Session: **Extreme Events in Winter Time**
Sub-topic: **Management in extreme events conditions**

# Characterization of extreme weather events on Italian roads

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## Abstract

According to climate modellers, probability, frequency, duration, intensity (seriousness) of extreme weather events (extreme temperatures and rainfall) are increasing and will be more frequent in future. The former will lead to higher surface runoff and flood events while the latter will cause landslides phenomena and a break of roads network. The impact of such events depends greatly on the physical hydraulic and mechanical properties of soils. Increasing numbers of extreme events in winter time in recent years have demonstrated the paramount importance of effective and integrated management of land resources in the protection of the environment and of the road network. In Italy more than 10% of the territory has been classified as having a high or very high hydro-geological risk, affecting 80% of the Italian municipalities. The impacts on population and the economic damages are relevant. In Italy over the last 20 years, floods and landslides had an impact on more than 70 000 people and caused economic damage of at least 11 billion euro. Since 2000, the Italian Ministry for the Environment entrusted ISPRA the task of monitoring the programmes of emergency measures to reduce hydro geological risk. (ReNDiS project, database of mitigation measures against floods and landslides).

## 1. A little of history

The scientific programme for the assessment of extreme weather events is part of a national program for mitigation of hydrogeological risk. This program is based on the identification of risk areas with different levels of hazards and damage and future planning. In Italy already with primary legislation (Act of Parliament No. 2359 of 25 June 1865) prefects and mayors could dispose of private property for landslides, dam failures, collapse of bridges and in all cases of emergency. In 1906, have issued special rules, for the defence of inhabited localities and roads by landslides, flooding and coastal erosion caused by severe storms.
The Royal Decree No. 193 of 1909 excluded constructability on inappropriate sites (landslides, muddy or soggy soil, marshy coastline, etc...) but only eighty years after in Italy it was promulgated Act No. 183 of 1989 on the "soil Protection" by the imposition of the authorities of watershed and the predisposition of the specific projects. With Act of Parliament No. 225 of 1992, was created the National Service of Civil Protection, for all rescue operations in disaster prevention and risks post-event. For twenty years the Italian system structure potential events at watershed level and determines the cognitive framework of reference (return periods, extent of damage expected).
A national programme for the strengthening of hydrometeorological monitoring networks and abundant rain falls was hired with the law n ° 267, 08/03/1998.

### 1.1 Methodology

Over the past 130 years, the Italian climate became warmer and dry but is evolving very rapidly in the Alpine environment. While temperatures are a significant increase, precipitation have contradictory trends and not well conceived. The intensity of the phenomena of full instead is increasing at an alarming rate. In order to contribute to the evolution of knowledge on climate change and hydraulic risk developed studies focused on weather-climatic characterization of rainfall events at watershed scale, but it is still too early to identify specific trends nationally. It is impossible to say anything about the trends, it should focus on the phenomena of risk.
The risk is represented by the possibility that a natural or human-induced phenomenon may cause adverse effects on the population, buildings and infrastructures.

The notion of risk is linked not only to the ability to calculate the probability of a hazardous event, but also by the ability to define the damage. Risk and danger are not the same thing: the danger is represented by the calamitous event that can affect a given area (the cause), the risk is represented by its possible consequences, i.e. of the damage that can be expected (the effect).
To assess concretely a risk therefore is not enough to know the dangers, but we must also carefully assess the value displayed, i.e. property (land, buildings, equipment) present on the territory which may be affected by an event.
The risk is then translated into the formula:

$$R = P \times V \times E$$

P = danger: the probability that a particular phenomenon to occur over a period of time in an intensity area given.

V = vulnerability: this vulnerability to potential damage to persons, buildings, infrastructure and economic activities can be damaged as a result of stresses induced by the events of a certain intensity.

E = The economic value or the set of units related to each of the hazards for a given area. The exposed value is a function of the type of hazard. Value is the number of units (or 'value') for each of the elements at risk present in a given area, infrastructures or buildings.

