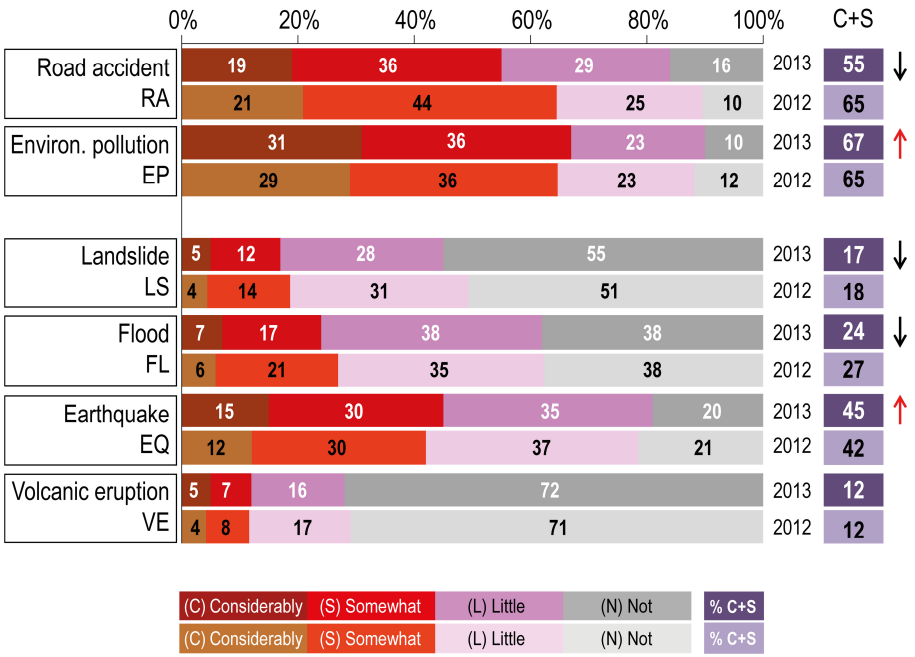

Fig. 1. Answers to Question 1 (Q1: How much you feel exposed to each of these risks: (a) landslide, (b) flood, (c) earthquake, (d) volcanic eruption, (e) road accident, (f) environmental pollution?), at the national scale, and for the 2012 and the 2013 surveys. Horizontal bars show the percentage of interviewees that responded to be (C) "considerably", (S) "somewhat", (L) "little", or (N) "not" exposed to natural hazards, including landslides (LS), floods (FL), earthquakes (EQ), and volcanic eruptions (VE), to road accidents (RA), and to environmental pollution (EP). Black (red) arrows show a reduction (increase) in the percentages in 2013, compared to 2012. See Table 1 for the questions and the list of the possible answers.

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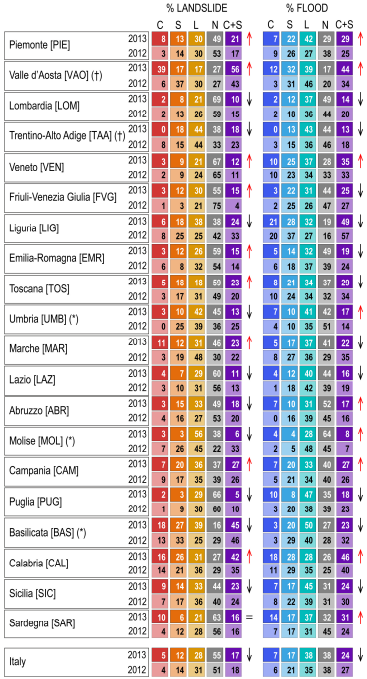

Fig. 2. Answers to Question 1 (Q1: How much you feel exposed to each of these risks: (a) landslide, (b) flood), per region and for Italy, and for the 2012 and the 2013 surveys. Colours show percentage of interviewees that responded to be (C) "considerably", (S) "somewhat", (L) "little" or (N) "not" exposed to landslides or floods. The cumulated percentage of interviewees that responded to be "considerably" or "somewhat" exposed (C + S) is also given. Black (red) arrows show a reduction (increase) in the percentages in 2013, compared to 2012. A cross (†) marks regions where oversampling was performed to obtain statistically significant results. An asterisk (∗) marks regions for which the number of interviews was insufficient to obtain statistically significant results. See Table 1 for the questions and the list of the possible answers.

