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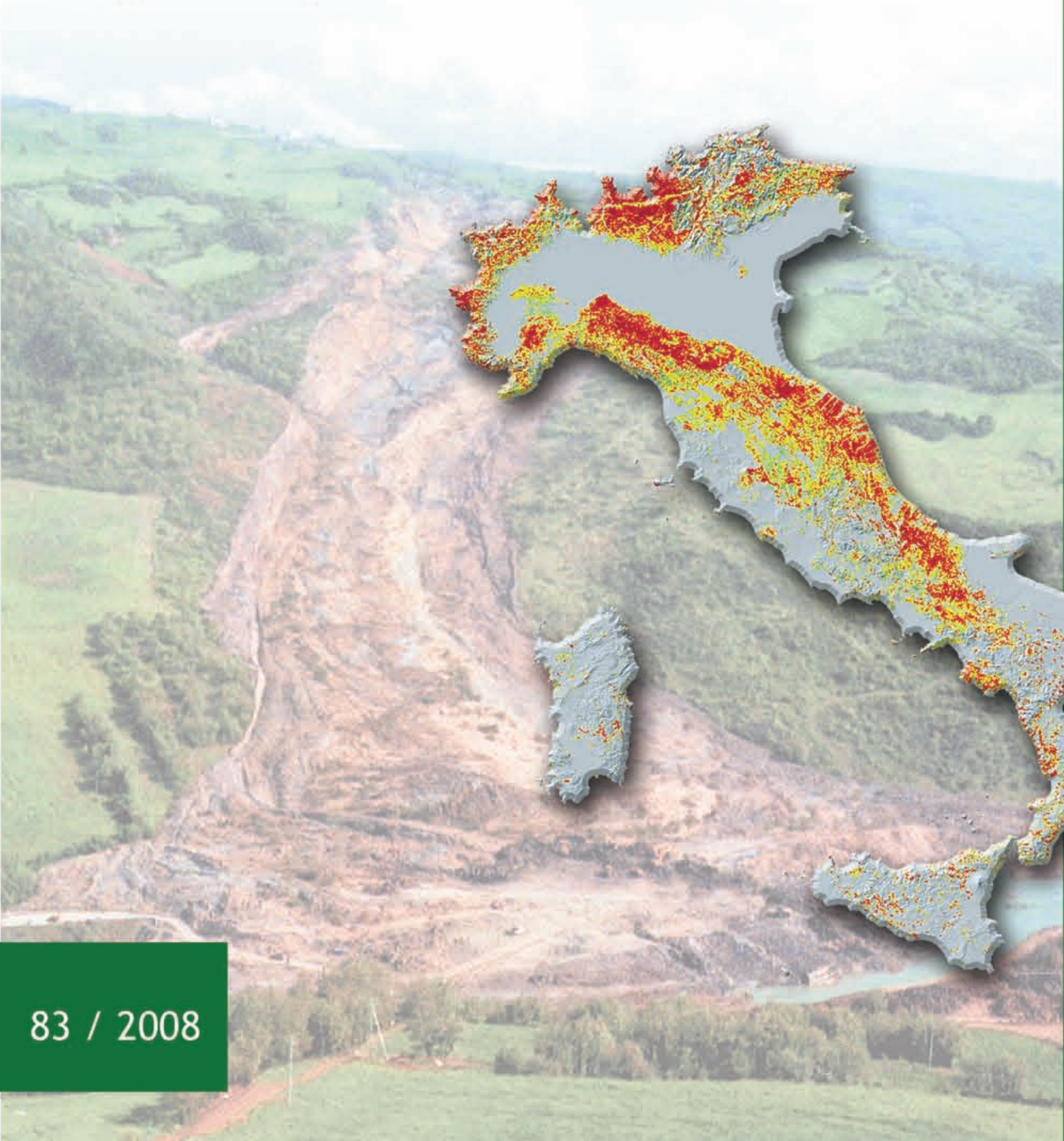
RAPPORTI

Landslides in Italy

Special report 2008



83 / 2008

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ISBN 978-88-448-0355-1

ISPRA is the Italian National Institute for Environmental Protection and Research established by Italian Law 133/2008, based on Decree Law no. 112 dated 25 June 2008, as published in Official Journal no. 195 dated 21 August 2008. The Institute performs the functions of three former institutions: APAT (Agency for Environmental Protection and Technical Services), ICRAM (Central Institute for Applied Marine Research) and INFS (National Institute for Wildlife).
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Graphic layout
ISPRA

Cover graphics: Franco Iozzoli

Cover photos: Landslide index of Italian territory. Back cover photos: Covatta landslide (Southern Italy), photo by Sergio Baranello; manuscript by Giovanni Villani XIV century, Riccardiana Library Florence; IFFI Project Website; extremely rapid debris flow, Cetara (Campania region) 1910, ISPRA photographic library.

Translation
Centro Servizi Europa ’92 S.r.l.
Via Veio, 7 - 00183 Roma
Translator: Graham Clarke

Printing coordination
Daria Mazzella
ISPRA

Printed by
CSR
Via di Pietralata, 157 - 00158 Roma
Tel. 06 4182113 - Fax 06 4506671

Printed on TCF paper

1st printing: November 2008
2nd printing: September 2011

Text available on ISPRA website at www.isprambiente.gov.it

This document is a summary of *Rapporto sulle frane in Italia. Il Progetto IFFI: Metodologia, risultati e rapporti regionali* ("Report on landslides in Italy. Italian Landslide Inventory Methods, results and regional reports") (Rapporti APAT, 78/2007).

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Acknowledgements
Special thanks to Maria Dalla Costa, Luca Demicheli, Eutizio Vittori, Claudio Margottini, Luca Guerrieri, Daniele Spizzichino (ISPRA) and Javier Hervas (JRC - Joint Research Centre - European Commission) for their significant contribution in promoting the Italian Landslide Inventory results and activities at international level.

CONTENTS

INTRODUCTION

This document is a *Summary* of the ***Rapporto sulle frane in Italia - Il Progetto IFFI: Metodologia, risultati e rapporti regionali***, ("Report on landslides in Italy. Italian Landslide Inventory: Methods, results and regional reports") published as part of the series of APAT Reports in 2007. The full version of the *Report* is divided into 25 sections. The first four sections (*General Part*) give details of the methodology, the technical specification, the statistics and data processing, and the online mapping services. Sections 5 to 25, prepared by the Technical Departments/Geological Surveys of the Regions and Self-Governing Provinces, provide the landslide data within their own territory.
The *Summary* describes briefly the contents of the *General Part* and provides an up-to-date overview of the state of the art regarding landslides in Italy.
The full version of the Report (in Italian) may be consulted at:
http://www.isprambiente.gov.it/site/it-IT/Pubblicazioni/Rapporti/Documenti/rapporto_2007_78.html

THE LANDSLIDE HAZARD IN ITALY

Due to its relief and its lithological and structural characteristics, Italy is a country in which the landslide risk is particularly high. Landslides, which are extremely widespread throughout Italy, are the most frequently occurring natural disasters and are the cause, after earthquakes, of the highest number of victims (Fig. 1). There has been a significant increase in the human pressure on the country since the Second World War with the expansion of urban areas and road and rail infrastructures, often in unstable areas. In this context, landslide phenomena have become a major problem with regard to the safety of the population and damage to residential areas, infrastructures, service networks, and environmental and cultural heritage. In just the last twenty years there have been disastrous events in Val Pola (1987), Piemonte (1994), Versilia (1996), Sarno and Quindici (1998), north-west Italy (2000) and in Val Canale - Friuli Venezia Giulia (2003).

Figure 1: Panoramic view of the mud and debris flows which struck Sarno (Campania Region) on May 5, 1998

THE ITALIAN LANDSLIDE INVENTORY

Following the disastrous event at Sarno there has been an even more urgent need for a complete and homogeneous overview on the distribution of landslides within Italy, with regard both to the recording of information and mapping of the landslides. And this has been the aim of the Italian Landslide Inventory *(Progetto IFFI - Inventario dei Fenomeni Franosi in Italia*), with the funding of 4.1 million Euro in 1997 by the Italian Government. The aim of the Project, implemented by ISPRA (formerly, APAT - Italian Environment Protection and Technical Services Agency) and by the Regions and the Self-Governing Provinces, is to identify and map the landslides in accordance with standardised and shared methods. It also represents an important tool for landslide risk assessment, land-use planning and mitigation measures.
The role of ISPRA – Geological Survey of Italy in the implementation of the project is to guide, coordinate and control the activities, process the national statistics and communicate and distribute the data. Italy's Regions and Self-Governing Provinces collect, record and computerise the landslide information.
APAT allocated 0.65 million Euro in 2004 for updating and integrating the project database.
The Inventory has so far surveyed 482,272 landslides covering an area of approximately 20,500 km^2, which is equivalent to 6.8% of the Italian territory. 5,708 Italian municipalities - 70.5% of the total number - are affected by landslides.

METHODOLOGY

The choice of an adequate methodology has constituted one of the most important aspects of the project, in order to obtain results which are homogeneous and comparable at a national level.
A special Technical Working Group was set up in June 2000 to define the method for collecting and recording the information and mapping the landslides, comprising personnel from the Geological Survey of Italy and representatives from the Regions, CNR-GNDCI, Serchio and Arno River Basin Authorities, Ministry of the Environment, Ministry of Public Works, Ministry of Agricultural and Forestry Policies, Ministry of Cultural Heritage and the Civil Defence Department.
The work method is based on the collection of the historical and archive data, aerial photo interpretation, field surveys, a "Landslide Data Sheet" prepared *ad hoc*, and detailed mapping (Fig. 2).
For the classification and nomenclature of the landslides (geometry, type of movement, state of activity, distribution, style, rate of movement etc.) significant use has been made of the classification by Varnes (1978), recommendations by the International Association of Engineering Geology (IAEG, 1990), the International Geotechnical Societies UNESCO Working Party on World Landslide Inventory (WP/WLI, 1990, 1991, 1993a, 1994), the Multilingual Landslide Glossary (WP/WLI, 1993b), recommendations by the International Union of Geological Science Working Group on Landslides (IUGS/WGL, 1995) and the classification proposed by Cruden and Varnes (1996).
The international classification has been partly modified to meet the practical needs of surveying and mapping the landslides. For example, some types of movement have been introduced: sinkholes, deep seated gravitational slope deformation, areas affected by numerous rockfalls/topples, areas affected by numerous sinkholes and areas affected by numerous shallow landslides. The last three classes have been introduced in order to classify those landslides which are limited in size, recurrent and referable to same type of movement, which affect large sectors of slopes.

