CHAPTER 7

ENVIRONMENTAL RISK

NATURAL RISK
ANTHROPOGENIC RISK

Introduction

The definition of environmental risk must take into account the interaction between risks of natural origin and anthropogenic risks, as regards the vulnerability and value of the resource exposed to danger.

The human species has always been exposed to a large number of dangers caused by natural events, such as volcanic eruptions, earthquakes, tidal waves, floods, drought, landslides, etc. Given the massive human interventions in the environment, it is difficult, or even impossible, today, to distinguish between risks of natural origin and anthropogenic risks. Moreover, on the one hand, the development of new and powerful technologies applied to the production of energy, goods and services has considerably improved the quality of our life. On the other hand, new sources of so far unknown hazards have emerged.
The definition of environmental risk must therefore take into account the interaction between such risks, as regards the vulnerability and value of the resource exposed to danger, In fact, the risk (R) is the product of the following three parameters: $R = P * V * E$, where P indicates the hazard level, that is the probability that a given event will occur at a given magnitude in a given area and within a certain interval of time, V indicates vulnerability, that is the liability of a resource exposed to suffer a damage as a consequence of given calamitous event, and E indicates the exposure, that is the value of the full set of elements at risk inside of the exposed area. Risk is expressed in terms of economic value of the potential risk for human lives, infrastructures, historic, architectonic, cultural and environmental resources.

The seismic risk and the hydro-geological risk have been the most recurrent in Italy, in the period 2008-2009.

For reasons of clarity, in the present chapter the risk of natural origin is treated separately from anthropogenic risk. Among the risks of natural origin, it has been decided to address the topics of seismic risk and hydro-geological risk, which have been the most recurring events, in Italy, in the period 2008-2009.
It should be noted that the components of natural risk addressed herein directly involve the geo-sphere, while the components of anthropogenic risk regard industrial activity.

NATURAL RISK

Natural events can be either of exogenous or endogenous origin.

Natural events that are likely to give rise to conditions of risk can be subdivided into two main categories of underlying causes: events of endogenous origin (including for instance volcanic eruptions, earthquakes, etc.), set off by forces within the earth, and

those of exogenous origin (including floods, landslides, avalanches, etc.), occurring on the terrestrial surface. The magnitude and frequency of such events may range within a wide scale. Certain phenomena tend to occur in a sudden and extreme way, while others operate more slowly and continuously (subsidence is a typical example). Both types of events are likely to cause serious damages on man and human interests and activities.
The concept of natural risk should, therefore, be understood as an interaction between the processes of instability that "naturally" occur in the territory remodelling its shape, and human assets, whether physical or economic, social or environmental. The interaction between the natural events referred to above and anthropic activities is reciprocal: inappropriate modes of use and management of the territory frequently result in an amplification of disturbances underway or in the triggering of new ones.

An inappropriate use of the territory by man may amplify disturbances underway or trigger new ones.

Seismic risk

The specific location of Italian territory within the Mediterranean geodynamic setting (convergence of the European and African plates, interposition of the Adriatic micro-plate, presence of the Apennine chain, opening of the Tyrrhenian basin) make Italy one of the countries facing the greatest seismic danger. A similar level of hazard, combined with the widespread presence of exposed elements (urban centres, infrastructures, and the architectonic, artistic and environmental heritage), and the noteworthy vulnerability of the same, creates conditions of high to very high risk for extensive sectors of Italian territory. The areas facing the greatest seismic risk are found in the Friuli area, along the central-southern spine of the Apennine range and especially in the sectors of the inter-Apennine basin, along the Calabrian edge of the Tyrrhenian and in Southeast Sicily (Figure 7.1).

Italy faces one of highest levels of seismic hazard of any European country.

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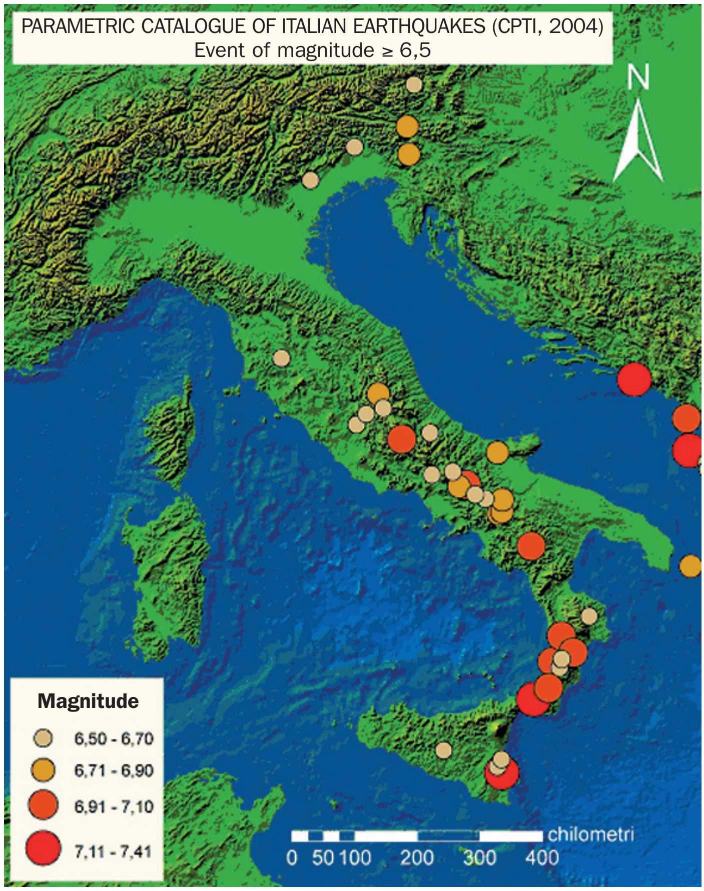

Figure 7.1: Distribution throughout the national territory of the major seismic events of the past (magnitude≥ 6.5)[1]

Seismic events of local magnitude (ML) greater than 2, occurred on the national territory from January 1st 2008 to September 30th 2009, are shown in Figure 7.2. The figure also shows the main characteristics of earthquakes of local magnitude ML >5. In 2008, only three events exceeded such threshold: one occurred not far from the Calabrian coast, with a noteworthy depth of the epicentre,

[1] Source: Parametic Catalogue of Italian Earthquakes – INGV data processed by ISPRA

which caused no significant damage; two other events occurred in the Frignano area, where they caused damages to some bell towers, churches, and some structures, toppling chimneys and eaves. No damages to people were registered.
In 2009, the most significant events occurred in the area of L'Aquila. The seismic event of April 6th of ML = 5.8 and Mw = 6.3, caused 300 victims and serious damages to buildings, as well as to the artistic and cultural heritage. More than 50 municipalities in the Abruzzi have suffered damages that have rendered part of the buildings unfit for habitation, with the consequence that the Civil Protection Agency has had to provide for 171 emergency camps.

Seismicity creates conditions of very high risk in Italy. The event occurred in L'Aquila on April 6th caused over 300 victims and serious damages to buildings and to the artistic and cultural heritage.

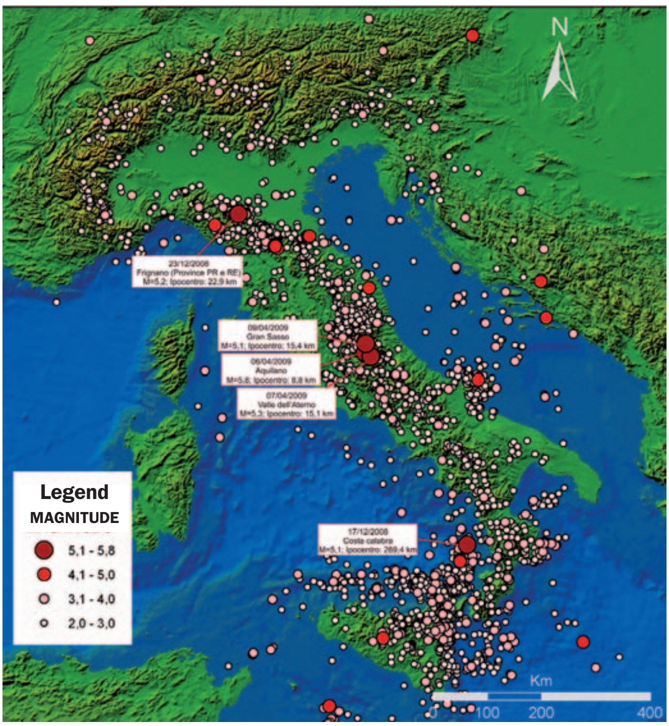

Figure 7.2: Main seismic events registered from January 1st 2008 to September 30th 2009[2]

[2] Source: INGV data processed by ISPRA

The seismic crisis in the area of L'Aquila (April 2009)

On April 6th 2009, at 3:33 a.m., the town of L'Aquila and surrounding areas were stricken by an earthquake of magnitude Ml 5.8 (Mw 6.3).

The sequence of the major events involved an area of about 30 km².

On April 6th 2009, at 3:33 a.m., the town of L'Aquila and surrounding areas were stricken by an earthquake of magnitude Ml = 5.8 (Mw= 6.3). The epicentre was located some kilometres southward. Other two events of M > 5 occurred on the following day (ML = 5.3; epicentre located between Fossa, San Martino d'Ocre and San Felice d'Ocre, about 10 km southeastward from L'Aquila), and after two days (ML = 5.1; epicentre located near Campotosto, about 15 km northwestward from L'Aquila). Such events of greater magnitude were preceded by hundreds of *foreshocks* of lesser magnitude, following one after another since January 2009, and were followed by several *aftershocks*. The sequence of major events involved an area of about 30 km², extended in northwest-southeast direction (Figure 7.3). The hypocentral depths registered generally range between 10 and 12 kilometres, except for the event of April 7th, whose epicentre was located at a depth of 15 km. Focal mechanisms of the seismic sequence clearly show the presence of a normal fault extended in northwest-southeast direction.