Regards mudslides and water courses, assessing risk and determination of the necessary work to prevent damage in areas prone to landslides are evaluated through:
-formation of debris models: trigger scene (all of the energy loss associated with the internal behaviour of the material is described by a term effective friction between the casting base and bedrock, these models are called to " Coulomb rheology", excess pore pressure, etc.); phase of mobilization post-collapse (avalanche and liquefaction effect);
-models of propagation (erosion, deposition and impacts): dynamic characteristics of flows of mud or macro-viscosite (landslides):
-models structural assistance (on the slopes, streams and threatened settlements),
-preparation of alarm systems and of the regulation of the territories;
-interaction with channelized infrastructures;
-specific work.

## 1.2 Landslide and historical series

The historical series of landslides that hit the territory of Italy is marked by particularly relevant events and among them are:
- (Arezzo) Pieve Santo Stefano flood produced after the event of the local collapses of Belmonte February 14, 1855; caused by occlusion of the Tiber which After a month of incessant rain; a landslide detaches from the Hill and sliding towards the South of the village. The natural dam formed made disappear Pieve Santo Stefano beneath the waters. Grand Duke Léopold II arrives for visit and he sailed as a sign of disbelief on the village (on the outer wall of the sanctuary of the Madonna dei Lumi, a plate of marble shows the raised water level at this stage).
- On 25 and 26 October 1954 mudslides and debris produced by heavy rains flooded some areas of Salerno and five neighboring towns (Cava dei Tirreni, Maiori, Minori, Vietri and Tramonti) causing damage and losses: 318 dead or missing and 157 wounded about 5,500 evacuees. Roads and railway network between Naples and southern Italy were destroyed in several places.

-October 9, 1963, approximately 300 million cubic meters of rock break from the slopes of Monte Toc, on the border of the province of Belluno and Pordenone and slip into the Vajont reservoir. The sliding of the huge rockfalls, one of the largest in the Alps at this historic time, pushed the water from the tank against Casso and Erto, two villages on the opposite side to the one who broke the shift of land and beyond the artificial dam. A wave of a few tens of meters in height exceeded the dam, almost without ruining and achieved in a few minutes from the town of Longarone, which was flooded and destroyed after the display of the landslide. The landslide catastrophic Vajont caused the death of around 2,000 people.
-On 3 and 4 November 1966, in what will be known as " The 1966 Flood of the Arno River in Florence" the season of rains in Italy was so strong that only in the province of Belluno there were many landslides and collapses that destroyed or endommagerent more than 4300 buildings 528 bridges 1346 roads, and some of them in several places.
-On 7 and 8 October 1970 heavy localized but very intense, typical of the Ligurian coast, brought down 900 mm of rain in 24 hours, corresponding to 90% of the average annual precipitation and determined damage to Genes and twenty municipalities. The streets and the two lines of railway between Genoa and Alexandria were broken in several places by flooding and landslides.
-December 13, 1982, a large, deep landslide, about 342 acres of territory, began to move just north of the port of Ancona.The large landslide endommaged the coastal road and the path tracks along a 2.5-kilometers front and destroyed more than 280 buildings including two hospitals and the Faculty of Medicine of the University of Ancona.
- 17-19 July 1987, in Valtellina (Lombardy), strong and prolonged precipitation determined many landslides and debris but a few days later, on 28 July, an avalanche of rock of 35 million cubic meters is broken away from Monte Zandilla, about 7 km south of Bormio and crushed in the Valley of the Adda, and the clogged. Total: 49 killed, 12 missing and 31 injured. The only downfall of roche caused 27 deaths and 9 injuries. Downstream of the important landslide, for several weeks, were evacuated more than 20,000 people. The damage were observed in 162 municipalities of 5 different provinces (Sondrio, Como, Lecco, Bergamo and Brescia), for a total of economic damages estimated between 1000 and 2000 billion lire (500-thousand million euros).
- Between 2 and 6 November 1994, Northwest of the Italy has been affected by a particularly intense weather event: the hardest hit region was the Piedmont, where thousands of landslides caused 78 deaths, a disperse and 93 injured, 9500 evacuees, 496 municipalities damaged and particularly severe damage to the road network with 10 bridges completely destroyed and 100 damaged. In the South of Piedmont a few towns and villages remained isolated for several days due to the damage caused by landslides in many places. Major damages took place in Tanaro Valley (right tributary of the Po), in the cities of Alessandria, Asti and Alba.
- On 19 June 1996, the areas of Versilia and Garfagnana in Tuscany were hit by flash floods; there were 14 casualties, 474 mm of rain fell in 12 hours, causing hundreds of landslides in a very small watershed, with very serious consequences for the Valley and the flooding of large tracts of land Plains, 13 dead and 1,500 homeless.
- On 5 May 1998, Sarno, Campania, was hit by a flash flood that triggered a mudslide. The insistent rain has triggered many flows of debris atop Alvano, East of Naples. Landslides, not consolidated for the volcanic soils, were particularly destructive. The towns of Episcopio, Siano and Bracigliano, Quindici were inundated by waves repeated mud and debris. There were 157 dead, 5 missing and 70 injured in 13 different locations and hundreds of displaced and homeless. The event produced a significant impact throughout the Italy and abroad and gave rise to the drafting of new legislation on procedures for landslide risk assessment.
- 8, 9, 10 September 2000 flood in Soverato: 561 mm of rain in three days and 13 dead.