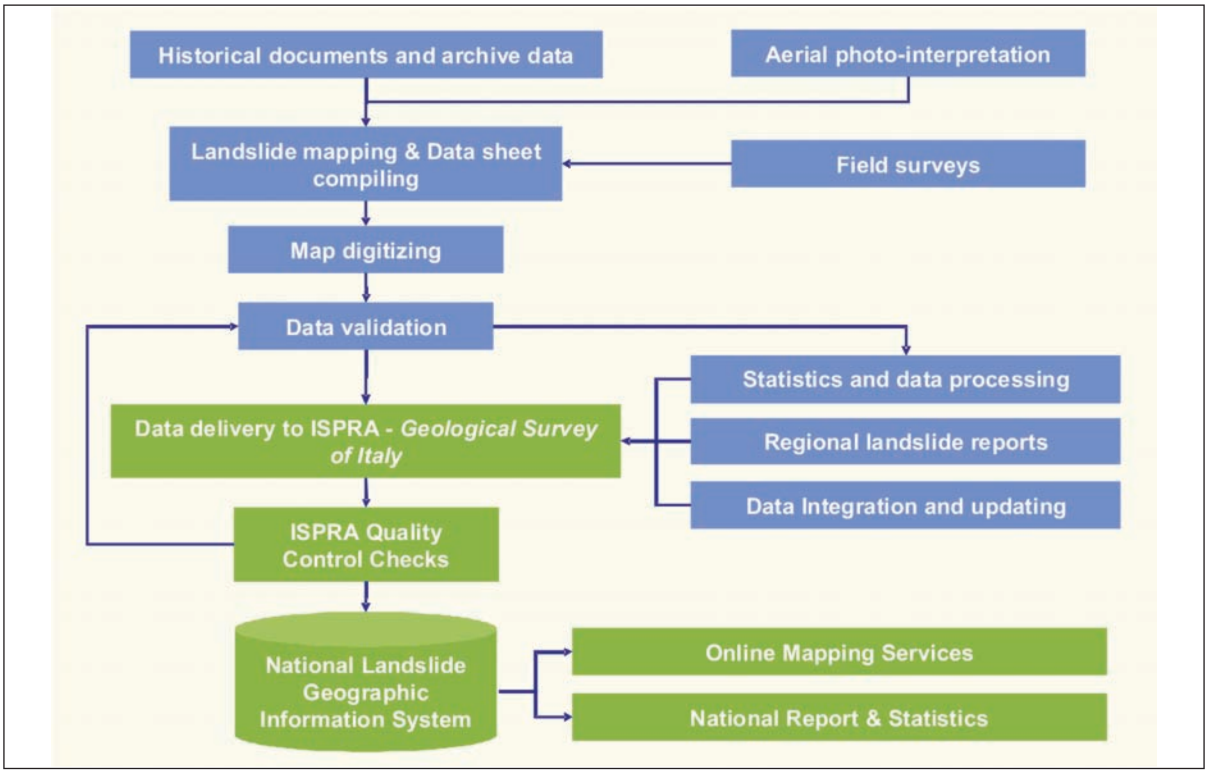


Figure 2: Flow diagram of main work phases

The **search for historical data** on landslides in archives is absolutely essential for the reconstruction of the landslides which occurred in the past and to assess the frequency of the landslides.

The main sources examined were as follows:

- National projects: AVI (Inventory of information on sites historically affected by landslides and floods), SCAI (Study of Unstable Urban Areas), CARG (Geological Map of Italy, 1:50,000 scale);
- Landslide inventory map prepared by Regions, River Basin Authorities, Universities, National Research Council;
- River Basin Plans (PAI - Law 267/98 and subsequent amendments and integrations);
- Civil Defence Emergency Declarations (Law 225/92 and subsequent amendments and integrations);
- National, regional, provincial and local libraries and archives
- Scientific publications;
- Technical reports.

The historical documents on the Monte Falterona landslide which occurred at the village of Castagno in the San Godenzo Municipality (Tuscany) on May 15, 1335 and the rapid mud and debris flows in the Cetara Municipality on October 24, 1910 are presented as examples.

The Monte Falterona landslide constitutes the most ancient record contained in the IFFI Inventory with information of a certain detail (ID-Landslide: 0481022100). The historian Giovanni Villani describes the landslide event in the XIV century manuscript *“Cronica Fiorentina”* in book XI chapter 26 (Fig. 3).

A large portion of Monte Falterona detached itself on May 15, 1335, from the side facing Dicomano in Mugello, and after travelling more than four miles it buried the village of Castagno, with the loss of all the houses, inhabitants, livestock and trees … the waters of the River Dicomano became murky due to the mud and debris transported, reaching the River Sieve and the River Arno down as far as Pisa. The River Arno was turbid for more than two months, making the water unsuitable for any purpose; not even the horses wanted to drink it. The inhabitants of Florence had grave concerns that the water would never again become suitable for drinking.

Figure 3: Giovanni Villani, Cronica Fiorentina, XIV century manuscript. (Riccardiana Code 1533). Florence Riccardiana Library, reproduced with permission of the Ministry of Cultural Heritage.

With regard to the event on October 24, 1910 which severely struck the town of Cetara (SA) (Fig. 4), the article written by the journalist G. Civinini in the “Corriere della Sera” daily newspaper enabled a detailed reconstruction of the dynamics of the landslides.

Figure 4: Landslide at Suora Clara, Cetara (Campania Region), 1910

Aerial photo interpretation still represents the fastest tool to carry out systematic geomorphological surveys over wide areas. The most significant advantages derive basically from an overall view of the physical territorial elements, such as the morphological, structural and geological characteristics, which are sometimes difficult to detect in field surveys. However, this survey method has limitations in the identification of small and medium-sized landslides or landslides in wooded or highly built-up areas.
The aerial photo interpretation, which has been used extensively in the Project, has been calibrated by means of spot field surveys.
The **field surveys** enable the information acquired during the aerial photo interpretation phase to be checked and integrated and to enrich and update the archive data (Fig. 5).

Figure 5: 60,000 m^3 rock fall – "Cima Una" in Val Fiscalina (Self-Governing Province of Bolzano), October 12, 2007

The standardisation of information on landslides in Italy has been one of the main aims of the Project. Prior to its implementation, no homogeneous landslide inventory existed for the entire country, with the exception of the AVI Archive. The numerous existing inventories, censuses or archives covered different geographical areas, from those of River Basin Authorities, to the regional, provincial, municipal or local ones, and they differed in terms of the criteria for recording, computerisation and classification of the landslides.
The IFFI **Landslide Data Sheet** has been prepared for collecting the landslide information, subdivided into three levels of progressively increasing detail (Annex 1):
- 1st level: contains the basic information (location, type of movement, state of activity) and is mandatory for every landslide;
- 2nd level: contains the geometrical, geological, and lithological parameters, land use, causes and activation date;
- 3rd level: provides detailed information on the damage, investigations and remedial measures.

With regard to the **mapping**, every landslide is represented by (Fig. 6):
- a georeferenced point placed, by convention, at the highest point of the landslide crown;
- a polygon, if the landslide may be mapped at the adopted survey scale;
- a line when the landslides have a very elongated form with a width which may not be mapped.

A scale of 1:10,000 has been adopted for the surveying and mapping of the landslides throughout most of Italy; a scale of 1:25,000 has been used in high mountainous areas or in low population areas.

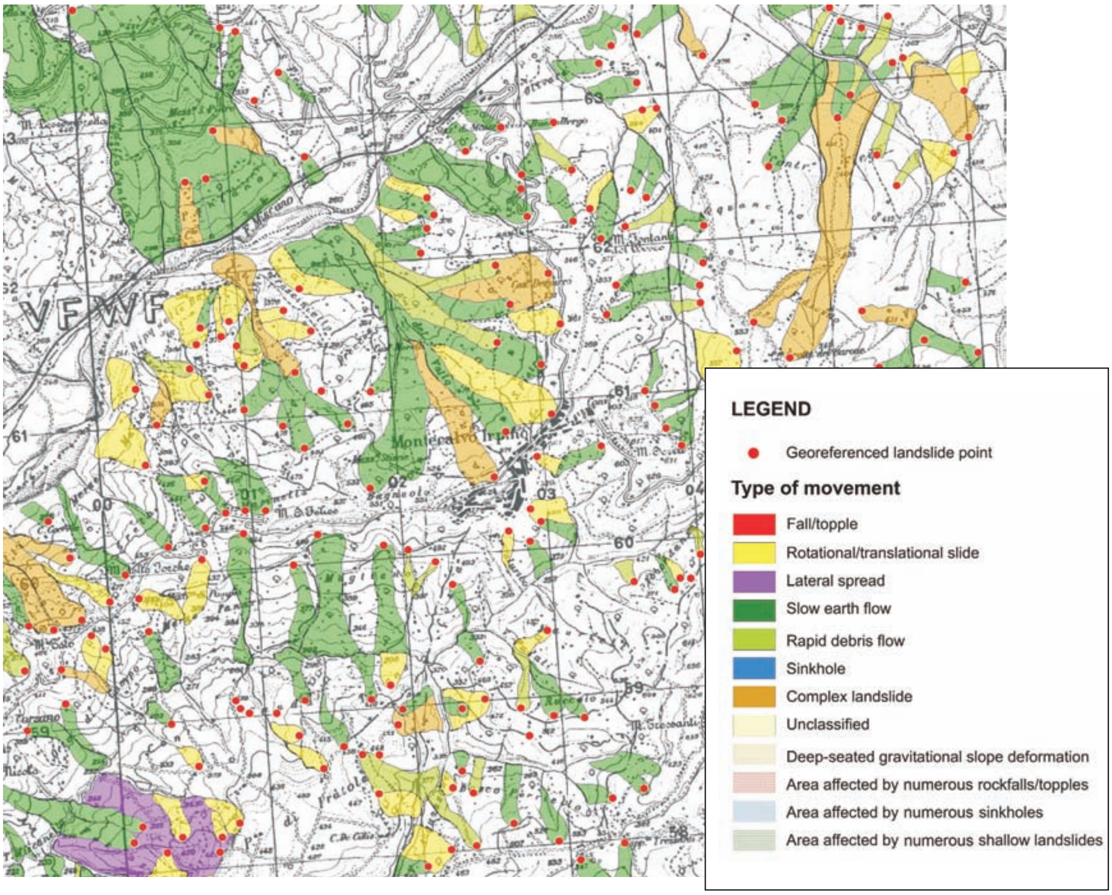


Figure 6: Legend and mapping extract

The Italian Landslide Inventory database consists of computerised mapping and the relative alphanumeric and iconographic database. The landslide identification code (ID-Landslide), which links the Landslide Data Sheet to the mapping, enables an unequivocal identification of the landslide within the entire country.
Before being entered in the IFFI database, the landslides have been subjected to quality controls (formal, spatial, relational and completeness checks).
The Geological Survey of Italy has developed the *"IFFI Controllo Forniture"* application, which is an extension of *ArcView* 3.x, enabling semi-automatic checks to be carried out and to identify omissions and potential errors, recording them on special shapefiles.
With regard to the completeness, territorial coverage and level of detail of the information stored in the database, comparisons have been made with other archives (AVI, SCAI, CARG and PAI - River basin Plans).