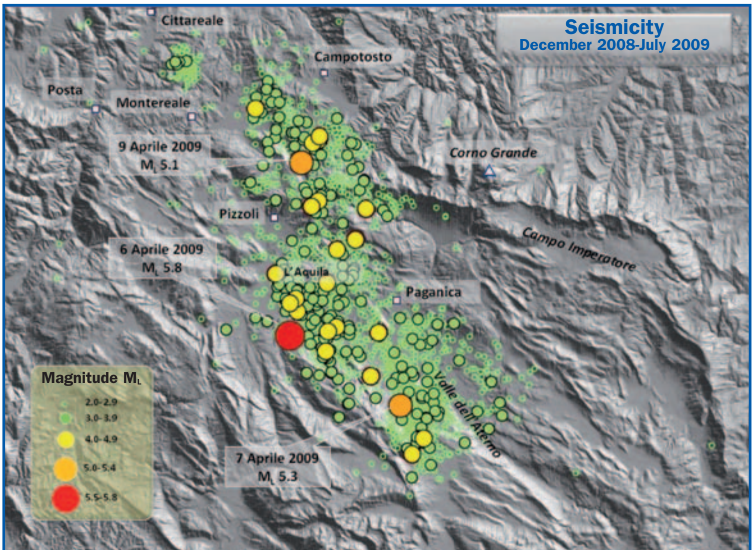

Figure 7.3: Location of the seismic sequence in the area of L'Aquila from December 2008 to July 2009[3]

[3] Source: INGV data processed by ISPRA

The scenery of damaged buildings – as results from data collected by the Quick Earthquake Survey Team (QUEST) – has immediately appeared to be irregular. The most damaged area extends in the northwest-southeast direction, and the peak value of macroseismic intensity (I ≥ 9 MCS) has been registered only in certain sites located in less severely damaged areas, with I ≤ 8 MCS. Such peak values seem to have been caused by the local seismic vulnerability, in some cases combined with evident site effects (for example, Onna and other villages in the Aterno valley, located on recent non-consolidated alluvial sediments). The epicentral area had already been stricken in the past by seismic events with moderate to high intensity. In 1461 and 1703, two earthquakes occurred with X MCS intensity. Moreover, the same area was stricken in 1349 by other two destructive events with IX-X MCS intensity, and in 1762 with IX MCS intensity. The 1703 earthquake was characterised by a long sequence of three main events following one after the other in a span of a few days, which occurred along a direction oriented north-northwest-south-southeast: the first earthquake, on January 14th (I= XI MCS), had its epicentre in Norcia and caused the destruction of many sites in southern Umbria; the second one, on January 16th (I=VIII MCS), hit a restricted area between Montereale, Cittareale, Accumuli and Amatrice; the third seismic event, occurred on February 2nd (I= X MCS), and destroyed the town of L'Aquila, killing 2,500 residents. This event caused surface faulting along the Pizzoli fault, as well as considerable secondary effects, including the deep-seated gravity deformation of Monte Marine, not far from Pizzoli, the huge landslide at Villa Camponeschi, near Posta, as well as liquefaction phenomena in the Aterno valley, near the Pizzoli mill.

The epicentral area had already been stricken in the past by other seismic events with moderate to high intensity.

Effects induced by the April 6th earthquake on the environment

The paroxysmal event of April 6th (Mw = 6.3) produced a number of effects on the physical environment, both primary (surface faulting) and secondary (slope movements, fractures, liquefaction phenomena, hydrological anomalies). Here follows a summary of the detailed report on these phenomena and their distribution on the territory[4].

ISPRA detected about 200 seismic-induced effects, over an area of about 1,000 square kilometres (extending far beyond the epicentral area).

[4] Blumetti A.M., Comerci V., Di Manna P., Guerrieri L. e Vittori E. of ISPRA (with the cooperation of some researchers of the Italian National Research Council (CNR) and of the University of the Insubria) available for consultation on the site http://www.apat.gov.it/site/_files/Inqua/2009_abruzzo_earthquake_report.pdf

Following such event, ISPRA detected about 200 seismic-induced effects, over an area of about 1,000 square kilometres (extending far beyond the epicentral area). Near Paganica, just a few kilometres east of L'Aquila, a set of discontinuous fractures was found on the ground, with a regular alignment in the N120-N140 direction. Such fractures extend for 2.6 kilometres, and present up to 10 cm dip-slips, and openings a few centimetres wide. They represent an evident intersection with the fault topographic surface associated with the earthquake (Figures 7.4 and 7.5), with a deep greater linear extension.

The fault plane along which the earthquake occurred produced a surface rupture of the soil near Paganica. Such surface faulting, indicated by the red line in the figure, can be easily detected for a length of 2.6 kilometres.

Figure 7.4: Surface rupture of the Paganica fault[5]

The rupture of the Gran Sasso aqueduct caused the opening of a trench.

The displacement occurred along such alignment on the occasion of the earthquake caused the pipeline rupture of the Gran Sasso aqueduct, and the consequent leakage of such a huge mass of water under pressure, that the jet of water (the pipeline has a diameter of 70 cm, and a capacity of 500 litres per second) dug a trench in just a few hours (shown in Figure 7.5).

[5] Source: ISPRA

Figure 7.5: The Gran Sasso aqueduct[6]

The Gran Sasso aqueduct restored, after the damages caused by surface faulting-induced displacement. The red line indicates the fracture caused by the earthquake of April 6th 2009.

Some ground fractures were found along the Paganica fault, that, during the months following the main event, have undergone an evolution, in terms of a progressive increase in the width initially observed.

Inspections were also been carried out along the other faulting areas, finding evidence of slight reactivation (of a few centimetres), near Bazzano, Pettino and Roio, most likely due to mere seismic shaking.

Seismic shaking also induced a great number of secondary effects.

Seismic shaking also induced a great number of secondary effects. Along the calcareous slopes, several landslides (fall type) have occurred, with the falling of plurimeter-sized rocks causing damages to dwellings, as well as the closure of important roads. Impressive collapses have occurred near Fossa (Figure 7.6), along the SS 17 road at San Venanzio gorges, along the SS 696 at San Potito, the Paganica-Camarda at S.ta Maria d'Apparì, and at the access road to the Stiffe cave, near San Demetrio ne' Vestini. Following the shock, Lake Sinizzo's shorelines collapsed almost all along its subcircular perimeter (Figure 7.7).

Lake Sinizzo's shorelines slided down, following the earthquake of April 6th, almost all along the perimeter.

[6] Source: ISPRA

The landslide swept away the village located downstream of the road shown in the figure, damaging buildings and motor vehicles.

Figure 7.6: Landslide (fall type) near Fossa[7]

Lake Sinizzo's shorelines (municipality of San Demetrio ne' Vestini, AQ) slided down, following the earthquake of April 6th, almost all along the perimeter.

Figure 7.7: Lake Sinizzo's shorelines[8]

[7] Source: ISPRA
[8] Source: ISPRA

Some liquefaction phenomena were also identified: sand boils were observed inside a borrow pit near the industrial area of Bazzano and Vittorito (near Sulmona).
Furthermore, hydrologic variations were registered: near Tempera, wells have suffered a dramatic decrease in their water capacity, or even dried up; in others, water became temporarily muddied.
Some springs completely dried up, others suffered from variations in their capacity, and in some cases, springs were also found hundreds of meters far from the original location.

Some liquefaction phenomena and hydrologic variations were also identified.

Measurement of co-seismic deformations using satellite data

The effects produced on the ground by a seismic event can also be evaluated using satellite data, such as for instance GPS (Global Positioning System) measurements and SAR (Synthetic Aperture Radar) data processing.
Measurements provided by permanent GPS stations, are a powerful instrument for the identification of ground deformations of tectonic and volcanic origin. Several networks especially devised for geodetic and geodynamic research are presently operating on the national territory.
In the case of L'Aquila earthquake, data provided by permanent GPS stations activated in the Abruzzi territory by public agencies, research institutes (ASI, CNR, INGV, ISPRA, DPC), public local administrations (Abruzzi Region, Umbria Region) and private bodies, were particularly useful to evaluate co-seismic deformations produced by the mainshock.
Some of the nearest stations to the epicentre belong to the GPS network activated by ISPRA in co-operation with the Civil Protection Agency.
The aim of this network is to evaluate the elastic deformation rate accumulated near the faults considered as active in the Gran Sasso area, as well as the relation between the active deformation rate obtained and the slip rates associated with faulting systems, on the basis of paleoseismological, geological and geomorphologic studies.
Preliminary processing of GPS data provided by permanent and non-permanent stations - measured in the days following the main-

The effects produced on the ground by a seismic event can also be evaluated by applying methods based on the use of satellite data.

shock – allowed to define the fault geometry responsible for the main dislocation, and to identify ground displacements produced by the earthquake of April 6th (Figure 7.8).

The bigger Figure shows planimetric displacements (blue and red arrows: displacements detected by GPS stations; yellow arrows: displacements calculated by the hypothesised fault model). In the box: vertical displacements observed (blue) and calculated (yellow), the red rectangle indicates the surface projection of the fault resulting from the inversion of GPS data (normal fault dipping SW at 50°).

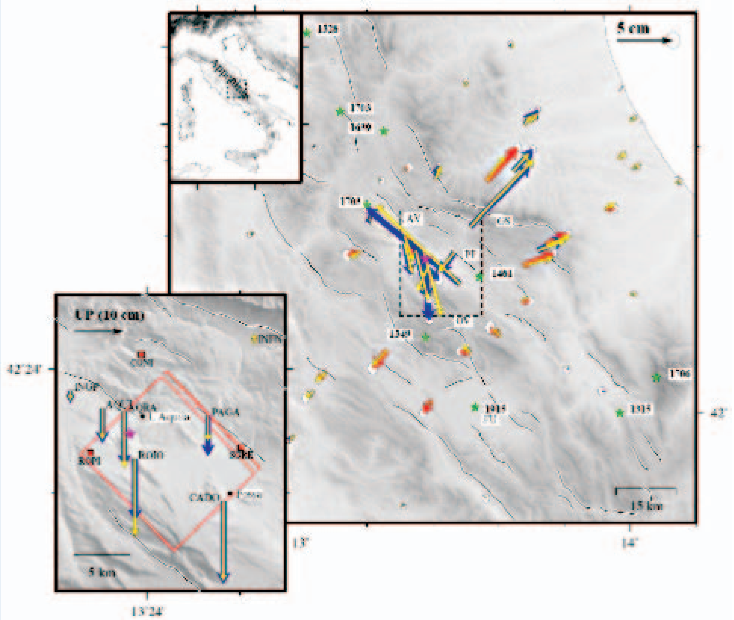

Figure 7.8: Co-seismic displacements induced by the earthquake of April 6th 2009 (Mw 6.3)[9]

Radar data analysis integrated with information available on ground deformations produced by the main shock.