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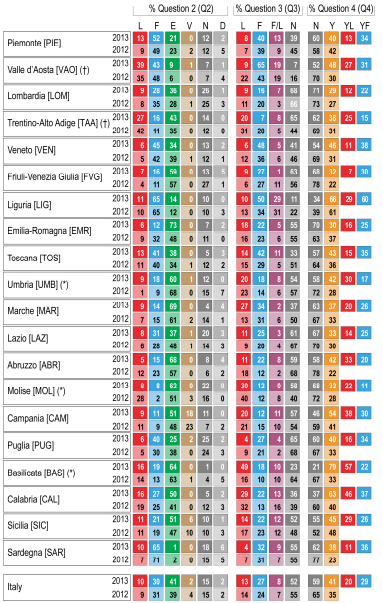

Fig. 3. Answers to Question 2 (Q2: Among these natural events: (a) landslide, (b) flood, (c) earthquake, (d) volcanic eruption, which you believe to be most frequent or most likely to occur in the municipality where you live, or nearby?), Question 3 (Q3: Do you have direct knowledge, because involved, or indirect information of a landslide or a flood occurred in the municipality where you live, or nearby?), and Question 4 (Q4: Do you think that geo-hydrological events such as landslides and floods can be a real threat to your personal safety?), per region and for Italy, for the 2012 and the 2013 surveys. Colours show percentage of the responses. Legend: L, landslide; F, flood; E, earthquake; V, volcanic eruption; N, None; D, I don't know; F/L, landslides and floods; Y, yes; N, no; YL, yes landslides; YF, yes floods. A cross (†) marks regions where oversampling was performed to guarantee statistically significant results. An asterisk (∗) marks regions for which the number of interviews was insufficient to obtain statistically significant results. See Table 1 for the questions and the list of the possible answers.

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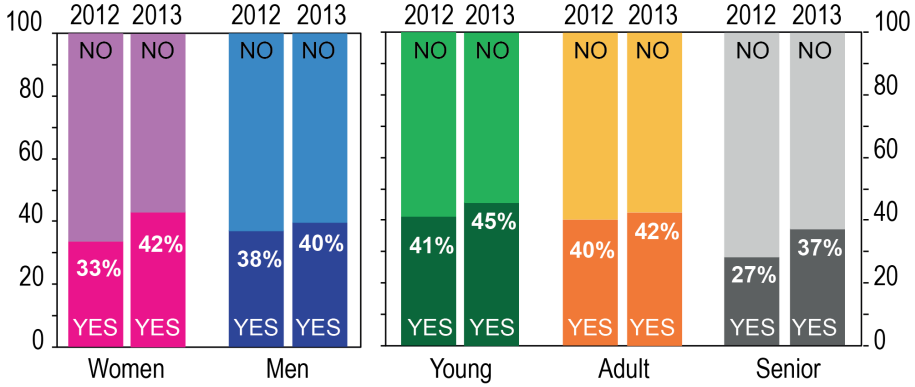

Fig. 4. Bar charts show percentage of answers "yes" and "no" to Question 4 (Q4: Do you think that geo-hydrological events such as landslides and floods can be a real threat to your personal safety?), per sex and age, for the 2012 and 2013 surveys. Young (15 to 34 years old). Adult (35 to 54 years old). Senior (55 years old or older). See Table 1 for the question and the list of the possible answers.

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	a	b	c	d	e	f
Piemonte [PIE]	31	12	17	20	16	4
Valle d'Aosta [VAO] (†)	23	9	18	15	30	5
Lombardia [LOM]	29	7	20	24	15	5
Trentino-Alto Adige [TAA] (†)	21	10	6	18	45	0
Veneto [VEN]	35	8	15	23	13	6
Friuli-Venezia Giulia [FVG]	20	13	27	17	17	6
Liguria [LIG]	31	8	6	29	19	7
Emilia-Romagna [EMR]	28	11	17	21	16	7
Toscana [TOS]	27	9	24	18	17	5
Umbria [UMB] (*)	26	10	15	17	19	13
Marche [MAR]	27	11	13	22	22	5
Lazio [LAZ]	31	7	13	27	17	5
Abruzzo [ABR]	25	13	15	21	17	9
Molise [MOL] (*)	29	8	18	37	8	0
Campania [CAM]	25	7	17	28	16	7
Puglia [PUG]	17	9	8	38	25	3
Basilicata [BAS] (*)	31	23	8	27	7	4
Calabria [CAL]	26	11	20	26	14	3
Sicilia [SIC]	24	13	10	33	15	5
Sardegna [SAR]	34	5	15	26	9	11
Italy	28	9	16	25	16	6