NATIONAL STATISTICS AND DATA PROCESSING

Up to 31 December 2007 the Inventory had surveyed 482,272 landslides, covering an area of almost 20,500 km^2, which is equivalent to 6.8% of Italy.

Table 1: Main parameters (Update: December 2007)

Region / Self-Governing Province	Number of landslides	Density of landslides	Landslide area	Landslide Index	Landslide Index in mountainous-hilly areas
	no.	no./100 km^2	km^2	%	%
Piemonte	35,023	126	2,540	9.1	15.0
Valle d'Aosta	4,359	134	520	16.0	16.0
Lombardy	130,538	547	3,308	13.9	29.9
Bolzano-Bozen	*1,995*	*27*	*463*	*6.2*	*6.3*
Trento	*9,385*	*151*	*879*	*14.2*	*14.7*
Veneto	9,476	52	223	1.2	3.1
Friuli Venezia Giulia	5,253	67	511	6.5	14.8
Liguria	7,515	139	425	7.9	8.1
Emilia Romagna	70,037	317	2,511	11.4	23.2
Tuscany	39,517	172	1,464	6.4	8.0
Umbria	34,544	408	651	7.7	8.7
Marche	42,522	442	1,882	19.4	21.2
Lazio	10,548	61	399	2.3	3.5
Abruzzo	8,493	78	1,241	11.4	12.5
Molise	23,940	539	623	14.0	15.7
Campania	23,430	171	968	7.1	8.8
Puglia	843	4	85	0.4	1.0
Basilicata	9,187	92	333	3.3	4.0
Calabria	9,417	62	822	5.5	6.0
Sicily	4,727	18	539	2.1	2.4
Sardinia	1,523	6	188	0.8	1.0
ITALY	**482,272**	**160**	**20,573**	**6.8**	**9.1**

The **landslide index** is the ratio of the landslide area to the total area, whilst the mountainous-hilly landslide index represents the ratio between the landslide area and the mountainous-hilly area of each Region/Self-Governing Province.

The parameters which provide the most representative overview of landslide distribution are the total landslide area and the landslide index calculated over the mountainous-hilly territory.

The regions with the highest landslide index over the mountainous-hilly territory are Lombardia, Emilia Romagna, Marche, Molise, Valle d'Aosta and Piemonte.

However, the data relative to the Regions of Basilicata, Calabria and Sicily represents an underestimate compared with the actual instability situation since, to date, the landslide survey activities have been concentrated mainly in urban areas or areas with main road and rail infrastructures.

A certain lack of homogeneity of the landslide data which may be noted from an analysis of Table 1 and Figure 7 is due not only to the different levels of detail of the previously existing inventories, but also to the greater or lesser degree of use of the aerial photo interpretation and field surveys, as well as the use of historical research and archives in the methodology adopted by each Regions/Self-Governing Provinces.
It should also be noted that the data is being integrated and updated for certain Regions and, consequently, the figures given in Table 1 may be revised.

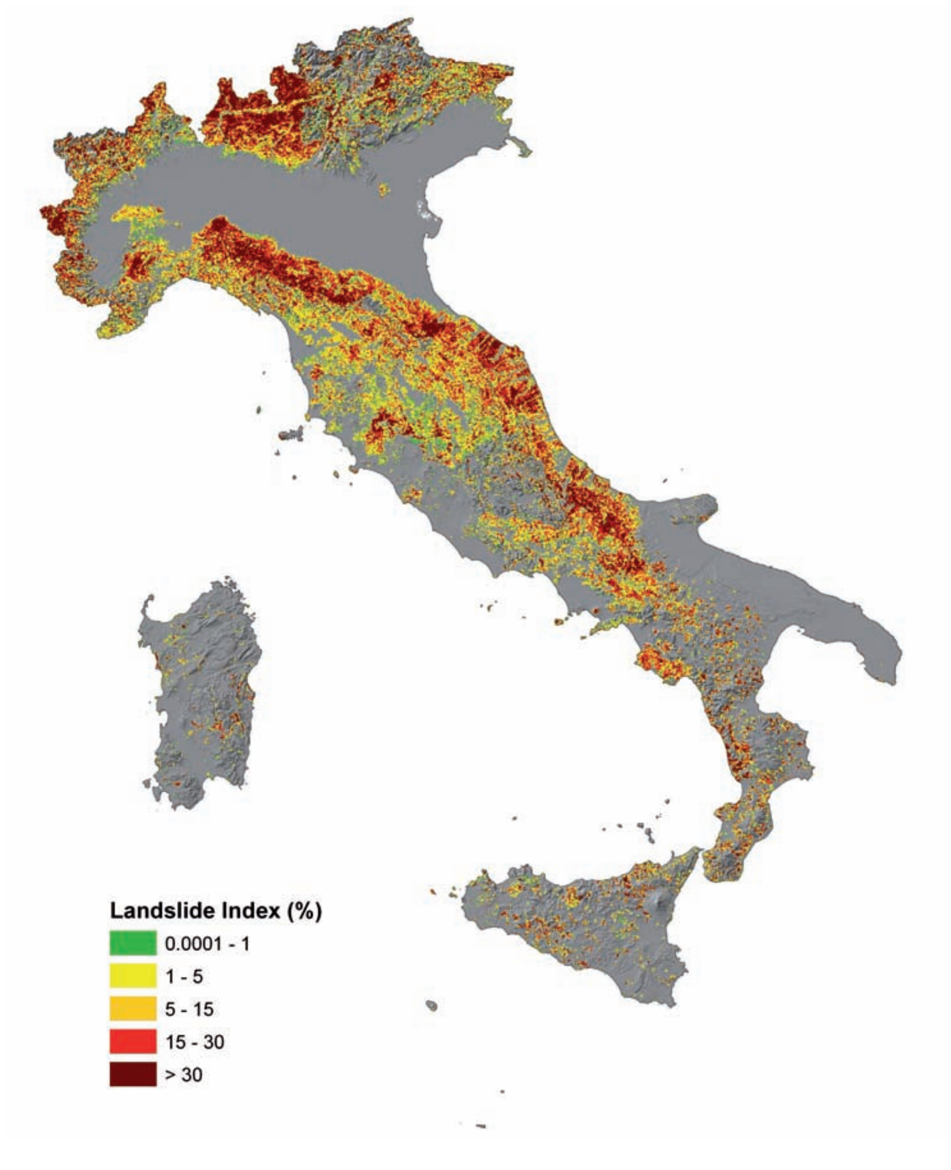


Figure 7: Landslide index (%) calculated over a 1 km wide grid

In order to calculate the mountainous-hilly landslide index a simplified digital terrain model of Italy has been preliminarily defined (Fig. 8), identifying three classes: alluvial plains, hills, mountains. This simplified digital terrain model of Italy has been obtained by using a 20x20 metre DEM. The alluvial plains include territories with an elevation <300 m and slope <3°; the hills have a slope >3° or an elevation between 300 and 600 m; the mountains include territories at an elevation >600 m. These threshold figures have been found from an analysis over large areas of Italy to be optimum values. Over an area of slightly more than 300,000 km^2, the mountainous-hilly territory represents three-quarters of the total (mountains 31%, hills 43%).

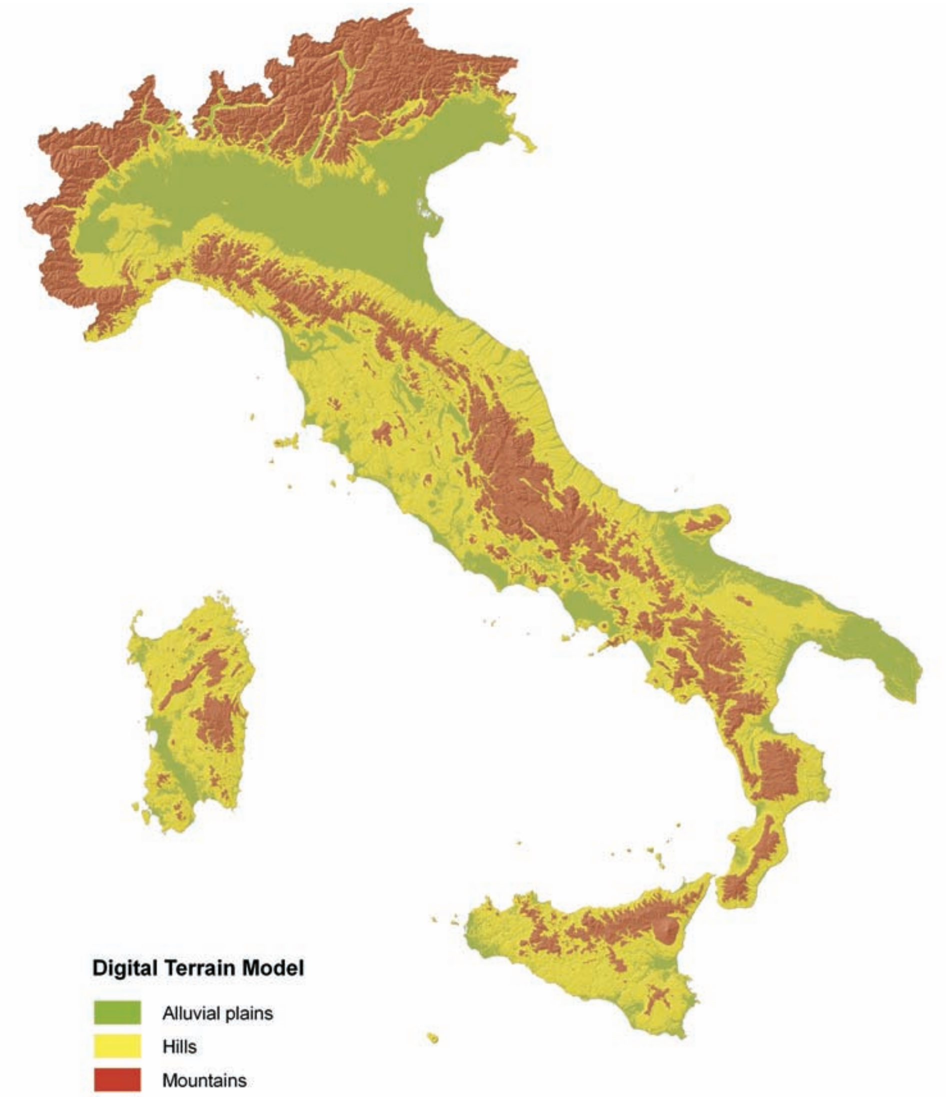


Figure 8: Simplified digital terrain model of Italy

The main **types of movement** found in Italy are represented by the rotational/translational slides with 32.5% of the total number of landslides, slow earth flows with 15.3%, rapid debris flows with 14.6% and complex landslides with 11.3% (Figs. 9 and 11). Even though a large part of the landslides are characterised by a complex type movement, they have been classified, where possible, on the basis of the prevalent type of movement, in accordance with the technical specifications of the Italian Landslide Inventory.