Radar data analysis, integrated with information available on ground deformations produced by the main shock, provides information - in agreement with GPS data (about 28 cm near the Bazzano built-up area) – about the distribution of ground deformations over the territory surrounding the epicentral area. The maximum ground displacement, along the satellite line of sight (LOS), estimated from SAR data, is about 25 cm, as shown in Figure 7.9, where each one of the concentric elliptical fringes shows a displacement of about 29 millimetres.

[9] Source: Cheloni *et al.*, 2010

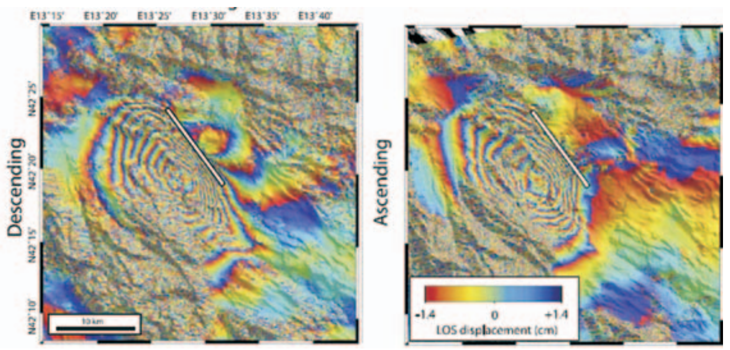

Figure 7.9: Envisat interferograms[10]

Envisat interferograms with the surface projection of the fault plane model.

Solutions

To limit risk situations, attentive planning and the introduction of adequate regulatory instruments are called for.

Seismic activities are outcomes of the planet's natural dynamics, meaning that there is little that man can do to control them. Nevertheless, conditions of risk can be significantly reduced through careful territorial planning and the introduction of legislative instruments that place limitations on the use of the soil and/or set technical-engineering standards. In order to arrive at effective risk mitigation, therefore, it is indispensable that the emergency approach, based on after-the-fact responses, be replaced with initiatives combining forecasting and prevention.

Forecasting can be carried out through specific studies of risk-prone areas, in order to determine the return period probability of events, while prevention mostly consists of making appropriate planning choices, as well as selecting and applying technical procedures designed on the basis of the knowledge obtained.

In terms of seismic risk, less vulnerable buildings should be constructed in areas exposed to this risk.

In terms of seismic risk (for the definition of risk, see the Introduction), although it is not possible to reduce the hazard component, less vulnerable buildings should be constructed in areas exposed to this risk. The seismic classification of the national territory can thus be a precious tool. Having been significantly reinforced, following the 1980 earthquake in Irpinia and, more recently, after the earthquake of 2002 in the Region of Molise, by the issue of Ordinance no. 3274 of 20 March 2003 and no.

[10] Source: R.J. Walters *et al.*, 2009

3519 of 28 April 2006 by the Prime Minister, the classification reflects the state of the art as far as knowledge of seismic risk in Italy is concerned, and presently refers to the seismic hazard map of the national territory drawn by the National Institute of Geophysics and Vulcanology (Figure 7.10). The seismic classification map provides an updated overview of the Italian territory, subdivided into 4 areas characterised by different levels of seismic hazard (Figure 7.11), each one needing the application of appropriate anti-seismic regulations for the construction of buildings and other public works. The Ordinance no. 3519/2006 – while asserting that the new classification has to be based on the actual basic seismic hazard of the territory, regardless of administrative limits and constraints – has however provided regions with appropriate criteria to be followed for the correct classification of municipalities according to seismic hazard level. The Decree 14/01/2008 issued by the Ministry of Infrastructures, defining the new building regulations, opened a new transitional phase, that is supposed to end by June 30th 2010, in which the project architect can refer either to the previous regulation (2004 Seismic Classification plus subsequent modifications, Figure 7.11) or to the Technical Rules. These rules are, in fact, the new reference regulation for anti-seismic engineering, directly based on the "basic seismic hazard", that is on the INGV seismic hazard map (Figure 7.11). In this map, values of maximum ground acceleration a_g are given for the points of a reference grid whose nodes are located at distance not exceeding 10 km (0,05° grid), and for various probabilities of occurrence over 50 years and/or different return periods TR.

The seismic classification map provides an updated overview of the various areas of Italian territory characterised by different levels of seismic hazard.

Unfortunately, a large part of the buildings in our country do not comply with anti-seismic standards, both because the stock of structures from the past has only rarely been upgraded to meet the current anti-seismic regulations, and because the marked urban expansion from the post-war period to the present suffers from a lack of attentive territorial planning, as well as the all too frequent, and deplorable, tendency to build in violation of construction codes.

The noteworthy vulnerability of the Italian building heritage is a structural problem that needs a long time to be solved, as well as the adoption of a hard policy of interventions to be planned on a national scale.

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This map presents seismic hazard in terms of maximum ground acceleration, with a 10% probability of exceedance over 50 years on rigid terrain (Vs_{30} > 800 m/s; cat. A, point 3.2.1 of DM 14/09/2005).

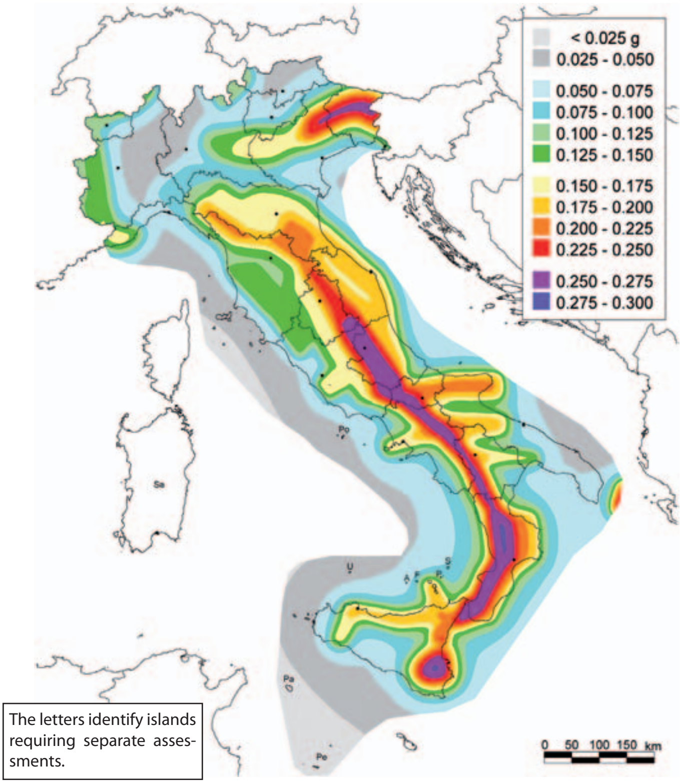

Figure 7.10: Seismic hazard map of the national territory (2004)[11]

as the adoption of a hard policy of interventions to be planned on a national scale. Nevertheless, low cost or even cost free interventions could be implemented in terms of providing information and promoting population's direct involvement. An interesting episode occurred in the province of Frosinone in October 2009, when L'Aquila earthquake was still alive in memory. The area between Campoli Appennino and Posta Fibreno was hit by a long low magnitude seismic series (3.5 maximum local magni-

[11] Source: Ordinance no. 3519 of 28 April 2006 by the Prime Minister, Attachment. 1b Reference seismic hazard for the national territory

The seismic classification map shows Italian municipalities subdivided into four seismic areas of decreasing seismic hazard, from area 1 to area 4; these areas correspond to four classes of maximum ground acceleration presenting a 10% probability of occurrence over 50 years.

The 3S area (created for the Tuscany Region by Regional Decree no. 431/06) is based on a precautionary principle under which the municipalities in the area, classified as facing "low seismic hazard", nevertheless follow the anti-seismic planning criteria indicated for medium seismic hazard areas (S2).*

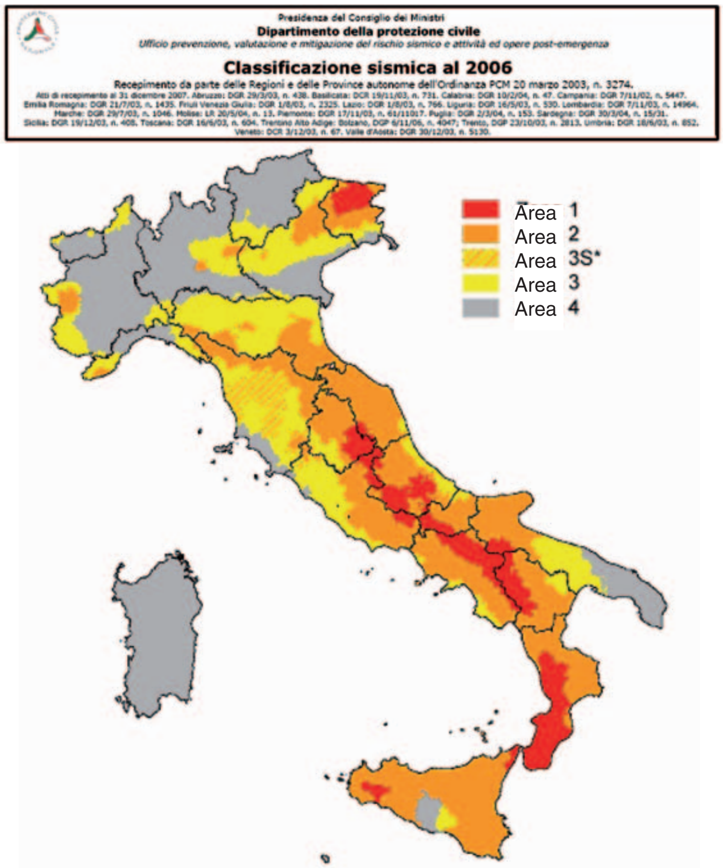

Figure 7.11: Seismic classification map[12]

tude). The apprehension and concern manifested by the citizens induced the Civil Protection Agency to set up a tent camp in the local sports ground, in order to shelter all those who considered their buildings unfit for habitation, being unsafe from the seismic point of view. Not only this is certainly a low cost operation: it also produces a great number of positive effects. In fact, the presence of a civil protection centre not only provides a lot of

[12] Source: Civil Protection Agency

citizens with a safe place to spend the night, it also helps to raise the awareness (or at least to raise the question) of the risk threatening all those who live in buildings that do not comply with anti-seismic standards. Since in any case public resources are inadequate to apply anti-seismic reinforcements to private building heritage, citizens themselves must become aware of their actual exposure to danger, in order to act personally and directly, according to one's means. In the best case scenario, a deeper awareness of the seismic risk could even become a deterrent from violation of construction codes applying anti-seismic standards. Risk awareness obviously leads to a growing demand for information by the citizens, which can even save human lives, provided it is punctual and effective. Indeed, the dissemination of accurate information can help to prevent wrong choices that could prove fatal.