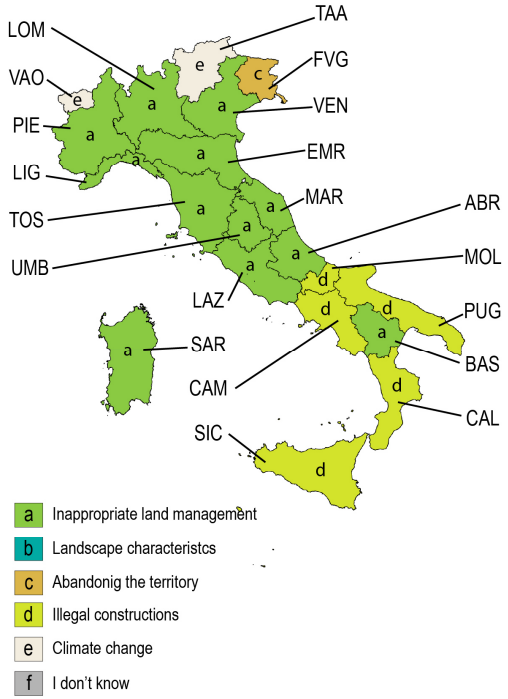

Fig. 5. Answers to Question 5 (Q5: In your opinion, which of the following factors have the most influence in the occurrence of landslides and floods), per region and for Italy, for the 2013 survey. Table shows the percentage of the responses for the different considered factors. Map shows the factors with the largest percentage of responses, for each region. Colours in the map match colours in the table. Considered factors: (a) illegal construction ("abusiveness"), (b) inappropriate land management, (c) climate change, (d) landscape characteristics, (e) abandoning the territory, (f) I don't know. A cross (†) marks regions where oversampling was performed to guarantee statistically significant results. An asterisk (∗) marks regions for which the number of interviews was insufficient to obtain statistically significant results. See Table 1 for the question and the list of the possible answers.

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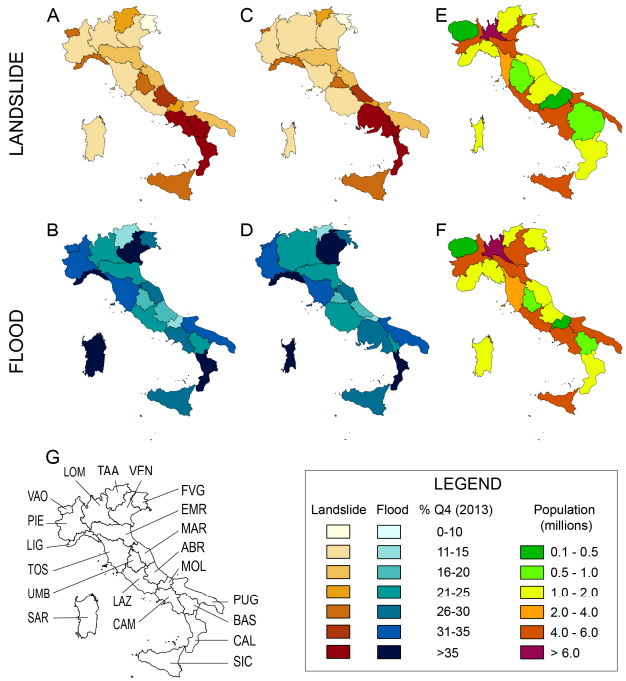

Fig. 6. Geographical distribution of the responses to Question 4 (Q4: Do you think that geo-hydrological events such as landslides and floods can be a real threat to your personal safety?) for landslides (shades of brown) and floods (shades of blue), in the 20 Italian regions. Shade of colours portray the percentage of the respondents that felt threated by landslides or floods, in each region (in 2013). Maps (A) and (B) show the true size and shape of the 20 Italian regions. Cartograms (C) and (D) prepared deforming the regions based on the total population in each region (in 2013). Cartograms (E) and (F) prepared deforming the regions based on the percentage of the respondents that felt threated by landslides or floods (in 2013), and coloured on the size of the population in each region (in 2013). Map G gives the true size and shape of the 20 Italian regions, for reference.

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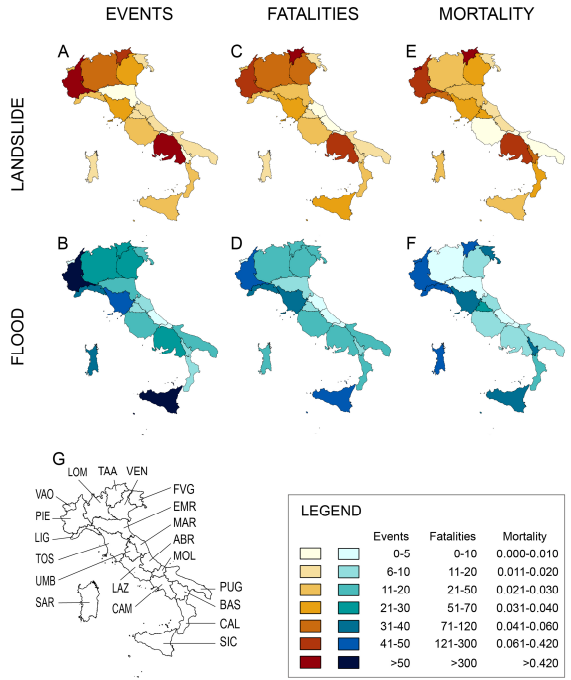

Fig. 7. Cartograms showing landslide and flood risk in the 20 regions in Italy, measured by the number of fatal landslide (A) and flood (B) events, the number of landslide (C) and flood (D) fatalities, and the average landslide (E) and flood (F) mortality, in the 50-year period 1964–2013. See Table 3. Cartograms prepared deforming the regions based on the size of the population in each region (in 2013). Map G gives the true size and shape of the 20 Italian regions, for reference.

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