The percentage values change significantly if the surface area of the landslide is taken into consideration for each type of movement instead of the total number of landslides. The deep-seated gravitational slope deformation, for example, represent only 0.34% of the total number of landslides but almost 10% of the total area of landslides, since, in general, they affect large slope areas.

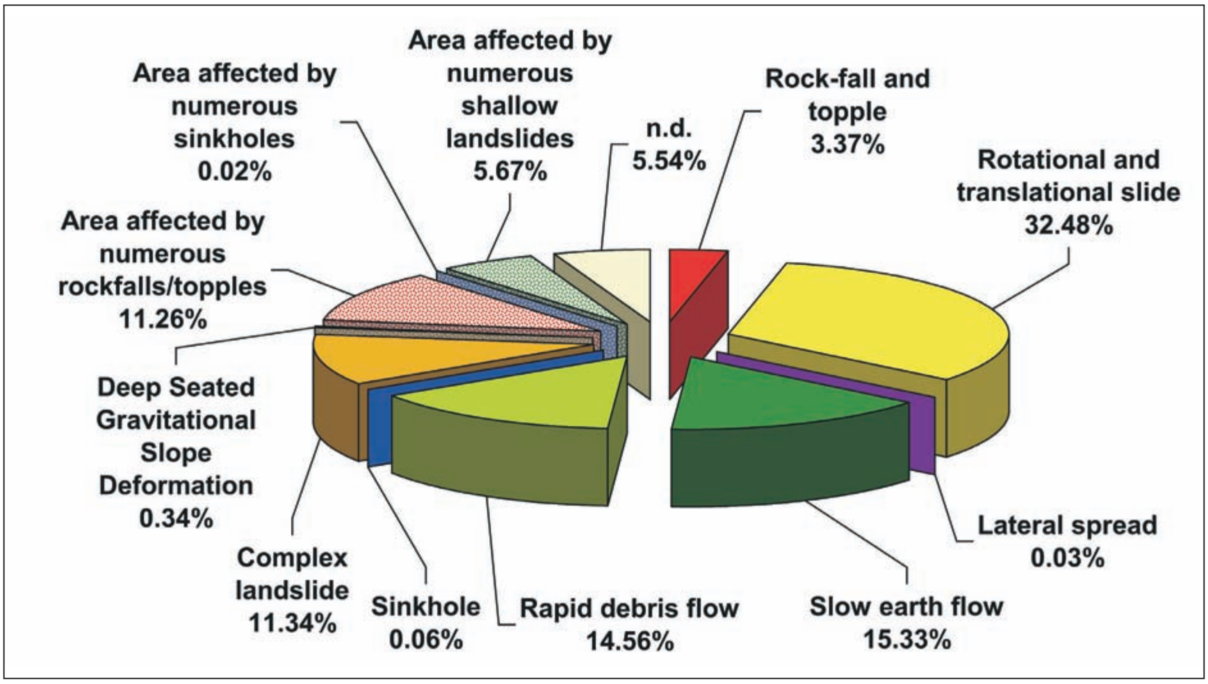
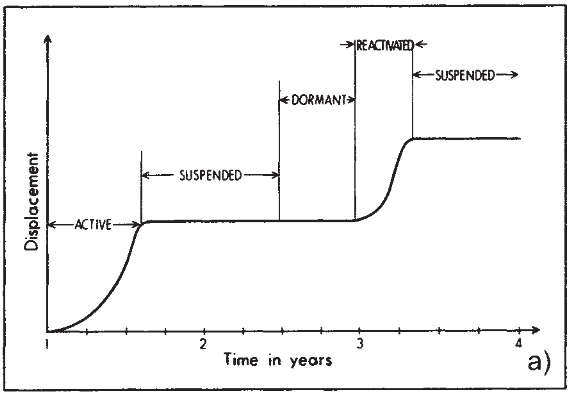


Figure 9: Type of movement (%)

The classification adopted for description of the **state of activity** (Fig. 10) is based on the recommendations by the WP/WLI (1993a), which were translated into Italian in Canuti & Esu (1995), Canuti & Casagli (1996) and more recently proposed by Cruden & Varnes (1996).



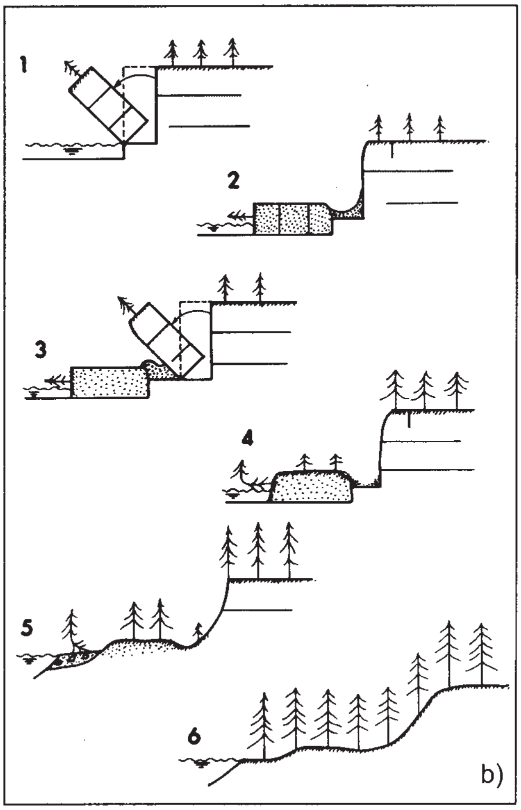


Figure 10: a) Diagram showing the state of activity of landslides over time; b) Toppling landslide in different states of activity: 1. active, erosion at toe of slope causes block to topple; 2. suspended, local cracking/fracturing in crown area; 3. reactivated, toppling of a new block; 4. dormant, the body of the landslide is colonised by vegetation, the slopes are remodelled by the weather; 5. naturally stabilised, fluvial deposits have protected the base of the slope; 6. relict, a uniform vegetation cover has been re-established (source: Cruden & Varnes, 1996)

45% of the landslides listed in the Inventory are classified as active, reactivated or suspended; 39% as dormant and 3% as stabilised. Lastly, 1% of the landslides are relicts.
The state of activity is undetermined for approximately 12% of the landslides.
The evaluation of the state of activity depends on the method used for its determination (direct observation during field surveys, archive data, analysis of aerial photos, data collected by *in situ* monitoring, or by DInSAR technique) and it is linked to the updating of the observation date. Very few landslides show a constant state of activity over time, whilst many more landslides alternate brief periods of activity with long periods of inactivity. This means that the allocation of a landslide to a particular class could already be “superseded” after a short period of time and, therefore, potentially misleading if the observation date is not known.
With regard to the method used for evaluation of the type of movement and the state of activity, aerial photo interpretation has been used to classify 302,651 landslides, field surveys for 106,910 landslides, monitoring for 377 landslides, historical or archive data for 147,410 landslides and reporting by authorities or eye witnesses for 10,606 landslides.

Figure 11: Complex landslide in district of Covatta reactivated on April 12, 1996, Ripalimosani (Molise Region)

In order to assess the relationship between the 482,272 landslides surveyed by the Italian Landslide Inventory and the steepness of the slope, the frequency distribution of the slope angle, at the Landslide Identification Point, has been analysed, for each type of movement. The instability of the slopes does not increase with an increase in the slope angle and a range of slope angles has been statistically found within which there is the maximum occurrence of the landslides. Two groups of curves may be clearly identified from an analysis of the frequency distributions: the curves relative to rapid or extremely rapid landslides - such as falls/topples, areas affected by numerous falls/topples and rapid debris flow - have a peak between 30° and 40°; the curves relative to slow earth flows, rotational/translational slides, complex landslides and areas affected by numerous shallow landslides have a peak between 10° and 15° (Fig. 12).

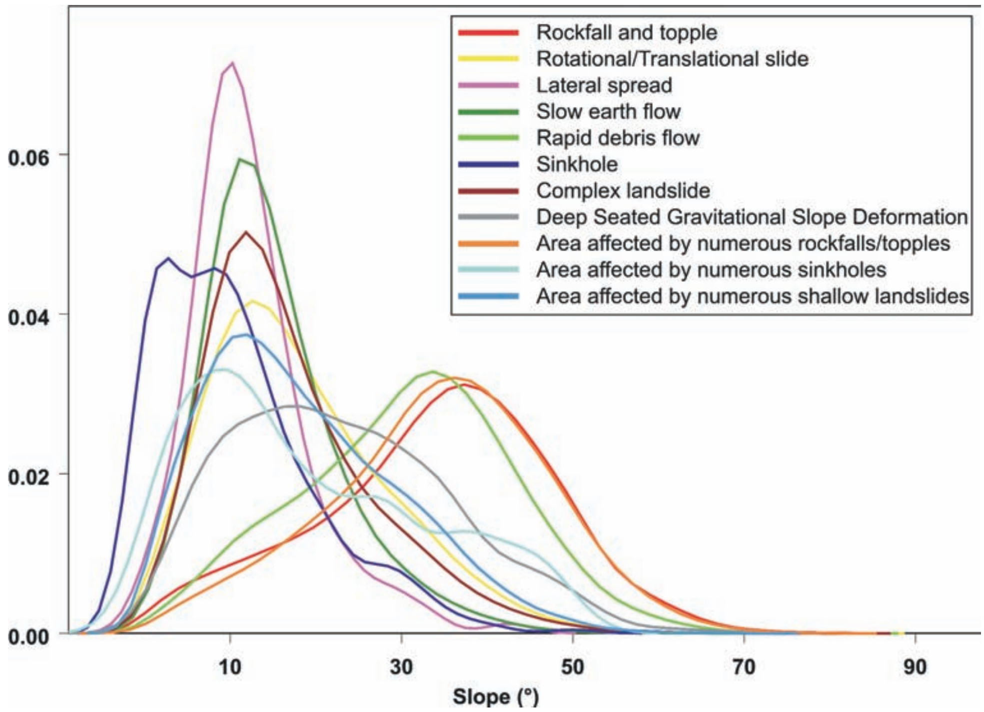


Figure 12: Frequency distribution of the slope angle at the landslide crown

The instability of a slope is often due to the interaction of several contributory natural and man-made **causes** (Fig. 13). Intense, short period rainfall and prolonged high precipitation are the most important factors for triggering slope instability phenomena.