The dissemination of accurate information can help to prevent wrong choices that could even prove fatal.

Last October, the apprehension for earthquake hazard in the province of Frosinone induced local government bodies to monitor the level of security in schools. As a result, several school buildings (for example, in the municipalities of Arpino, Sora, Veroli, etc.) were closed, and school activities were moved in more secure locations. The outcomes of the seismic monitoring carried out on public buildings of the Lazio Region, in the period 2004-2008, show a lot of high-risk school buildings (65.7% of all the monitored facilities). The state of alert of last October raised local bodies' awareness, encouraging more sensible behaviours. Focusing on these issues gives therefore positive results. A multiplicity of knowledge tools is available. Studies have been carried out by local agencies, regional government bodies (such as the one before mentioned), as well as by the Civil Protection Agency (for example, the 1999 Vulnerability map of public, strategical and special buildings in the regions of Abruzzo, Basilicata, Calabria, Campania, Molise, Apulia, and Sicily) on the vulnerability of public buildings, that should be taken into due consideration by local administrations in order to guarantee citizens' security.

The outcomes of the seismic monitoring carried out on public buildings of the Lazio Region, in the period 2004-2008, show a lot of high-risk school buildings (65.7% of all the monitored facilities).

Other simple precautions could also be taken in everyday life, in order to reduce one's vulnerability, such as, for instance, turning

gas off before going to bed, sleeping in the most secure area of one's home (where load-bearing beams or walls are located), eliminate libraries, bookcases and shelves from the walls near one's bed, sleeping as far as possible from windows, identifying possible forms of protection, such as a sturdy table to find shelter beneath. In Japan, for example, people always carry their own *bousai-bukuro*, that is an anti-seismic backpack, ready for use, containing a torch, some water, canned food, biscuits, working gloves, a dust mask, and if necessary other small useful things.

Geologic-hydraulic risk

The situation

Landslides and flooding are among the most frequent natural disasters in the Italian territory, causing serious damages both in terms of victims and loss of material goods. The way in which they tend to occur depends on the heterogeneous character of natural environment, as well as on the variability of the parameters related to natural processes.

In Italy the particular climatic conditions, the dynamics of hydraulic disturbances in mountain areas, combined with a peculiar geological-structural situation, determine the occurrence of disastrous events.

In consideration of the above, in Italy the particular climatic conditions (alternate long dry seasons and rainfall periods, sometimes even with intense precipitation), the hydraulic conditions in mountain areas, combined with a peculiar geological-structural situation, determine the occurrence of disastrous events. In fact, in mountainous areas and mountainsides of hydrographic basins (characterised by steep slopes often with no vegetation), erosion is particularly intense, generating surface runoff (with large amounts of materials transported), while alluvial plains are more often affected by the occurrence of extensive flooding (also due to the reduction of clear surfaces), sometimes with flash floods. Since 2002, ISPRA has carried out a systematic study on the main floods that have occurred in Italy from the post-war period to the present, publishing pluviometric data, plus information on types of flooding, numbers of individuals involved and urgent measures adopted to face the disturbances. Information analysed by ISPRA is recorded in the Environmental Yearbook database (2009 edition), containing data about the main events occurred during

2008 and 2009 (updated to October 2nd 2009), reporting data on victims, on total estimated damage, and on total estimated damage compared to GDP. The informations listed (indicating the period and location of flooding events), have been taken from the reports published by the main Italian media, while the data of figures on number of deaths and total estimated damage have been taken from ISTAT, CNR, Civil Defence Department, ARPA and local govenrment bodies.
During 2008, the precipitation trend has been generally negative, with scarce precipitation until autumn, with the beginning of a period of particularly intense precipitation lasted from November to February, characterised by average rainfall exceeding the normal seasonal trends for Italy.
Figures 7.12 and 7.13 show, respectively, data on victims and on total damage compared to GDP produced by flooding between 1951 and 2009 (updated to October 2nd). In particular, Figure 7.13 shows - with the exception of some sporadic events occurred around the 90's - a general downward trend in damage as compared to GDP until 2008 (figures for 2009 - presumably higher on account of the events occurred in the province of Messina – are not yet available). This could be attributed not only to an improvement in systems for safeguarding the territory and risk reduction, but also to a natural variability in the intensity and duration of events. Generally speaking, the severity of damages is also influenced by parameters related to territorial management, including anthropization, modifications of river courses, modifications of land use, etc.

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A series of widespread landslide phenomena, evolved into rapid mudslides and detritus flows, occurred in October 2009 in the province of Messina. caused 31 deaths and 6 missing.

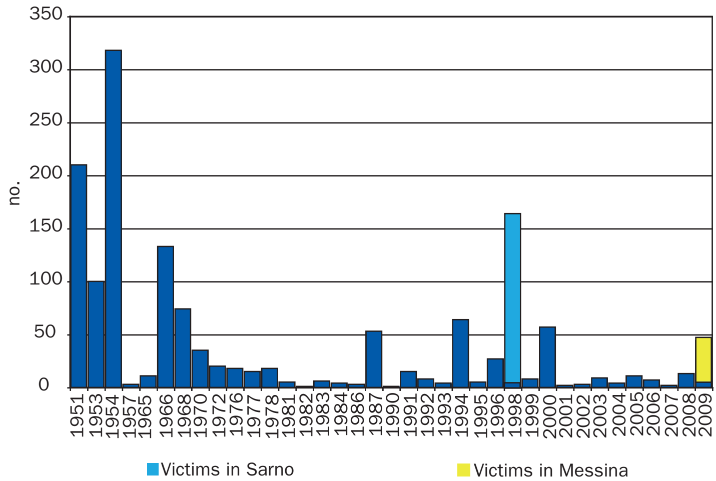

Figure 7.12: Victims of the main floods in Italy from 1951 to October 2009[13]

With the exception of some sporadic events occurred around the 90's - a general downward trend in damage as compared to GDP until 2008 has been registered. Figures for 2009 - presumably higher on account of the events occurred in the province of Messina – are not yet available.

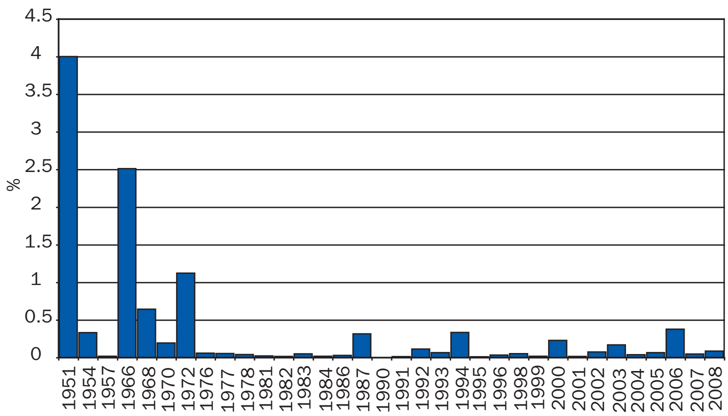

Figure 7.13: Estimated economic damage compared to GDP, for main flood events occurred in Italy from 1951 to 2008[14]

[13] Source: Main Italian media data processed by ISPRA
[14] Source: Official sources (ISTAT, CNR, Civil Protection Agency, ARPA and local government bodies) data processed by ISPRA

The estimated economic damage amounts to over 7 billions euros for the last nine years (included 2009 partial data). This parameter is also influenced by the course of socio-economic and demographic development, whose demands have resulted in a use of the territory that does not always respect its natural role, or rather the evolutionary processes under way.
Landslides present an even more complex scenario, due to multiple combinations of geological, morphological and climatic factors that – interacting with anthropic activities - give rise to phenomena which vary greatly in terms of type, kinetic properties, ongoing development and extension of the areas involved. In terms of landslide, Italy presents an especially high risk on account of its morphological characteristics (75% of the national territory is mountainous-hilly). Landslides are the natural disasters that occur with the greatest frequency and, after earthquakes, cause the greatest number of victims and the most damage to urban areas, infrastructures and environmental, historical and cultural heritage. In the last twenty years alone, catastrophic events have occurred in the Val Pola (1987), in Piedmont (1994), in Versilia (1996), in Sarno and Quindici (1998), in Northwest Italy (2000) and in Val Canale - Friuli Venezia Julia (2003). A census carried out under the IFFI Project (Italian Landslide Inventory) has identified 485,004 landslides involving an area of 20,721 km^2, equal to 6.9% of the national territory. This Inventory – updated to December 2007 - has been carried out since 1999 by the Italian Geological Service (since 2002 by APAT, now ISPRA), in co-operation with regional governments and autonomous provinces, for the purpose of identifying and mapping landslides on the basis of a standardised and widely accepted approach.
The landslide index, equal to the ratio between the area subject to landslides and the total surface area, calculated using a grid size of 1 km, provides an overview of the distribution of landslides in Italy (Figure 7.14). The data on Basilicata, Calabria and Sicily tend to underestimate the actual situation of instability, because surveys of landslide events carried out to date have focused on areas where urban centres or major transport infrastructures are located. Data gathered by the IFFI Project show that the most frequent types of movement (classified on the basis of the preva-

Italy presents an especially high risk of landslide, on account of its geological and morphological characteristics (75% of the territory is mountainous-hilly).

In Italy, more than 485,000 landslides have been identified, involving an area of over 20,700 km^2.

Not all landslides present the same level of hazard. Landslides with extremely rapid movement and involving noteworthy volumes of rock or soil cause the greatest damage and number of victims.