-Between 13 and 16 October 2000, Northwest of the Italy was affected by a particularly intense weather event. In the Alps West fell up to 600 mm of rain in 48 hours. Heavy rains produced numerous landslides, debris flows, causing flooding in the Valle d'Aosta, Piedmont and Liguria. Major damages took place in Aosta Valley. The landslides caused enormous damage and 37 dead or missing (18 in the Valle d'Aosta, Piedmont, 5 3 Liguria), 1 in South Tyrol Trentino and the other 10 in the Canton of Ticino in Switzerland, more than 40,000 evacuees.
- August 29, 2003, in the Val Canale and Canal del Ferro (Udine), rains concentrated in time and space (more than 300 mm of rainfall in 6 hours approximately) caused a landslide on the A23.
-In October 2009 in the hamlets of Giampilieri Superiore, Altolia and Brig (Messina) and in the municipality of Scaletta Zanclea heavy rains trigger the hydrogeological: a series of landslides and debris flows overwhelm many roads between Scaletta Zanclea and Giampilieri Superiore.
- 13-17 February in San Fratello (ME), about 2,000 people were displaced
- 25 and 26 October 2011 floods in Lunigiana and Cinque Terre, 542 mm of rain in six hours, 13 victims
- 4 November 2011, Genoa heavy rains upstream from the watershed, 6 dead.
- November 11, 2012 - in the province of Massa-Carrara a downpour invests throughout the territory with greater than 200 mm rainfall within two hours. He had accumulations of 300 mm in the hills. Heavy rains trigger of many mudslides: 5000 homes affected and 300 evacuees.
- November 28, 2012 between Carrara and Ortonovo territory that intercalates between Liguria and Tuscany, two weeks after the floods of November 11, a strong new storm are overtaking in the same areas and determines new landslides and damage on the already affected areas. The Aurelia national road between Massa and Sarzana is closed for a landslide. He had heavy rainfall of 40 mm in 15 minutes to 45 minutes et.109 mm to 134 mm, 60 minutes, until a comprehensive accumulation of 200 mm in two hours.
- As we have highlighted with this short list adverse climate events occurred in Italy, all the months of the year and they are not associated with autumn or winter only.

## 2. Extreme events at the local level

Exceptional weather events which affected the Province of Lucca and Massa Carrara, on 31 October and 1 November 2010 have allowed the launching of various initiatives for the security of the region. Interventions are related to the reconstruction and improvement campaign routes and vicinal lanes with improving it roadways, shoulders, ditches that marched parallel or that cross the road, and specifically:
-strengthening, improvement and adaptation of tracks and forest roads with the construction of new roads or road forest (for heavy trucks, agricultural tractors) to allow the planting of trees (afforestation, reforestation) and, in general, to allow the connection of woodland with public roads paved.
- improvement, adaptation and the standard of roads and tracks of existing forests, through the interventions of enlargement, development or the restoration of the drainage network, manufacture or repair of the passages and other associated works, stabilization of the pavement, consolidation or restoration of the slope of the road;
-realization and improvement of supply infrastructure and the accumulation of surface waters;
-improvement of water, harvesting, remodeling and waterproofing works for security;
-reduction of losses of pipes and piping of outdoor channels;
-hydrogeological regime;
-reduction, consolidation of slopes and water regime;

-securing and restoring forested area
-restoration and consolidation of slopes.