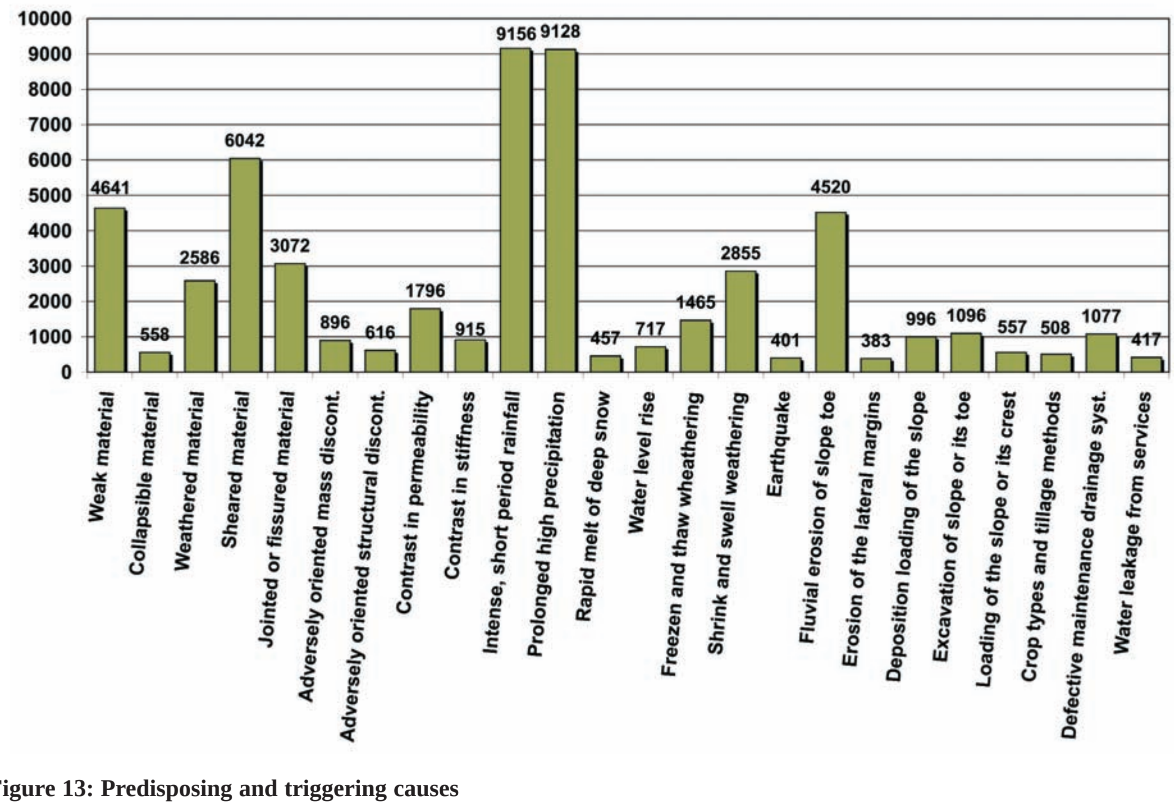


Figure 13: Predisposing and triggering causes

The man-made factors play an increasingly determinant role amongst the contributing causes, with both direct actions, such as road cuttings, excavations, overloading, and indirect actions, such as lack of maintenance of slope protection works. The road cuttings formed over recent decades in order to facilitate access to wooded areas for forestry activities have often resulted in instability of the slopes (Fig. 14).

Figure 14: Translational slide evolving as a flow triggered on a bend of a forestry road, Cervinara Municipality (Campania Region), December 15, 1999

The inventory contains information on the damage, for 36,890 landslides (Figs. 15-17).

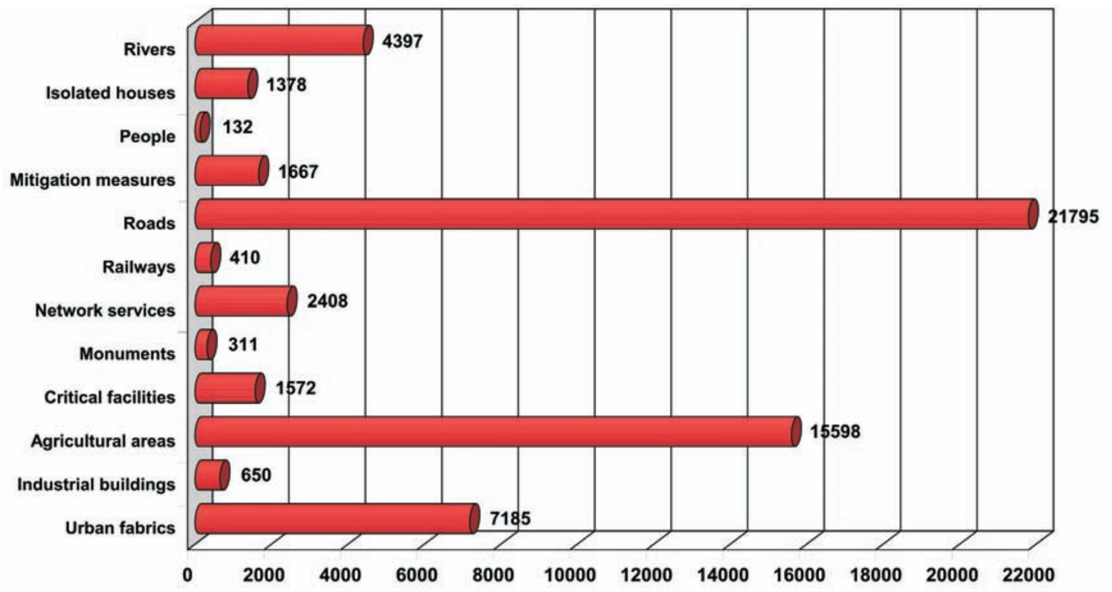


Figure 15: No. of landslides which caused damages. The sum of the values of each damage class is greater than the number of landslides with information on the damage (36,890), since the Landslide Data Sheet enables a multiple selection of the damage fields

The elements most commonly affected are roads, farmland and residential areas. With regard to injuries to individuals, landslides in Italy caused 6,608 fatalities until 2007.

Figure 16: Damage to the village of Cavallerizzo, Cerzeto Municipality (Calabria Region), March 7, 2005

Figure 17: Landslide at Borsoi, Tambre Municipality (Veneto Region), reactivation in autumn 2000 and in May - June 2004

LEVELS OF ATTENTION ON A MUNICIPAL BASIS

A preliminary evaluation of the level of attention, with regard to the landslide risk, on a municipal basis, was carried out by using the information contained in the database of the Italian Landslide Inventory and the Corine Land Cover Project 2000 (Fig. 18).

The level of attention has been defined as:

- *very high* when the landslide points, polygon and lines intersect continuous and discontinuous urban areas (CLC 1.1.1. and 1.1.2), industrial or commercial areas (CLC 1.2.1) extracted from the Corine Land Cover 2000;
- *high*, with regard to intersections with the motorway, rail and road networks, quarries, dump and construction sites (CLC 1.3.1, 1.3.2. and 1.3.3);
- *moderate*, for farm land (CLC 2), woodland and semi-natural environments (CLC 3), green urban areas and sports and recreational areas (CLC 1.4.1 and 1.4.2.);
- *negligible*, for the municipalities in which no landslide has been recorded.

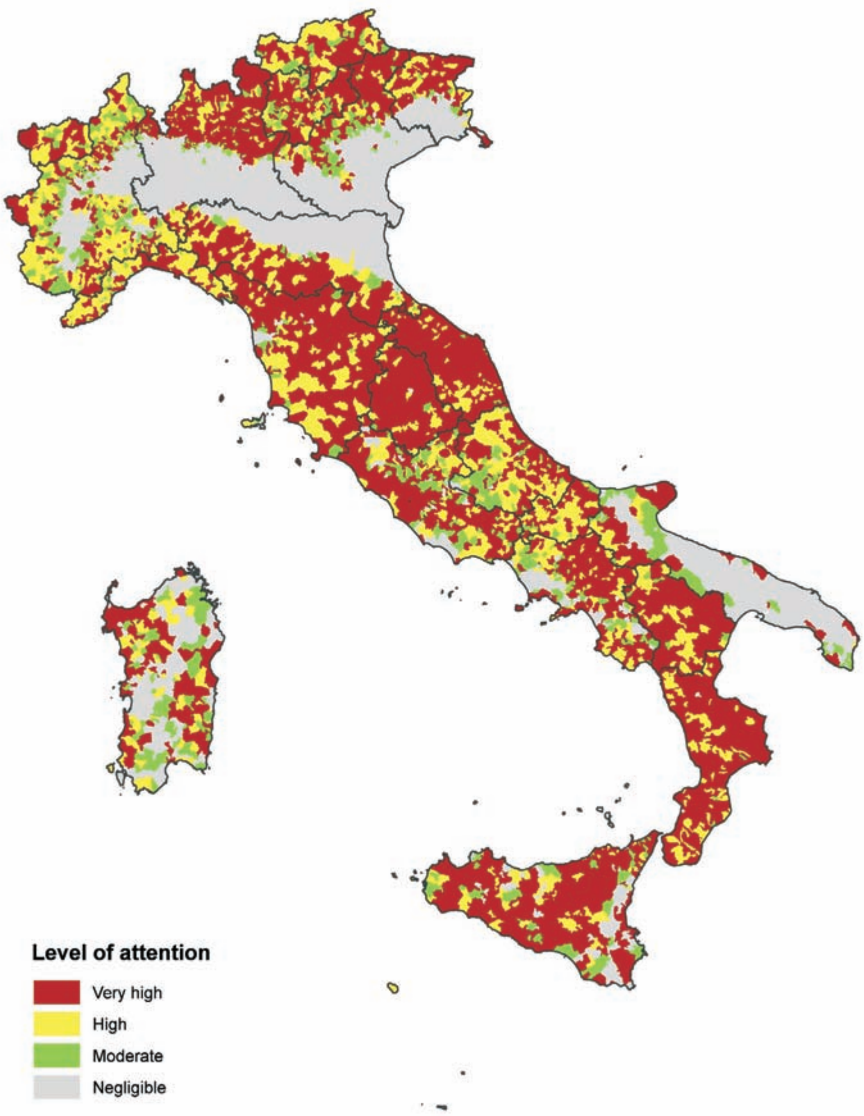


Figure 18: Level of attention with regard to the landslide risk, on a municipal basis

5,708 Italian municipalities out of a total of 8,101, that is, 70.5%, are affected by landslide phenomena, of which 2,940 with a very high attention level, 1,732 with a high attention level, 1,036 with a moderate attention level. 2,393 municipalities show a negligible attention level.