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lent component of the movement) are rotational/translational slide, at 32.4%, slow earth flow, at 15.6%, rapid debris flow, at 14.5%, and complex landslides, at 11.3%. A large number of landslides present renewed activity over time; quite often, dormant periods of a number of years, or even centuries, alternate, during extreme meteorological events, with periods of remobilisation, as

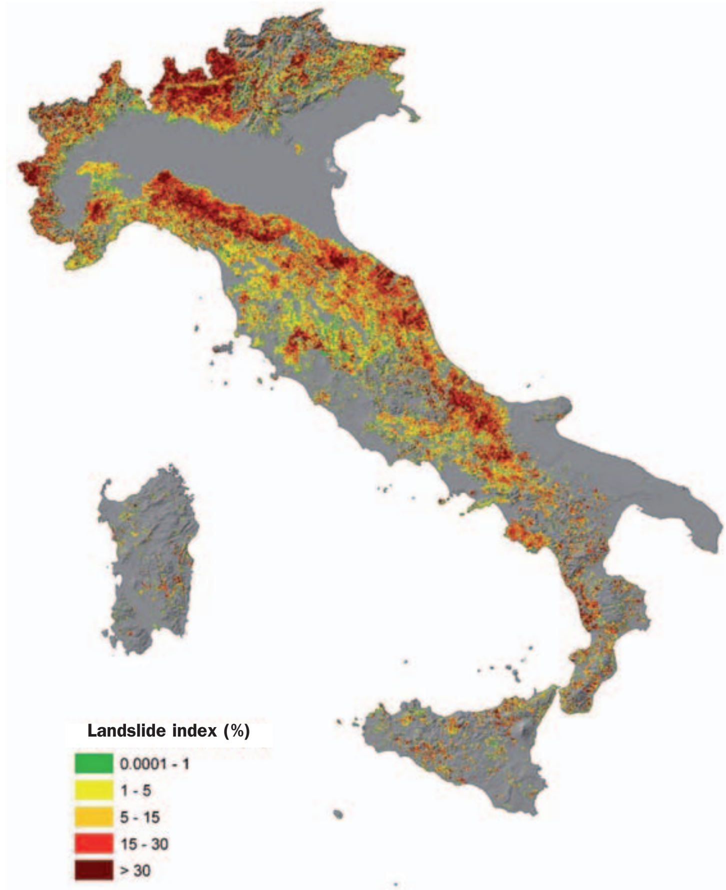

Figure 7.14: Landslide index (%)[15]

[15] Source: ISPRA

is the case for almost all landslides in the Apennine areas of the Emilia Romagna Region, characterised by slow movements. In contrast, new landslides most frequently are characterized by rapid kinetics, such as rockfalls or mud/debris flows. Not all landslides present the same level of hazard. Landslides with extremely rapid movement and involving noteworthy volumes of rock or soil cause the greatest damage and number of victims.

Italian municipalities affected by landslides are 5,708, equal to 70.5% of the total.

In order to obtain a preliminary landslide risk assessment related to the Italian territory, landslides (recorded in the IFFI database) have been overlapped with the exposed elements (infrastructures, urban centres, etc.), taken from the Corine Land Cover 2000 (Figure 7.15). Italian municipalities affected by landslides currently number 5,708, or 70.5% of the total. A total of 2,940 municipalities have been classified at very high levels of attention (intersections between landslides and continuous and discontinuous urban texture, as well as industrial or commercial areas), 1,732 municipalities at high levels of attention (intersections between landslides and the highway, railway and road networks, areas used for mining, dumping and worksites), 1,036 municipalities at moderate level of attention (intersection between landslides and arable lands, wooded territories, and semi-natural environments, green urban areas and sports and recreation areas), and 2,393 rate negligible levels of attention (municipalities in which no landslides have been registered).

Out of the 8,101 Italian municipalities, a total of 2,940 have been classified at very high levels of attention, 1,732 municipalities at high levels of attention, 1,036 municipalities at moderate level, and 2,393 call for negligible levels of attention.

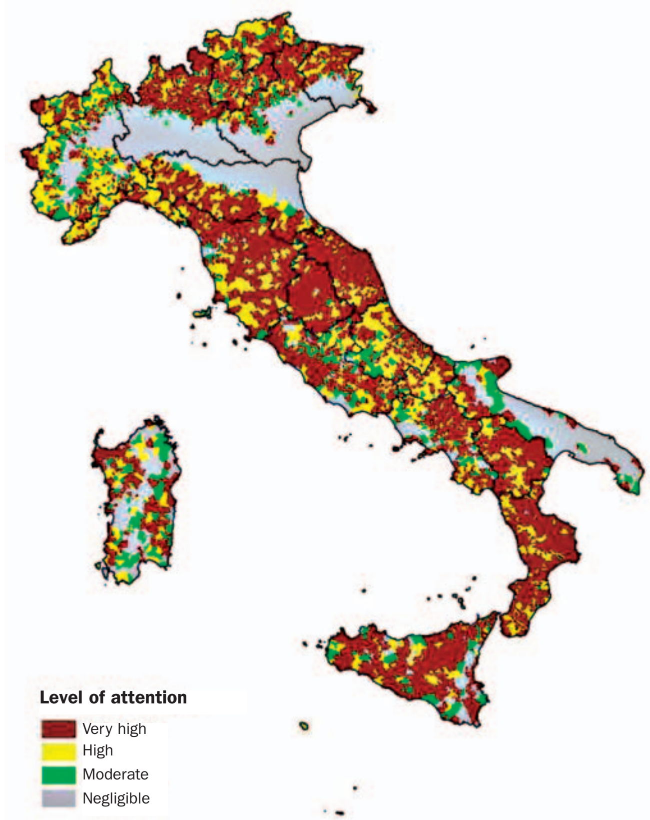

Figure 7.15: Level of attention for landslide risk, on municipality basis[16]

The estimated population exposed to landslide risk, on the basis of landslides recorded in the IFFI inventory and data gathered during ISTAT 2001 census, totals 992,403 inhabitants, equal to 1.74% of Italy's resident population. These data, grouped by municipality, show that the greatest number of individuals at risk are found in the regions of Calabria, Marche and Sicily (Figure 7.16).

[16] Source: ISPRA

The population exposed to landslide risk totals 992,403 inhabitants, equal to 1.74% of Italy's resident population.

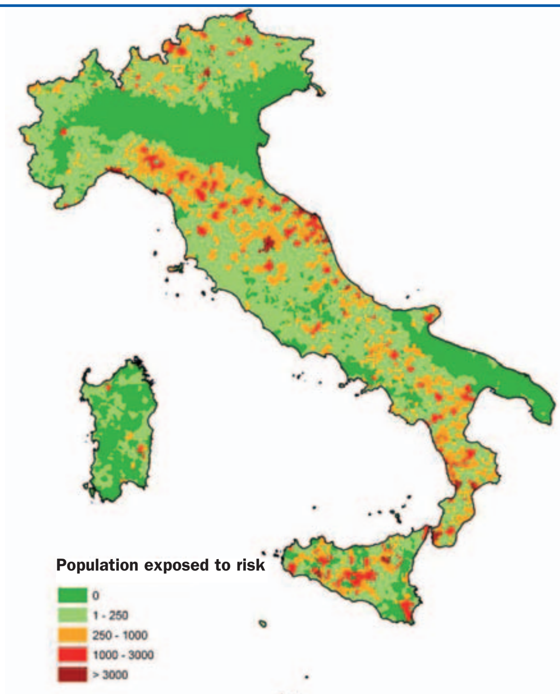

Figure 7.16: Population exposed to landslide risk[17]

In the period December 2008 - February 2009, exceptional precipitation in the whole national territory led to the occurrence of a series of landslide events that caused serious damage to urban areas, and particularly to transport infrastructures. Continuous precipitation raged over the whole period (November 2008 - January 2009), with 20 monthly rainy days registered both in December and in January. The heaviest precipitation was registered in the following periods: December 10-13; January 11-14, and January 24-28.

Moreover, precipitation in November 2008 exceeded by 67% the average of the last 208 years (average climate of the reference period - ISAC-CNR), while in December the rainfall intensity registered for the same period was more than twice as great.

In the period December 2008 - February 2009, exceptional precipitation in the whole national territory led to the occurrence of a series of landslide events, that caused serious damage to urban areas and particularly to transport infrastructures.

[17] Source: ISPRA

In January, cumulated precipitation doubled on average on a national scale, and almost tripled in the South of Italy (+172% in Sicily, +165% in the South-East, +156% in the South-West) compared with the last 30 years measurements (Observatory for Applied Agricultural Climatology and Meteorology, UCEA). In such rainfall regime, soils remained constantly rain-soaked for a long time, often near to a state of saturation, that is the critical condition determining the trigger of the disruptive events that have occurred. Almost all landslides were shallow, and characterised by limited size and high speed; reactivations of more extended and deeper landslides have also occurred, for example in Trivento and Petacciato (CB). More than 100 landslides have been identified by ISPRA (Figure 7.17), from information supplied by online daily papers and technical reports. These are only part of the events that have hit the national territory in the period under consideration. These landslides were, in fact, particularly catastrophic, in terms of loss of human lives and damages, devastating farmlands, local and/or country roads, rarely reported in the aforesaid information sources. A lot of main and secondary road networks (Highways A3 Salerno-Reggio Calabria, A14 Vasto-Termoli, A20 Messina-Palermo) and railway lines (ex. Potenza-Battipaglia, Battipaglia-Sapri, Catania-Caltanissetta) were interrupted. On January 25th 2009 a landslide invaded the roadway of A3 highway for nearly 20 meters, between the exits at Rogliano and Altilia-Grimaldi, causing 2 victims and 5 injured. Due to the critical situation in the area, the Salerno-Reggio Calabria highway remained closed for some days for about 60 km.

In 2009, other two dramatic natural events have occurred: the landslide at Cancia, in the municipality of Borca di Cadore (BL) and the mudslides in the municipalities of Messina and Scaletta Zanclea (ME).

In 2009, other two dramatic events occurred: the landslide at Cancia, in the municipality of Borca di Cadore (BL), and the mudslides in the municipalities of Messina and Scaletta Zanclea (ME). At Cancia, early in the morning of July 18th 2009, heavy rainfalls caused the triggering of a debris flow, from the south-western slope of the Antelao mountain, that determined the replenishment and the breakdown of the debris retention dam (a provisional remedial work provided by the Civil Engineering in the year 2000). Some dwellings downstream were swept away, and two people died.

On October 1st 2009, in the province of Messina, an extreme meteorological event, with rainfall of more than 200 mm over 24 hours, beated down on North-East Sicily, and hit the Ionian belt in the province of Messina between Messina (with the villages of Briga,

Giampilieri, Molino, Altolia, Pezzolo), Scaletta Zanclea and Itala. In the same area, the rainfall accumulation between 15th and 30th September 2009 was 300 mm, totalling about 500 mm in the period between September 15th and October 1st (Report on meteorological events, October 1st 2009, region of Sicily – Civil Protection Agency, 2009). It appears evident that the soil was already water-soaked, and the meteorological event of October 1st , with its exceptional rainfall, determined the trigger of a series of widespread landslide phenomena, such as rock falls and shallow slides, evolved into mud and debris flows, that swept away urban centres and infrastructures, with flows of up to 2-3 meters, causing 31 victims and 6 missing people. The interruption of the National road 114 Orientale Sicula, of the A18 highway, and of the Messina-Catania railway line have caused the total isolation of some villages, that could only be reached by sea or by air.