## 3. Impact of geological and hydrological events in Italy

The Italian national territory, due to its geological and geomorphological settings characterized by young orography, has always been affected by hydraulic and geological phenomena (synthetically misnamed as "hydrogeological risk", definition today diffusely in use) of considerable intensity. Between 1279 and 2002, in Italy, the catalogue AVI "*Aree vulnerate italiane*" (Exposed Italian areas), made by CNR-IRPI [1] reports 4,521 events with damage of which 2,366 related to landslides (52.3%), 2,070 to flooding (45.8%) and 85 to avalanches (1.9%). In the same period were recorded 13.8 victims per year in occasion of landslides events and 49.6 victims from flooding. Over the past 50 years, these estimates show a decrease in deaths caused by hydraulic phenomena (31 victims per year), with an exponential increase of the economic costs associated with them [2].
Only in the twentieth century in Italy have been recorded more than 10,000 killed, wounded and missing, in addition to 350,000 homeless and displaced people, thousands of buildings, tens of thousands of bridges and hundreds of kilometres of roads and railways destroyed or damaged. Events such as those of the Val Pola, in the Lombardia region (28 July 1987) with 28 victims, the flood of Piemonte (September 1994) with 69 victims, the flood and landslides in Versilia (June 1996) with 16 victims, landslides in Campania (May 1998) with 160 victims, the flood of Soverato (September 2000) with 13 victims, the one in Val d'Aosta and Piemonte (November 2000), the phenomena of 2003 in various areas of the country, the debris of Giampilieri Scaletta in the town of Messina in October 2009 with 31 killed, 6 missing people and 1054 displaced, the flood in the Cinque Terre and Lunigiana on the 25 and 26 October 2011, the flood of November 04, 2011 in Genoa and the flood of November 28, 2012 between Carrara and Ortonville on the border between Liguria and Tuscany. All these are only the most recent episodes of a general situation of incompatibility between the adopted policies of socio-economic development and the dynamics of the natural environment. The report Ecosystem at Risk (Legambiente & Civil Protection, 2011), estimates that in just ten years from 1991 to 2001 in Italy, have occurred 12 thousands landslides and over a thousand floods, causing 340 deaths and economic losses calculated over 10 billion euro (see Table 1.1). Only in 2003, the main flood events involving more than 300,000 people and the resources necessary to the restoration of the affected areas were 2,184 million Euros. Moreover, many are the episodes and minor flooding every year causing flooding of agricultural areas and small or large urban centres, causing serious damage even without victims.

Table 1.1. number of major landslides and floods in Italy (1991 – 2012)

| Years | N. landslides | N. floods |
|---|---|---|
| 1991 | 705 * | 112 * |
| 1992 | 780 * | 125 * |
| 1993 | 557 * | 95 * |
| 1994 | 692 * | 84 * |
| 1995 | 744 * | 81 * |
| 1996 | 2272 * | 152 * |
| 1997 | 2455 * | 103 * |
| 1998 | 1671 * | 84 * |
| 1999 | 700 * | 73 * |
| 2000 | 1177 * | 72 * |
| 2001 | 322 * | 22 * |

| | | |
|---|---|---|
| 2002 | | |
| 2003 | | |
| 2004 | | 11 ** |
| 2005 | | 12 ** |
| 2006 | | 17 ** |
| 2007 | | 15 ** |
| 2008 | | 13 ** |
| 2009 | >100 ** | 7 ** |
| 2010 | 88 ** | 14 ** |
| 2011 | 70 ** | 8 ** |
| 2012 | 85 ** | 10 ** |
| ** Source AVI - ** Source ADA ISPRA* | | |