POPULATION AT RISK

An estimate of the number of persons exposed to landslide risk has been obtained by intersecting the landslides with the 382,534 census districts in which Italy is divided. The analysis shows that 992,403 persons are at risk, that is, 1.74% of the Italian population (56,995,744 inhabitants, 2001 ISTAT census).
Figure 19 shows the total population at risk for the 8,101 Italian municipalities (NUTS 5, in accordance with the nomenclature of the statistical territorial units of the European Union).

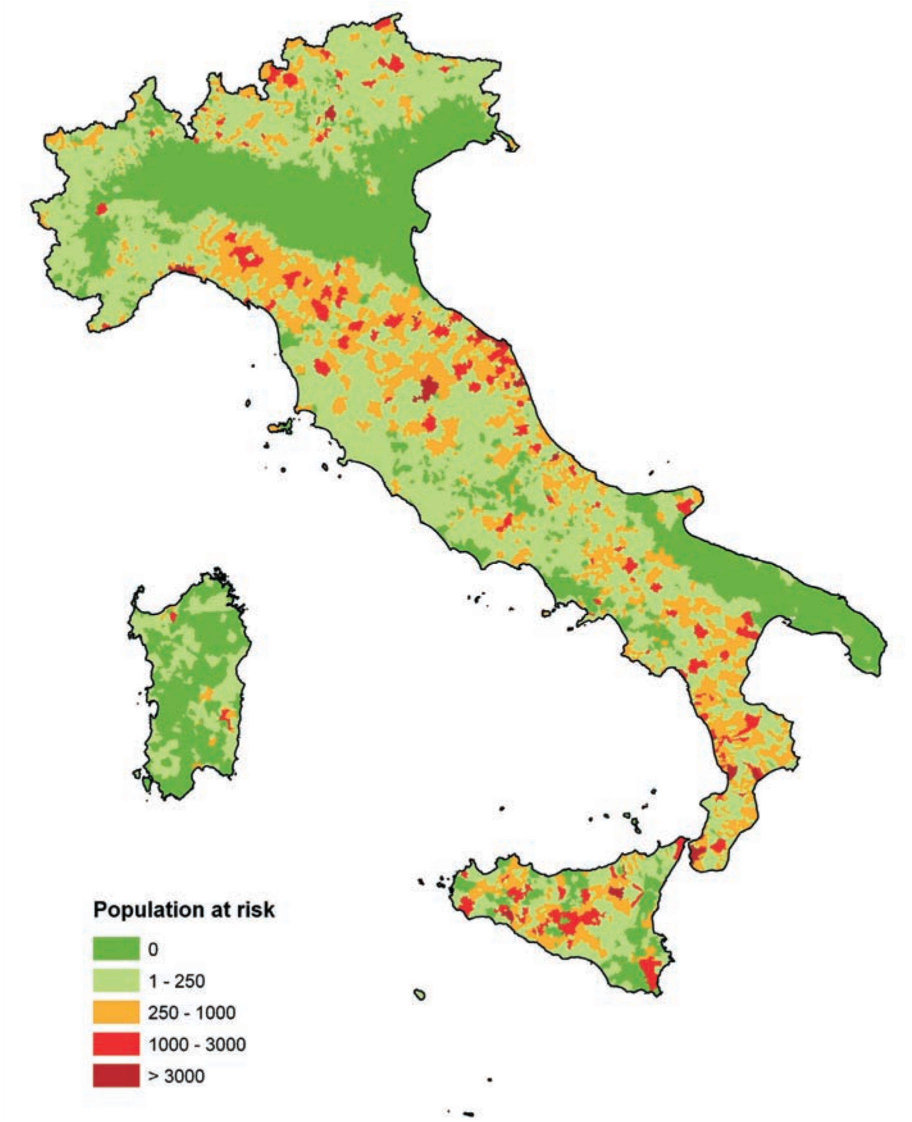


Figure 19: Population at risk, on a municipal basis

More than 3,000 persons are at risk in 14 municipalities; between 1,000 and 3,000 in 154 municipalities, between 250 and 1,000 in 909 municipalities, between 1 and 250 in 3,924 municipalities, and there is no risk of landslides for inhabitants in 3,100 municipalities.

DISSEMINATION OF LANDSLIDE INFORMATION

Dissemination of the information on landslides to the central and local public administrations and to the general public is extremely important to prevent the risk of landslides.
For this purpose, APAT set up an **online mapping service** for the Italian Landslide Inventory in 2005 (www.sinanet.isprambiente.it/progettoiffi).

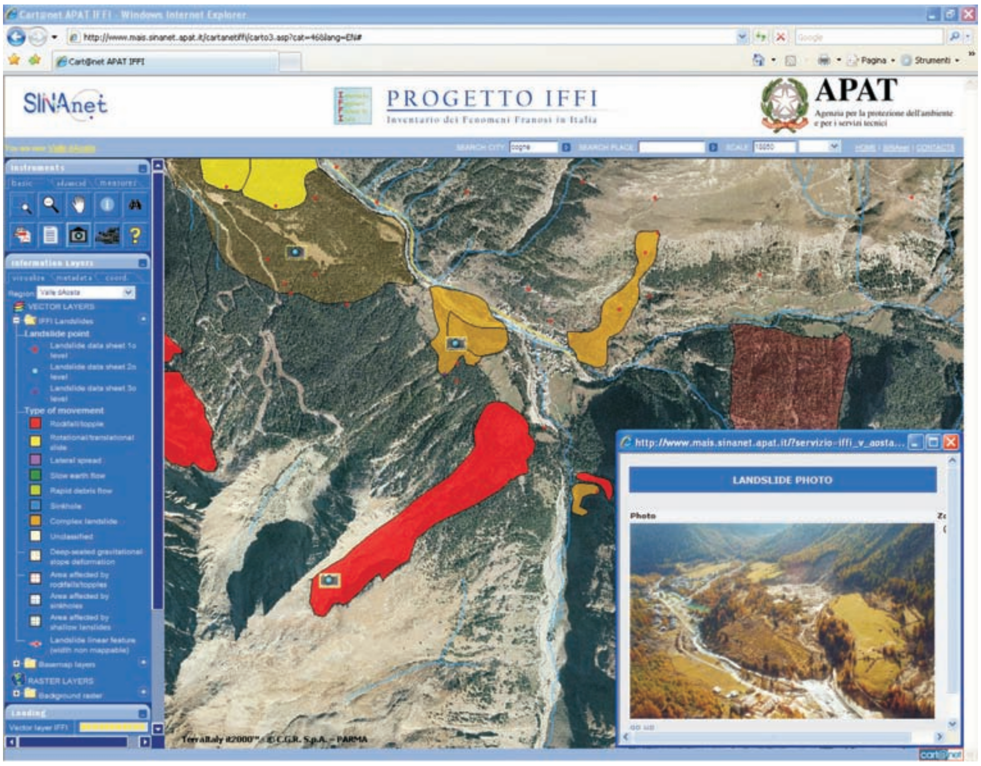


Figure 20: Online maps of the Italian Landslide Inventory

By means of simple and intuitive navigation, the user may view the landslides, urban areas (Corine Land Cover 2000), road and rail networks, rivers, the digital elevation model (20x20m DEM), satellite images (Landsat) and the IGM (Military Survey Office) 1:25,000 maps. Geographical searches may also be carried out, either by municipality or locality, and the database may be queried to acquire information on the landslides and visualise documents, photos and videos (Fig. 20).
The thematic layers are provided by ArcGIS Server (ESRI); the raster images being served by Image Web Server services (ERMapper) in ECW format (Enhanced Compressed Wavelet). The alphanumeric database is managed by SQL Server (Microsoft), whilst the base map layers are managed by ArcSDE (ESRI) connected to a Geodatabase (Oracle). The consultation and search for mapping and alphanumeric information takes place by means of the ECWP (Enhanced Compressed Wavelet Protocol) and http interchange protocols (Fig. 21).

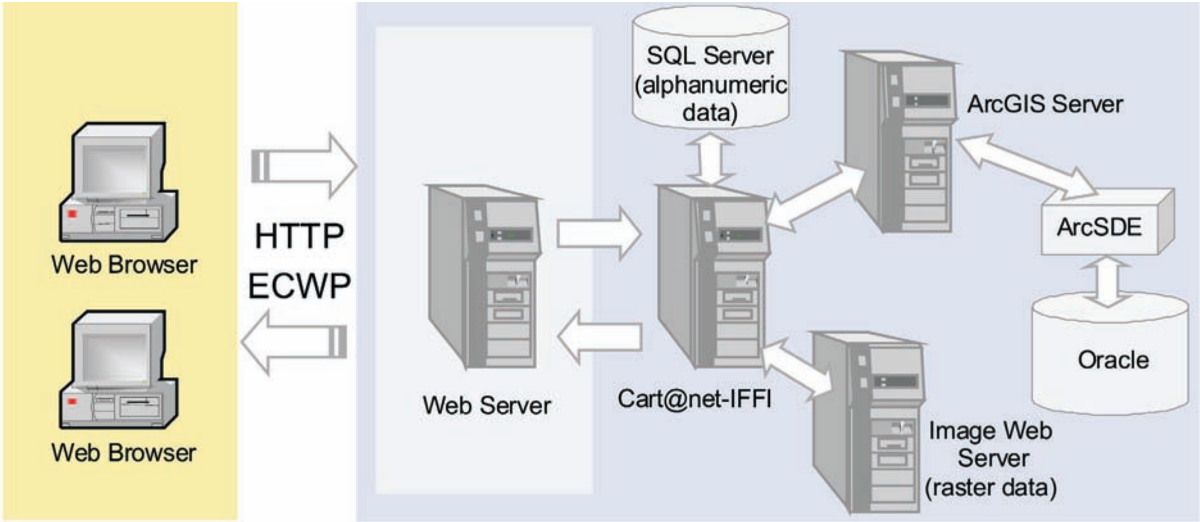


Figure 21: Architecture of the WebGIS Cart@net IFFI system

The website records over 100,000 hits per year.
A new tool for visualizing landslides in Google Earth has recently been developed.