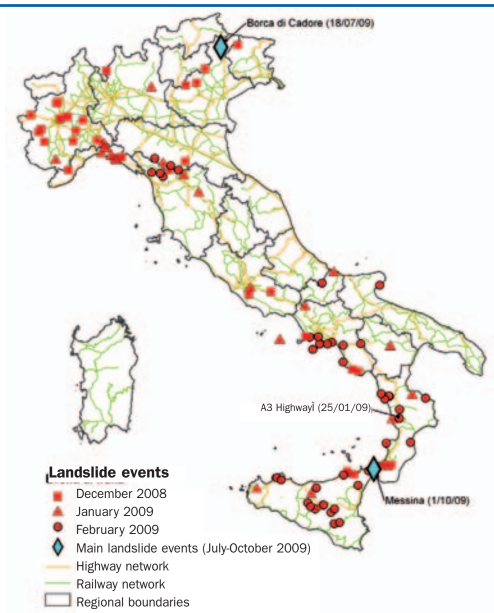

Figure 7.17: Landslide events in the period December 2008 – February 2009, and main events July-October 2009[18]

More than 100 landslides that caused damages to urban centres and infrastructures have been identified by ISPRA in the period December 2008 – February 2009. In 2009 other two dramatic natural events occurred: the landslide at Cancia, in the municipality of Borca di Cadore (BL), and the mudslides in the municipalities of Messina and Scaletta Zanclea (ME).

[18] Source: ISPRA

Events such as earthquakes, volcanic eruptions, landslides and flooding occur with great frequency in Italy, owing to the geological context of our country.

Disruptive events are influenced by a multiplicity of "natural" factors that are mainly tied to the special geo-morphological conformation, to the geological-structural situation of the Italian territory, as well as to the type and extension of the vegetative coverage and conditions of weather and climate.

Italy has registered a reduction in average annual precipitation, as well as an increased occurrence of extreme events.

The causes

Events such as earthquakes, volcanic eruptions, landslides and flooding occur with great frequency in Italy, due to to the geological context of our country. These extraordinary natural events contribute to shape and modify the earth's surface. The risk of such natural phenomena depends on the probability of their occurrence, as well as on the interaction with factors related to human activities; therefore, their evolution and tendency to landslide and/or flood hazard" is influenced by the simultaneous presence and interaction of natural and anthropic factors.

Disruptive events are influenced by a multiplicity of "natural" factors that are mainly tied to the special geomorphological conformation, to the geological-structural assessment of the Italian territory, as well as to the type and extension of the vegetative coverage and conditions of weather and climate. Anthropogenic causes include, among others, a use of the territory that does not pay sufficient attention to the characteristics and the delicate natural balances of the environment. The management of the environment does not always respects the "environmental" traits of the territory, allowing planning and implementation of increasingly invasive works (such as embankments, dikes, canals, reclamation works, and retaining walls), that prevent evolution according to natural dynamics.

The natural environment evolves in a dynamic and variable way, which is not ascribable to simple models. This is also confirmed by changing climate conditions that have been characterising Italy during the last decades. In particular, the pluviometric regime – showing an average reduction in precipitation, as well as a change in their temporal distribution, with a growing occurrence of short lasting but intense rainfall events – on one hand, could have determined in some areas a reduction in the occurrence of medium-intensity floods, on the other, caused an increased occurrence of extreme events and landslide phenomena. Physical mechanisms ruling the onset and the evolution of hazard "hydro-geological events" are very complex and not linear. As a matter of fact, the correlation between pluviometric events and landslides or floods is influenced by a multiplicity of factors that set off different effects from one place to

the next, even in situations that would appear to be similar.
As it has said before, among the causes of hydro-geological disruption, anthropic factors have an increasingly important impact, linked to a use of the territory that does not pay sufficient attention to the characteristics and to geomorphologic and hydraulic balances of the Italian territory. In fact, as of the Fifties, the demands of the socio-economic development have helped to generate a constant and unrelenting deterioration of our territory. Major factors associated to slope deterioration include depopulation and abandonment in mountainous areas; in facts, the frequent fire occurrence, as well as the over-urbanisation and "cementification" in the valleys, have determined a considerable increase in run-off water, and an important reduction in time of concentration. This entails a reduced infiltration of run-off water thus implying a deeper groove in river courses and slope erosion. This is one of the major causes for the fact that sudden flood waves increasingly often propagate through very large areas.

Anthropic factors play an increasingly important role, among contributing factors of landslide and flood events.

In particular, slope instability is due to the interaction of several concomitant factors: natural events (precipitation, earthquakes) and anthropic activities. Short-duration extreme precipitation and prolonged rainfall are the most important factors for the triggering of slope failures respectively for rapid-shallow landslides, and landslides with a more deeply located sliding surface, or involving mainly clay lithotypes. Anthropic factors play an increasingly important role among contributing factors, through either direct actions, such as roadway construction, excavation or overloads, or indirect actions, including negligent maintenance of remedial works. Roadway construction works executed over the last decades in order to facilitate access to forest and woodland areas have often determined slope stability problems (Figure 7.18).

Slope instability is due to the interaction of several concomitant causes: natural events (precipitation, earthquakes) and anthropic activities.

Translational earth slide flowing near a hairpin bend in a forest road, Cervinara (AV) 15/12/1999.

Figure 7.18: Anthropic contributing factors - Translational earth slide flowing near a hairpin bend in a forest road, Cervinara (AV) 15/12/1999[19]

In hilly or flat areas, the development of intensive farming, involving land levelling and vegetation removal, generates erosion as well as rapid waterflow.

In hilly or flat areas, the development of intensive farming (often monoculture), involving land levelling, tree cutting and removal of trees, hedges and channelling, generates erosion as well as rapid waterflow, and causes an increase in sediment transport in watercourses, whose banks are no longer able to contain the flow, even in case of normal meteorological events. Moreover, in alluvial plains, in order to extend available areas, watercourses have been rectified, therefore natural meanders have been cut, and floodplains have been deprived of vegetation (the so-called planitial wood, whose function consists in slowing down flood waves). Meander rectification has caused shortening of water courses, thus entailing an increase in water speed and destructive strength. At the same time, floodplains occupation related to urban settlement, infrastructures and productive activities, as well as the

[19] Source: ISPRA

uncontrolled pilferage of building materials from dry riverbeds, have determined respectively a reduction in space for the natural water flow, and a lowering of the low-flow channel.
Repercussions of such use of the territory also influence coastal systems, as watercourses are at present one of the sources of the sediments that are necessary for the coastline balance.
In general, it could be said that the interaction between disruptive events and anthropic activities is reciprocal, with the consequence that inappropriate modes of use and management of the territory frequently result in an amplification of disturbances underway or in the triggering of new ones.

Solutions

Hydraulic and landslides hazards can be significantly reduced through careful territorial planning and normal policies combining forecasting and prevention, beyond any emergency approach based on after-the fact responses. Forecasting can be carried out through specific studies of the zones subject to risk, in order to determine the probable return periods of events, while prevention mostly consists of making appropriate planning choices as well as selecting and applying technical procedures designed on the basis of the knowledge obtained.
An urban planning approach taking into consideration natural hazards (including the effects of seismic phenomena and those produced by intense meteorological events) needs to become an essential component in the decision-making process, on both the political and administrative levels. In terms of landslide hazard, forecasting includes an inquiring phase, aimed at the census, collection and updating of information about landslide phenomena (IFFI Project, Italian Landslide Inventory), the monitoring of movements through telemeasurement systems (e.g. topographic or satellite), the identification of landslide-prone areas, and models for possible scenarios; while surveys on flood phenomena mainly consist of hydrological studies (rainfall modelling through return periods and inflow-runoff model) and hydraulic studies (analysis of flood waves evolution inside the river bed, on the basis of hydrometric levels). Prevention – in terms of risk reduction – essentially requires measures aimed at removing or attenuating envis-

Conditions of risk can be significantly reduced through careful territorial planning and the introduction of legislative instruments providing limitations on the use of the soil and/or technical-engineering standards.

aged grounds effects, whether structural or non-structural.
The so-called structural interventions (with relative maintenance works) include works executed in the framework of hydro-geological reclamation, whose essential function is the mitigation of hydro-geological risk, reducing the degree of hazard and vulnerability of the territory. Non-structural interventions become really effective when – in a territorial and urban planning context - they provide instruments to reduce risk-prone elements, limiting the expected damage induced by hazardous events that may occur in a certain area, and reducing risk itself. Such an intervention strategy is implemented through rules and constraints contained in planning tools at different levels (for example, in drainage basin planning), in emergency planning (quiet, early warning, attention, early warning alarm, emergency care), information and cultural training related to the various types of risks and relative behaviours.
The regulatory and planning framework for land preservation is governed in Italy by Legislative Decree no. 152/06 on "Environment Regulation", plus subsequent modifications and updating containing provisions aiming at ensuring protection and reclamation of the ground and subsoil, the hydrogeological reclamation of the territory and precautionary measures against hazard situations. Some contents of this measure were already found in Law 183/89, which "Regulated the organisational and functional framework for land protection", followed by Legislative Decree 180/98 (referred to as the "Sarno Decree", converted into Law 267/98), issued in 1998 following the tragedy in Sarno (Campania).

One of the major instruments for fighting "hydro-geological disarray" is provided by numerous intervention programmes devised for high risk areas and very high risk areas– R3 and R4 of the Extraordinary Plans.