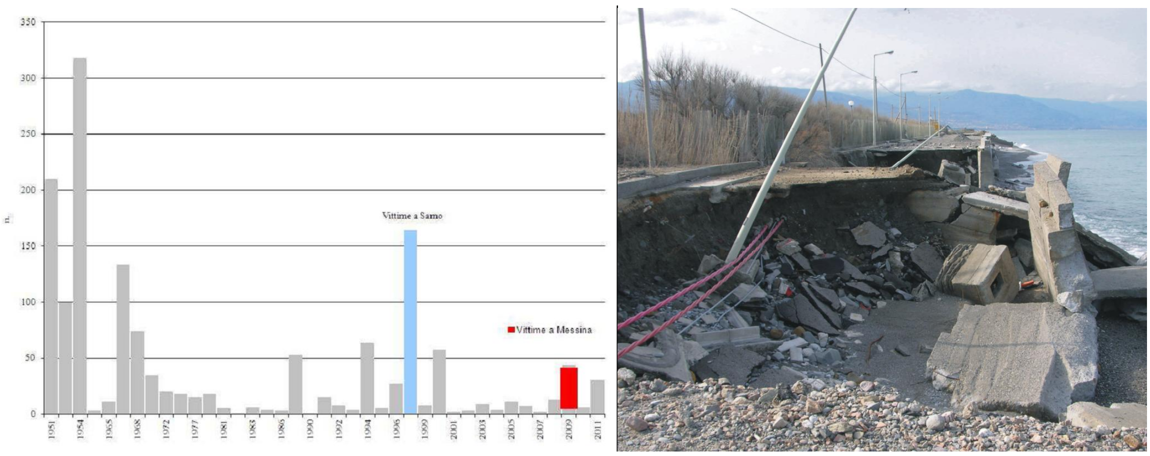


Fig. 1 - Victims of major floods in Italy [2]

Natural disasters and in particular those geological and hydraulic, both at European and global scale, seem to increase significantly at the global level (from CRED EM-DAT, 2008). The same trend seems to be found in the time series Italian where, for example, there are 4 events ultra centennial in Piemonte in the last 10 years [3].

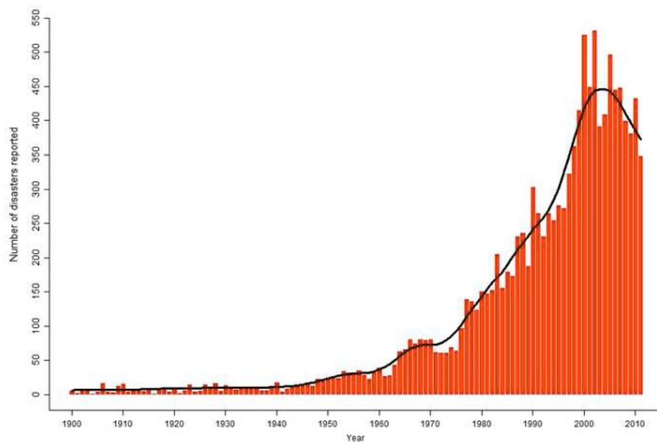


Fig. 2 - Number of natural disaster 1900–2011 (EM-DAT)

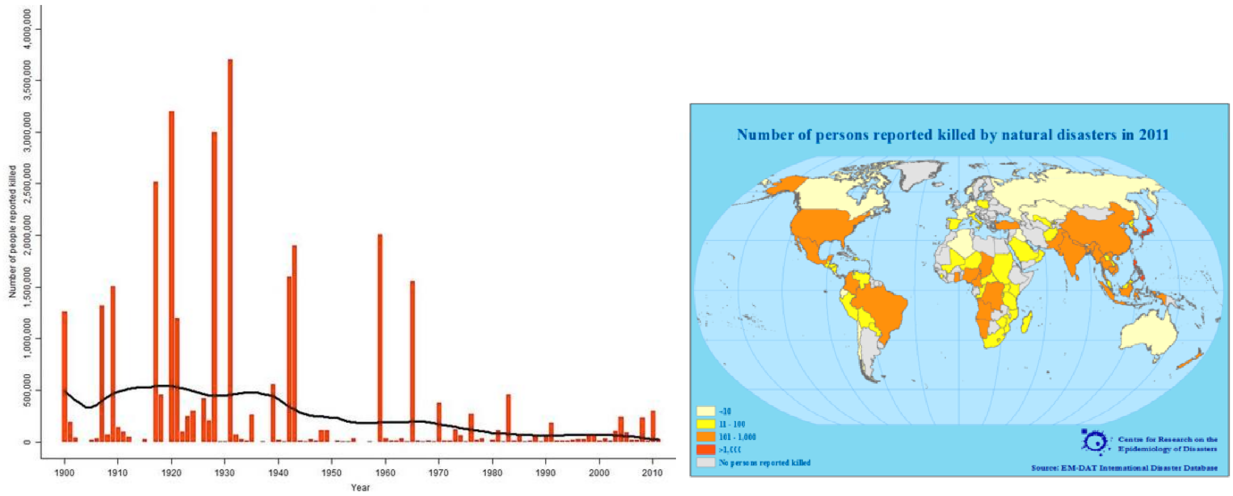


Fig.3 - Number of people reported killed by natural disasters 1900-2011.