The **WMS Service** (Web Map Service) of the Italian Landslide Inventory has been available since 2006. This enables the user to overlap the thematics of the landslides on other information layers available on Internet or stored on the user's own computer (Fig. 22). WMS is an interoperable and interchange protocol for sharing geographical datasets, in accordance with EU Directive 2007/2/EC INSPIRE (Infrastructure for Spatial Information in Europe).

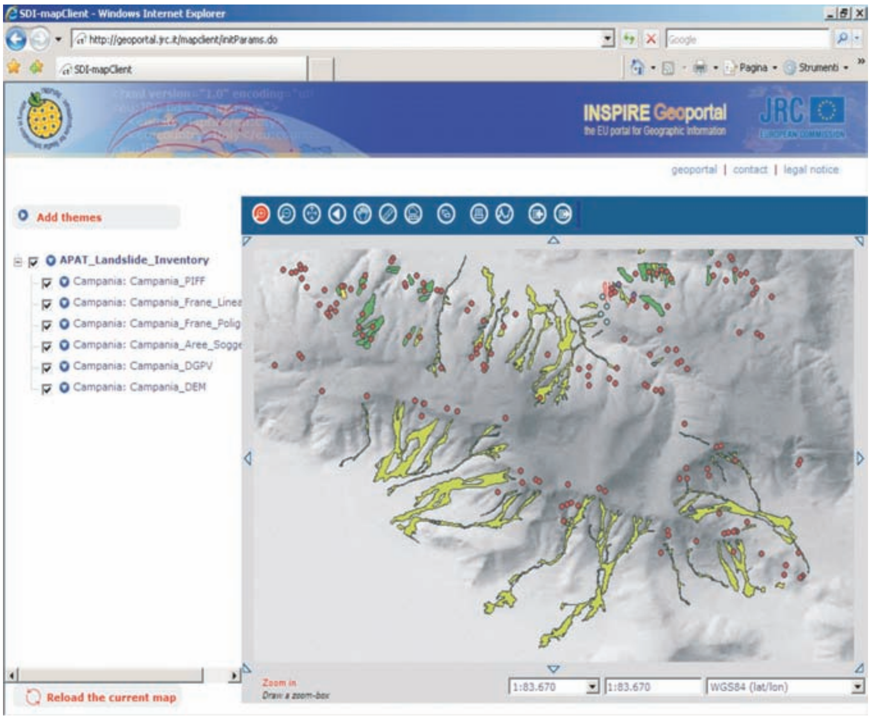


Figure 22: WMS service of the Italian Landslide Inventory displayed on INSPIRE Geoportal

A **National Workshop** was organised by APAT on 13 and 14 November 2007 on "The IFFI Project – Italian Landslide Inventory: methods and results" which, broadcast live on the Internet, presented the results achieved and enabled a comparison and exchange of experiences between the partners involved in the Project, researchers, and Public Administrations.
Further information may be obtained at:
http://www.apat.gov.it/site/it-IT/ContentsFolder/Eventi/2007/11/frane.html.

The Italian Landslide Inventory has been used by the River Basin Authorities for updating the River Basin Plans (PAI) and by the Regional, Provincial and Municipal Authorities for preparation of the Provincial Territorial Coordination Plans (PTCP), the Zoning Plans (PRG) and the Civil Defence Emergency Plans.
The online mapping service has been widely used by universities, research institutes, public and private companies which manage the infrastructure networks and by geologists and engineers operating in the sectors of landslide risk assessment and risk reduction measures. The use and importance in natural disaster emergency management and response has also been demonstrated.

CONCLUSIONS

The Italian Landslide Inventory provides a detailed overview on the distribution of landslides in Italy and on the most important parameters associated with them. The inventory contains more than 482,000 landslides which affect an area of approximately 20,500 km^2, that is, 6.8% of Italy. However, the landslides are not all equally hazardous; rapid phenomena (e.g. rockfalls, debris flows) and those which involve large volumes of rock or soil being the most dangerous.
5,708 Italian municipalities are affected by landslides, that is, 70.5% of the total number of municipalities.
The aims of the Project may be considered fully achieved bearing in mind that in 1999, before the start of the Project, approximately 70,000 landslides had been recorded by the Regions and Self-Governing Provinces.
The Italian Landslide Inventory is outstanding in the panorama of geo-thematic databases at a national, European and international level in terms of the:
- high levels of homogeneity with regard to the methods and standards adopted in the collection and computerisation of the data;
- total coverage of Italy;
- detail of the mapping of the landslides, which are represented with points and polygons (scale 1:10,000);
- completeness of the Landslide Data Sheet regarding the parameters which may be recorded to describe the landslide phenomena.

The ISPRA - Regions and Self-Governing Provinces System has been successful in the implementation of the Project since work groups, specialised in landslide identification and mapping, have been set up within every Region and a national network has been created to share and exchange information, methods and procedures.
In addition to its doubtless scientific importance, the Italian Landslide Inventory represents an invaluable tool for hazard and risk assessment, for land use planning and mitigation measures. The Italian Landslide Inventory has been integrated in the Regional Information Systems and used by the River Basin Authorities and by the Regional, Provincial and Municipal Authorities.

The dissemination of the information on landslides via Internet represents an indispensable tool for prevention of the risk. On the one hand, it enables the public administrations to implement a correct territorial planning and, on the other, it helps build the awareness of the general public regarding the conditions of risk in the territory. In this respect, the Website records over 100,000 hits per year. The interoperability and sharing of the data is also ensured, at a national level, by the WMS Service in compliance with EU Directive 2007/2/EC INSPIRE.
The understanding of landslide processes has a strategic importance for preventing risks, contributing over time to a significant reduction in damage and, therefore, costs. Bearing in mind that the majority of the landslides can be reactivated, the collection and analysis of information on past events is extremely important. Dormant periods lasting many years or several decades are often followed, as a result of extreme weather conditions, by periods of remobilisation.

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ANNEX 1

PROGETTO IFFI	ISPRA – Italian National Institute for Environmental Protection and Research *Geological Survey of Italy - Land Protection and Georesources Department*	LANDSLIDE DATA SHEET *Vers. 2.33 (2001)* by: Amanti M., Bertolini G., Ceccone G., Chiessi V., De Nardo M.T., Ercolani L., Gasparo F., Guzzetti F., Landrini C., Martini M. G., Ramasco M., Redini M., Venditti A. Translated by: Trigila A. & Iadanza C. (2008). Modified from: *Guida al censimento dei fenomeni franosi ed alla loro archiviazione.* AMANTI M., CASAGLI N., CATANI F., D'OREFICE M. & MOTTERAN G. (1996) - Miscell. VII Serv. Geol. d'It., Roma.
*Alphanumeric code		Landslide ID

GENERAL INFORMATION

	Location	
*Date of report	*Region	*Province
*Reporter's Name	*Municipality	
	*River Basin Authority	
*Public Institution	Topographic Map	
	Scale / Number	Locality

GEOMETRY

Crown elevation (m)	Azimuth α (°)
Toe elevation (m)	Total area A (m^2)
Horizontal length L_h (m)	Width W (m)
Height H (m)	Volume of displaced material V (m^3)
Slope angle β (°)	Depth of surface of rupture D_r (m)

POSITION ON THE SLOPE

Crown		*Toe*
○	Ridge	○
○	Upper part	○
○	Middle part	○
○	Lower part	○
○	Flood plain	○

GEOLOGY

Geologic unit 1 | Geologic unit 2

Description 1 | Description 2

Discontinuity 1: dip direction/ dip | Discontinuity 2: dip direction/ dip

1 2 Bedding attitude
- ○○ horizontal
- ○○ dipping into the slope (anaclinal)
- ○○ obliquely to the slope
- ○○ obliquely (orthoclinal)
- ○○ obliquely (plagioclinal)
- ○○ downslope (cataclinal)
- ○○ downslope steeper than slope
- ○○ dipping out of the slope
- ○○ parallel to the slope

1 2 Rock mass structure
- ○○ massive
- ○○ stratified
- ○○ fissile
- ○○ moderately jointed
- ○○ fractured
- ○○ schistose
- ○○ vacuolar
- ○○ chaotic

1 2 Joint spacing
- ○○ very wide (> 2m)
- ○○ wide (60cm – 2m)
- ○○ moderate (20cm – 60cm)
- ○○ close (6cm – 20cm)
- ○○ very close (<6cm)

1 2 *Geotechnical properties
- ○○ rock
- ○○ lapideous rock
- ○○ weak rock
- ○○ debris
- ○○ grained soil
- ○○ dense grained soil
- ○○ loose grained soil
- ○○ cohesive soil
- ○○ firm cohesive soil
- ○○ soft cohesive soil
- ○○ organic soil
- ○○ complex unit
- ○○ alternating beds
- ○○ mélange

1 2 Weathering
- ○○ fresh
- ○○ slightly weathered
- ○○ moderately weathered
- ○○ severe weathered
- ○○ completely weathered

Notes:

1 2 *Lithology
- ○○ limestone
- ○○ travertine
- ○○ marl
- ○○ limestone-marly flysch
- ○○ sandstone, arenaceous flysch
- ○○ shale, _olitic flysch
- ○○ acid extrusive rock
- ○○ basic extrusive rock
- ○○ pyroclastic rock
- ○○ acid intrusive rock
- ○○ basic intrusive rock
- ○○ weakly foliated metamorphic rock
- ○○ foliated metamorphic rock
- ○○ evaporite
- ○○ sedimentary siliceous rock
- ○○ conglomerate or breccia
- ○○ debris
- ○○ gravel
- ○○ sand
- ○○ silt
- ○○ clay
- ○○ mixed soil
- ○○ man-made ground

*LAND COVER

○ urban areas	○ annual crops associated with permanent crops	○ reforestation	○ sparsely vegetated areas
○ mineral extraction sites	○ permanent crops	○ coppice woodland	○ bush
○ arable land	○ riparian vegetation	○ forest trees	○ pastures