One of the major instruments for fighting "hydro-geological disarray" (or, better yet, **"**geological- hydraulic**"** disarray) is provided by numerous intervention programmes devised for areas in which the greater vulnerability of the territory implies a more serious hazard for people, goods and environmental heritage (high risk areas and very high risk areas – R3 and R4 of the Extraordinary Plans). For this purpose, the Ministry of the Environment, Land and Sea has financed, since 1999, in accordance with Legislative Decree 180/98 ("Sarno Decree"), plus subsequent modifications and updates, 3,216 urgent initiatives for the reduc-

tion of hydro-geological risk, at a total cost of roughly 2,4 billion euros.
A further regulatory tool for the assessment and management of flood risk is the Directive 2007/60/EC of 23 October 2007. The “Floods Directive” aims to minimize the adverse consequences of floods – which occur with increasing frequency, due to climate change – by adopting joint cross-border policies for protection against flood risk. The Directive provides an articulated strategy consisting of a preliminary phase of flood risk assessment, followed by the establishment of flood risk maps and the development of risk management plans for areas at risk. Management plans should focus on prevention and protection against flood risk.
The dissemination of information on hydro-geological instability (landslides, floods, avalanches) among the central and local bodies of the Public Administration, as well as the general population, also plays a very important role in landslide risk prevention. Heightening the awareness of citizens also provides them with increased knowledge of the risks involving their own territory, as well as of the forms of conduct to be followed before, during and after the event. To this end, ISPRA created an on-line mapping service for the IFFI project (www.sinanet.apat.it/progettoiffi), making it possible to query the database and obtain information on landslides, in addition to visualising documents, photographs and videos (Figure 7.19). Other activities that ISPRA has carried out since 2000, include monitoring of initiatives financed in accordance with Legislative Decree 180/98, plus subsequent modifications and updates, whose data are filed in the National List of Land Defence Interventions (ReNDiS). The aim is to provide a comprehensive regularly updated framework of works and resources used in land defence, making them available to all local government bodies involved in planning and implementing such initiatives. In this context, ReNDiS is a tool for knowledge, virtually able to improve co-ordination and, therefore, the optimisation of national expenditure for land defence. Through data publishing (Figure 7.20), the National List is aimed at meeting the needs for “transparency” as regards local governments’ behaviour in terms of land defence.

The dissemination of information on landslides, floods and avalanches among the central and local bodies of the Public Administration, as well as the general population also plays a very important role in landslide risk prevention.

The on-line mapping service for the IFFI project, makes it possible to query the database and obtain information on landslides, in addition to visualising documents, photographs and videos.

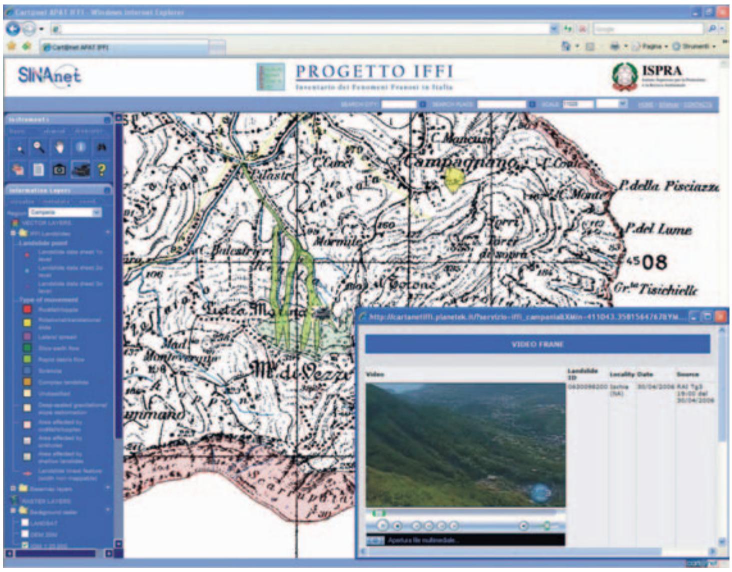

Figure 7.19: IFFI Project WebGIS[20]

ReNDiS aims to provide a comprehensive regularly updated framework of works and resources used in the land defence, making them available to all local government bodies involved in planning and implementing such initiatives.

Figure 7.20: National List of Land Defence Interventions - ReNDiS-Web[21]

Finally, taking for granted that the mitigation initiative should always have a decidedly minor value compared with the resource

[20] Source: ISPRA; www.sinanet.apat.it/progettoiffi
[21] Source: ISPRA

to be protected, it is indispensable that the emergency approach – that is extremely expensive - is replaced with initiatives combining forecasting and prevention, that could be more convenient and effective, as it has been stressed by the former UN Secretary General, Kofi Annan, in the UN Secretary General's Report for 1999: *"(...) Building a culture of prevention is not easy, however. While the cost of prevention has to be paid in the present, its benefits lie in the distant future. Moreover, the benefits are not tangible; they are wars and disasters that do not happen."*

It is necessary to overcome the emergency approach.

ANTHROPOGENIC RISK

Anthropogenic risk is defined as the risk (direct or indirect) caused by human activities that are potentially dangerous for both the environment and human life. This broad definition encompasses so-called "industrial risk" arising from activities carried out in industrial establishments.

Anthropogenic risk is either directly or indirectly tied to human activities that are potentially dangerous for human life and the environment.

A "Major-Accident Hazards Establishment" (MAH establishment) is defined as an establishment containing dangerous substances (used in the production cycle or simply stored) in quantities that exceed the thresholds established under the Seveso regulations (Directive 82/501/ EEC, plus subsequent modifications).

The handling and/or use of huge quantities of substances classified as toxic, flammable, explosive, oxiding, or dangerous for the environment can eventually lead to the occurrence and uncontrolled development of an accident posing a serious threat, either immediate or delayed, to human health (potentially inside or outside the establishment), or to the surrounding environment, due to: discharge and/or diffusion of toxic substances for the human beings and/or the environment; with fires or explosions or toxic release.

In the Eighties, the European Community took into consideration this type of establishments for the first time, in order to prevent major accidents in industrial plants, and to better protect the populations and the environment as a whole, issuing a special directive (the abovementioned 82/501/EEC, also known as the "Seveso Directive").

The Seveso Directive, plus subsequent modifications, aims at reducing major accident hazards, as well as their impact on man and the environment.

Operative application of the directive by the member states of the European Community has made clear the urgent need for updates and modifications, to the point where the Seveso Directive has been updated twice in the last years, under Directives 96/82/EC and 2003/105/EC, transposed into national law with Legislative Decrees 334/99 and 238/05.
These regulations aim at reducing the probability of accidents, as well as their consequences on man and the environment. To this end, operators of potential major-accident hazards establishments are obliged to fulfil special commitments, such as the production of specific technical and informative documentation, and the implementation of safety management systems. They must also submit to inspections and controls by the competent authorities.

The situation

ISPRA, together with Ministry of Environment, Land and Sea, collects information on major-accident hazards establishments supplied by operators to the competent authorities.

The information on major-accident hazards establishments supplied by operators to the competent authorities (including the Ministry of the Environment, Land and Sea, under the specific obligations indicated in Legislative Decree 334/99, with administrative and penal sanctions handed down in the event of failure to present the declaration, or of incorrect or incomplete declarations) are collected by the ISPRA, together with the Ministry of the Environment, Land and Sea, through the production and updating of the National Inventory of Major-Accident Hazards Activities (MAH industries), as stipulated under Legislative Decree 334/99 (Art. 15, fourth paragraph), and validated through a cross-analysis with data already in the possession of the regional governments and the regional agencies with territorial jurisdiction. Thanks to the information collected in the above-mentioned Inventory, it is possible to outline a global view of the potential danger represented by major-accident hazards establishments for the Italian territory.
When, for example, the following information is known:
- the number of major-accident hazards establishments, on a regional basis (Figure 7.21);
- the number of major-accident hazards establishments, on a provincial basis (Figure 7.22);

- the number of municipalities with 4 or more major-accident hazards establishments (Figure 7.23);

then the areas with the highest concentrations of MAH establishments can be identified, in order to implement controls and precautionary measures adequate to keeping a possible accident in any one of the establishments from involving other plants and causing serious consequences both for man and the environment ("domino effect"). For this purpose – with a view to obtaining more accurate results, thanks to georeferenced perimeters of all MAH establishments – it is possible to identify the areas in the national territory with more or less high concentration of MAH establishments, regardless of municipal, provincial or regional boundaries. Such areas can be approached applying the specific and more punctual risk assessment and monitoring criteria provided for in art. 13 of Legislative Decree 334/99, whose technical provisions are about to be finalized by the Ministry of the Environment, Land and Sea.

When the number and distribution within the territory of major- accident hazards establishments is known, it is possible to identify the areas with the greatest concentration of major-accident hazards establishments.

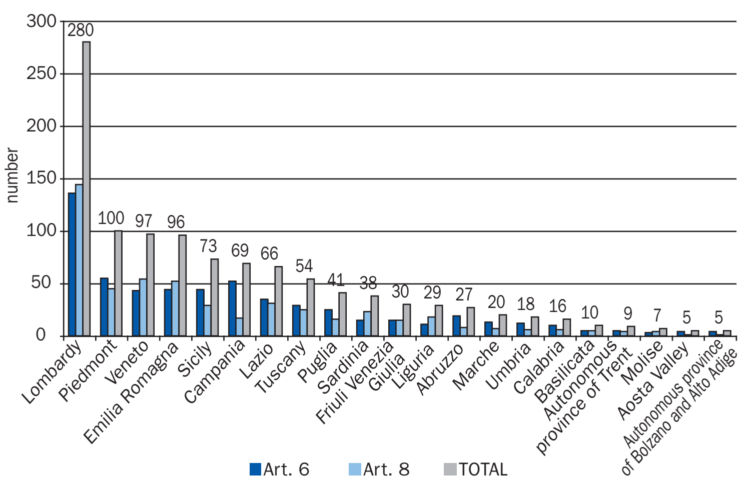

Figure 7.21: Distribution by region of establishments subject to Legislative Decree 334/99 plus subsequent modifications and updating (30/6/2009)[22]

The regions with the greatest concentration of major- accident hazards establishments are: Lombardy, Piedmont, Veneto, and Emilia Romagna.

[22] Source: Ministry of the Environment, Land and Sea data processed by ISPRA

The highest concentrations of major-accident hazards establishments are found in the provinces of Central and Northern Italy, notably Milan, Bergamo, Brescia and Ravenna in the North, and Naples in Centre-South.

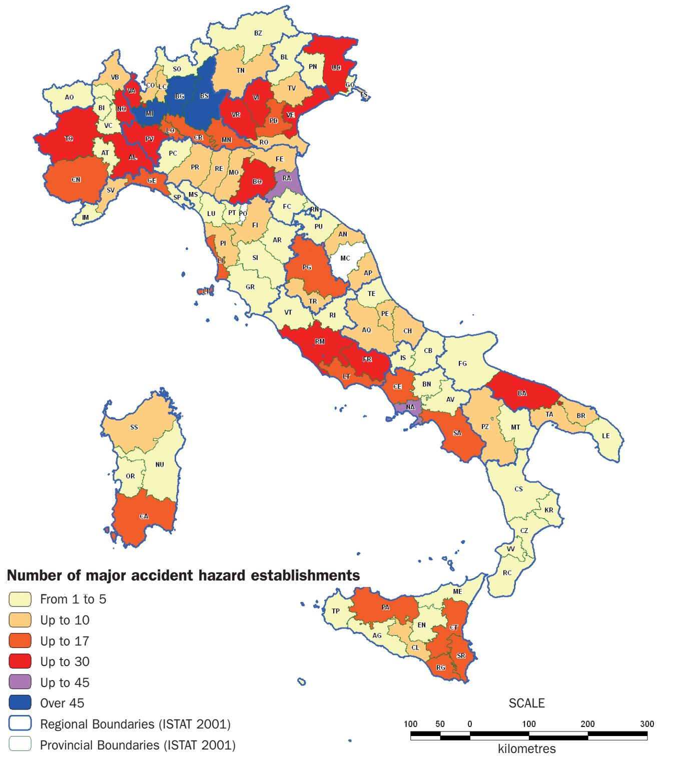

Figure 7.22: Number of major accident hazard establishments – Distribution by province (30/6/2009)[23]

When the activities of an establishment are known, then its potential risk can be identified.

An analysis of the types of establishments (Figure 7.24) also points to further considerations regarding our country's map of industrial risks. Such information makes it possible to identify the industrial activities that are most widespread among major-accident hazards establishments, as well as their distribution within the national territory. When the activities of an establishment are known, then its potential risk can be foreseen, at least in general terms. For example, storage sites for LPG or explosives, as well as distilleries and plants for production

[23] Source: Ministry of the Environment, Land and Sea data processed by ISPRA

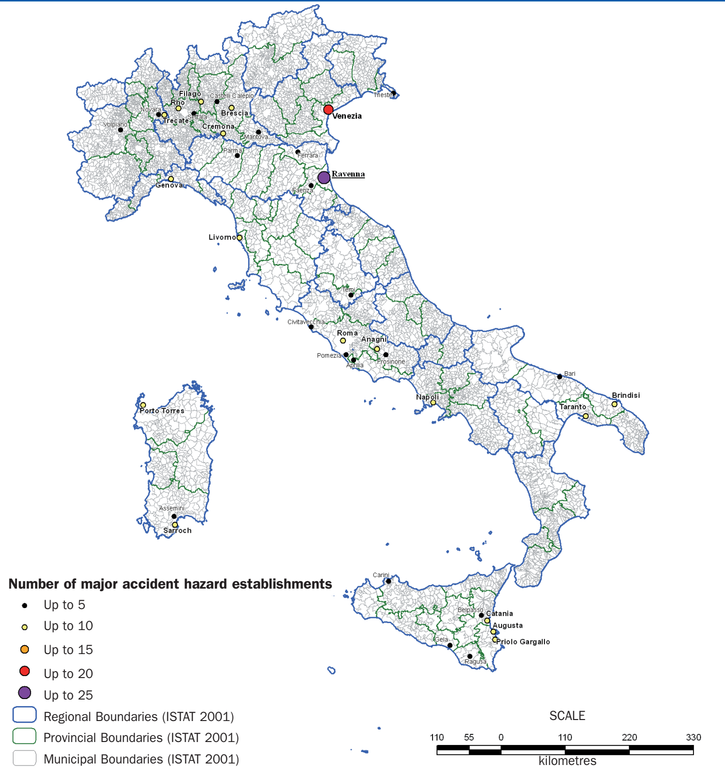

Figure 7.23: Municipalities with 4 or more mayor accident hazards establishments (30/6/2009)[24]

Municipalities with 4 or more major- accident hazards establishments include Venice and Ravenna.

and/or storage of technical gases present, for instance, a prevalent risk of fire and/or explosion, with effects traceable, in the event of an accident, to radiation or overpressure of varying intensity, with possible structural damage to plants and buildings, as well as damage to human health. Chemical establishments, refineries, toxic gases and agrochemicals storage depots, are exposed not only to the risk of fire and/or explosion, as in the case of the facilities referred to earlier, but also to the risk of diffusion of toxic and eco-toxic substances, even at a

[24] Source: Ministry of the Environment, Land and Sea data processed by ISPRA

Chemical and/or petrochemical establishments, as well as liquefied gas storage facilities (mostly LPG), are the most widespread, corresponding to roughly 50% of the total number of establishments.

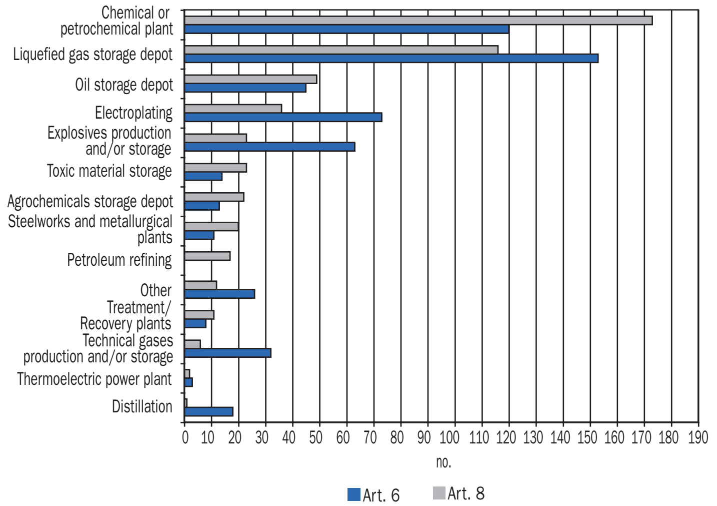

Figure 7.24: Distribution on a national basis of establishments subject to Legislative Decree 334/99 plus subsequent modifications and updating, by type of activity (30/6/2009)[25]

distance, giving rise to immediate and/or delayed danger for both man and the environment. An analysis of the types of activities that are carried out on the national territory shows a prevalence of chemical and/or petrochemical establishments, as well as liquefied gas facilities (notably LPG), corresponding, when taken as a whole, to 50% of the total number of establishments. Chemical and petrochemical establishments are mainly concentrated in Lombardy, Piedmont, Emilia Romagna and Veneto. Refineries (17 plants in Italy) are distributed more or less throughout the national territory, with especially heavy concentrations in the regions of Sicily and Lombardy, which respectively contain 5 and 3 plants. A similar situation is observable with regard to mineral oil storage depots, which are concentrated near the country's major urban areas. LPG tank storage sites are currently widespread in Campania and Sicily, as well as in Lombardy, Tuscany, Veneto and Emilia Romagna. The sites of these plants are often located near urban areas, and are particularly concentrated in the provinces of Naples, Salerno, Brescia, Venice and Catania.

In Italy there is a prevalence of chemical and/or petrochemical plants, as well as LPG facilities (roughly 50%). Prevalence of chemical and/or petrochemical plants, as well as LPG facilities (roughly 50%). The former are essentially concentrated in Northern regions, while the latter are also widespread in the South.

[25] Source: Ministry of the Environment, Land and Sea data processed by ISPRA

Such information – combined with risk scenarios, and correlated with the vulnerability level of the surrounding territory – makes it possible to produce risk maps to be used for land use planning, providing information to the public, and ensuring adequate emergency preparedness and response.

The causes

The potential danger tied to the presence of major-accident hazards establishments in Italy is comparable to that of the other major European industrial countries, though Italy presents certain peculiarities tied to the development and history of its industry, as well as to choices made in the past, notably in terms of energy supply. An example worth note is the concentration of refineries to be found in Sicily and Lombardy, as well as the development of major petrochemical complexes in the post-war period, as well as in the Po Valley (Ravenna, Ferrara), in the Venetian Lagoon (Marghera), and, starting from the Sixties and Seventies, in Southern Italy (Brindisi, Priolo, Gela, Porto Torres, etc.). Within the overall European framework of establishments at risk of accident, one of the Italian peculiarities is the impressive development of the network of LPG tank storage sites, supplying gas to the areas of the country that are not reached by the methane distribution network.
Another characteristic of the Italian situation is the presence of industrial districts characterised by a concentration of small and medium-size industries with production activities that are similar or belong to the same production chain, such as the chemical or pharmaceutical sectors in certain areas of the Lombardy Region (where 25% of major accident hazard establishments are located) and in the Pontine area, or the electroplating industry in Veneto, Piedmont and Lombardy. These establishments often operate in congested territories located near urban areas, or in any case densely populated zones, characterised by the presence of population centres that would be highly vulnerable in the event of accidents.

Solutions

The regulatory framework on the control of major-accident hazards on the European and national levels is now thorough and complete, following the passage of three subsequent directives subsequently transposed into national legislation. Procedures

One of the peculiarities of Italy is the impressive development of the network of LPG tank storage sites, supplying gas to the areas of the country that are not reached by the methane distribution network. Another national characteristic is the presence of industrial districts, characterised by a concentration of small and medium-size industries with operations are similar or belong to the same production chain.

Procedures adopted in Italy are in line with those applied in the other EU countries.

adopted in Italy are in line with those applied in the other EU countries, confirming a substantial alignment with European standards, though there is room for improvement in terms of:

- streamlining and accelerating procedures for the assessment of safety reports and the intensification of inspections and controls;
- increasing awareness of municipal administrations as regards problems tied to industrial risk, with reinforcement of the activities involved in the land use planning and the supply of information to the public;
- qualitative improvement of activities related to external emergency planning in the event of accidents.

The abovementioned improvements can be introduced, provided that the following requirements are satisfied:

- the certainty of resources being available to the municipal governments and technical agencies involved, including the introduction, as provided for under the Seveso regulation, of a system of fees to be paid by operators of major-accident hazards establishments, based on the controls carried out by the Public Administration;
- progressive decentralisation of regional controls, in accordance with provisions of the "Bassanini Law", once the presence of the competent local authorities and/or guarantees of their reinforcement have been verified, notably in Southern regions; organisation and follow-up of monitoring procedures by the Ministry of the Environment, Land and Sea;
- accurate and timely definition, on a national level, of detailed technical references and criteria, to be supplied to local authorities and technical organs responsible for control activities.

Within this framework, a point of vital importance is the enhancement of the Environmental Agencies System, which – given its role, competence and the experience acquired - can offer a valid contribution to the solution of many of the problems at issue.
Moreover, a hopeful sign is to be noticed in current updating of legislation concerning risk assessment and monitoring in areas with high concentration of MAH establishments, envisaging a major technical role to be played by ISPRA and regional agencies in terms of risk area identification, risk assessment, and intervention planning.