*SLOPE ASPECT

○ N	○ E	○ S	○ W
○ NE	○ SE	○ SW	○ NW

HYDROGEOLOGY

Superficial water
- ☐ absent
- ☐ stagnant
- ☐ diffuse runoff
- ☐ concentrate runoff

Springs
- ○ absent
- ○ diffuse
- ○ local

Groundwater
- ○ absent
- ○ unconfined
- ○ confined

No. | Depth (m)

Notes:

CLASSIFICATION

1st lev	1	2	*Type of movement ○ unclassified
○	○	○	fall
	○	○	topple
○	○	○	rotational slide
	○	○	translational slide
○	○	○	lateral spread
○	○	○	slow earth flow
○	○	○	rapid debris flow
○	○	○	sinkhole
○			complex
○			deep-seated gravitational slope deformation
○			area affected by numerous rockfalls/topples
○			area affected by numerous sinkholes
○			area affected by numerous shallow lanslides

1 2 Rate of movement
- ○○ extremely slow (< $5*10^{-10}$ m/s)
- ○○ very slow (< $5*10^{-8}$ m/s)
- ○○ slow (< $5*10^{-6}$ m/s)
- ○○ moderate (< $5*10^{-4}$ m/s)
- ○○ rapid (< $5*10^{-2}$ m/s)
- ○○ very rapid (< 5 m/s)
- ○○ extremely rapid (> 5 m/s)

1 2 Material
- ○○ rock
- ○○ debris
- ○○ earth

1 2 Water content
- ○○ dry
- ○○ moist
- ○○ wet
- ○○ very wet

Notes:

ACTIVITY

***State** ○ unclassified

○
- ○ active | ○ dormant | ○ stabilized | ○ relict
- ○ reactivated | | ○ artificially stabilized
- ○ suspended | | ○ abandoned

Distribution
- ○ moving
- ○ retrogressive
- ○ advancing
- ○ widening
- ○ diminishing
- ○ enlarging
- ○ confined

Style
- ○ single
- ○ complex
- ○ multiple
- ○ composite
- ○ successive

***METHOD USED TO CLASSIFY THE TYPE OF MOVEMENT AND STATE OF ACTIVITY**
- ☐ aerial photo-interpretation°
- ☐ field survey
- ☐ monitoring
- ☐ historical/archive data
- ☐ reporting

° Aerial photo interpretation:
- Flight ID
- Strip number
- Photo number

***DATE OF THE MOST RECENT OBSERVATION FOR THE EVALUATION OF THE STATE OF ACTIVITY**

ACTIVATIONS

DATING OF THE MAIN EVENT

Certain date		
Uncertain date	min	max
Year		
Month		
Day		
Time		
Radiometric age	Years BP	precision
		±

Source of information
- ☐ newspapers
- ☐ remote sensing images
- ☐ publications
- ☐ historical documents
- ☐ oral testimony
- ☐ lichenometry
- ☐ videos
- ☐ dendrochronology
- ☐ archives
- ☐ radiometric methods
- ☐ maps
- ☐ others

CAUSES

Geological
- ☐ weak material
- ☐ sensitive material
- ☐ collapsible material
- ☐ weathered material
- ☐ sheared material
- ☐ jointed or fissured material
- ☐ adversely oriented mass discontinuities
- ☐ adversely oriented structural discontinuities
- ☐ contrast in permeability
- ☐ contrast in stiffness

Morphological
- ☐ tectonic uplift
- ☐ volcanic uplift
- ☐ glacial rebound
- ☐ fluvial erosion of the slope toe
- ☐ wave erosion of the slope toe
- ☐ glacial erosion of the slope toe
- ☐ erosion of the lateral margins
- ☐ subterranean erosion, piping
- ☐ deposition loading slope or its crest
- ☐ vegetation removal

Physical
- ☐ intense, short period rainfall
- ☐ prolonged exceptional precipitation
- ☐ rapid snow melt
- ☐ thawing of permafrost
- ☐ freezing spring water
- ☐ rapid drawdown
- ☐ water level rise
- ☐ freeze and thaw weathering
- ☐ thermoclastism
- ☐ shrink and swell weathering
- ☐ weathering
- ☐ earthquake
- ☐ volcanic eruption
- ☐ dam breaking

Human
- ☐ excavation of slope or its toe
- ☐ loading of slope or its crest
- ☐ drawdown of reservoirs
- ☐ reservoir level rise
- ☐ irrigation
- ☐ crop types and tillage methods
- ☐ poor maintenance of drainage systems
- ☐ water leakage from utilities
- ☐ vegetation removal (deforestation)
- ☐ reforestation
- ☐ mining and quarrying (open pits)
- ☐ mining and quarrying (underground gall.)
- ☐ creation of dumps of very loose waste
- ☐ artificial vibration

Note: (X) *contributing* (■) *triggering*

PRECURSORY SIGNS

- ☐ new fissures, cracks
- ☐ trenches
- ☐ localised rockfalls
- ☐ bulges
- ☐ slope reversed
- ☐ subsidence, differential settlements
- ☐ new cracks in structures
- ☐ creaking of structures
- ☐ tilting of utility poles or trees
- ☐ appearance of springs
- ☐ disappearance of springs
- ☐ disappearance of water courses
- ☐ change in water flow from springs
- ☐ sudden change in well water levels
- ☐ pore water pressure in soil
- ☐ underground noises

*DAMAGE — n.d. (not determined)

Type of damage ☐ direct ☐ collapse into reservoir ☐ water course blockage ☐ blockage and landslide dam break ☐ artificial dam break

Persons ☐	☐ deaths no.	☐ injuries no.	☐ evacuated no.	☐ at risk no.
Buildings ☐	☐ private no.	☐ public no.	☐ private at risk no.	☐ public at risk no.
Cost (€.)	**Assets**	**Activities**	**Total**	

	Level		Level		Level		Level
Urban centres	☐	**Public service structures**	☐	**Cultural heritage**	☐	**Roads**	☐
town		hospital		monuments		motorways	
village		barracks		historical-architectural heritage		state road	
rural settlement		school		museums		provincial road	
scattered houses		library		art-works		municipal road	
Economic activities	☐	Public Administration building		**Lifelines**	☐	others	
commercial centre		church		water pipelines		**Remedial works**	☐
craft trade centre		sports facilities		sewers		river engineering works	
factory		cemetery		power lines		slope stabilization works	
chemical plant		power station		phone lines		protection works	
mining and quarrying		port		gas pipelines			
livestock centre		bridge or viaduct		oil pipelines		***Water course*** ☐	
Farm land/ Forests	☐	tunnel		canals		**Name**	
arable land		penstock		cable ways			
arable land with trees		railway station		**Railways**	☐		
permanent crops		reservoir		high speed rail			
pastures		dam		double track		**Damage:** ○ potential	
woodland		incinerator		single track		○ deviation	
reforestation		dump sites		urban rail		○ partial obstruction	
		water treatment plant		railways (unclassified)		○ complete damming	

Level of damage: *N = negligible; A = aesthetic (minor); F = functional (major); S = structural (total)*

STUDIES/INVESTIGATIONS

Technical reports
- ☐ survey report
- ☐ geological report
- ☐ preliminary design
- ☐ final/construction design

Investigation and monitoring
- ☐ geognostic boreholes
- ☐ geotechnical lab tests
- ☐ groundwater investigations
- ☐ geoelectrical investigations
- ☐ ground level seismic
- ☐ down hole seismic
- ☐ cross hole seismic
- ☐ penetrometer
- ☐ pressuremeter
- ☐ scissometer
- ☐ inclinometers
- ☐ piezometers
- ☐ fissure gauges
- ☐ extensometers
- ☐ clinometer
- ☐ settlement gauge
- ☐ micro-seismic network
- ☐ topographic monitoring
- ☐ hydro-meteorological monitoring
- ☐ others

REMEDIAL MEASURES

Earthworks
- ☐ profiling, terracing
- ☐ reduction of head loads
- ☐ rock removal
- ☐ increase of base loads

Retention systems
- ☐ gabions
- ☐ walls
- ☐ bulkheads
- ☐ piles
- ☐ reinforced soil

Damage mitigation
- ☐ consolidation of buildings
- ☐ delocalization, demolition
- ☐ evacuation
- ☐ early warning system

Drainage
- ☐ surface drainage
- ☐ drainage trenches
- ☐ drainage wells
- ☐ sub horizontal drains
- ☐ drainage tunnels

Protection measures
- ☐ mesh
- ☐ shotcrete
- ☐ rock fall shaped berms
- ☐ rock fall catch ditches
- ☐ rock fall barriers

Soil Bioengineering, forestry works
- ☐ grass seeding
- ☐ reforestation
- ☐ selective cutting
- ☐ live fascine, live wattle fences
- ☐ check dams
- ☐ river bank protection

Reinforcement
- ☐ dowels, bolts
- ☐ ties, anchors
- ☐ block strapping
- ☐ injection/jet grouting
- ☐ micro-piles
- ☐ thermal, chemical, electrical treatment

Cost of investigations (€)	**Planned cost of remedial works (€)**	**Actual cost of remedial works (€)**

DOCUMENTATION

Archives
- ☐ **AVI archives**
- ☐ **SCAI archives**
- ☐ **DPC archives**
- ☐ **ISPRA archives**
- ☐ **Others**

Geological Map
- ○ YES
- ○ NO
- ○ Not covered

NATIONAL LEGISLATIONS

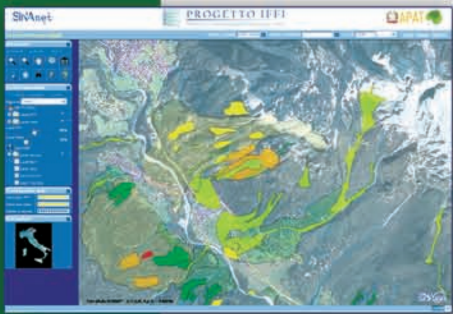
- ☐ Law 267/98 Urgent plans
- ☐ Law 267/98 Urgent remedial measures
- ☐ Law 267/98 PSAI
- ☐ Law 183/89 River Basin Plans
- ☐ Regional landscape planning
- ☐ Provincial territorial coordination plans
- ☐ Civil Defence Emergency Declarations
- ☐ Law 365/00
- ☐ Others

BIBLIOGRAPHY

Authors	Year	Title	Journal / Book / Report	Publisher	vol.	pages

Notes:

Finito di stampare nel mese di settembre 2011
presso la Tipolitografia CSR
Via di Pietralata, 157 - 00158 Roma
Tel. 06.4182113 - Fax 06.4506671



ISBN 978-88-448-0355-1

RAPPORTI
83 / 2008