A recent study by the Ministry of the Environment, as a result of the surveys carried out by the River Basin Authority, in accordance to DL 180/98 and subsequent amendments (so called "Sarno Decree"), showed the presence in Italy of about 13,000 high-risk areas and very high risk for floods, landslides and avalanches. These areas are extended 29.517 $km^2$, accounting for 9.8% of the country (4.1% floods, landslides 5.2%, 0.5% avalanches) covering 6,633 Italian municipalities (81.9%), urban centres, infrastructure and production areas, all closely associated with the social and economic development of the country (Source: Ministry of the Environment, 2008).
The IFFI Project (Inventory of landslides in Italy) carried out by ISPRA has created a complete and homogeneous inventory of landslides distribution throughout the country, even when not dangerous for urban infrastructure and land in general. This project census and map the landslides occurred throughout the entire Italian territory. To date, more than 486,000 landslides have been recorded, affecting an area of 20,800 $km^2$, accounting for 6.9% of the national territory [4,5]. For each landslide is available a online detailed digital map (scale 1:10,000) and a datasheet containing the main parameters describing the phenomenon (eg, location, type of movement, activity status, lithology, land use, cause, date of activation, damage and the mitigation measures).

In the period 1993-2003 financial resources have been allocated for more than 1 billion € per year for flood damages. The annual average costs for Government works summed up to 600 million € per year (2009 data), 25% related to measures funded with Law 180/98 (about 4.5 BILLION in 11 years), whereas on the “8x1000 funds” have been spent around 50 million € / year.
It’s been estimated that 44 billion Euros are necessary to secure the entire Italian territory (27 in the Center-North, 13 in the South, 4 for restoration works of the coasts).
Concerning the funds allocated post-event, in accordance with the ordinances of Civil Protection, the most updated data refers to 353 ordinances from 2003 to 2013 for a total of 3,546,635,769 Euros.

## 4. ***ReNDiS*** **Project**

The ReNDiS Project developed and managed by ISPRA, has as its main purpose the collection, updating and implementation of a national database on monitoring the emergency measures financed by the MATTM to reduce landslide risk (DL180 and amendments). The project (started in 1999) consists of a Web-GIS platform made entirely

with open source technologies, and consists of a Geo-database (main archive) and two secondary applications, the first (ReNDiS-ist) for data management and the second (ReNDiS-web) interface online for public access and viewing and accessing data on the network.
Any information within the database is organized as a single record (equivalent to one mitigation measure work) and is continuously monitored in its implementation (funding, planning and execution phase) at a national scale. In table x we show total funds allocated for each Region. At present, 4710 mitigation works were funded by the Italian Ministry of the Environment for a total amount of more than 4 billion euro.

Table 2 Geographical location of funding resources

| REGION | n. interventions | Funding (MLD €) |
|---|---|---|
| Abruzzo | 144 | 118 |
| Basilicata | 235 | 111 |
| Calabria | 450 | 393 |
| Campania | 287 | 384 |
| Emilia-Romagna | 317 | 269 |
| Friuli Venezia Giulia | 72 | 84 |
| Lazio | 275 | 304 |
| Liguria | 115 | 113 |
| Lombardia | 481 | 415 |
| Marche | 262 | 164 |
| Molise | 161 | 80 |
| Piemonte | 458 | 236 |
| Puglia | 212 | 315 |
| Sardegna | 98 | 138 |
| Sicilia | 424 | 629 |
| Toscana | 528 | 403 |
| Trentino - Alto Adige | 61 | 39 |
| Umbria | 90 | 97 |
| Valle d'Aosta | 29 | 30 |
| Veneto | 173 | 151 |
| TOTAL | 4.872 | 4.473 |

The ReNDiS project is currently the main operational tool for information management on monitoring mitigation works the interventions financed by the Ministry of the Environment. The goal is to build progressively a unitary and comprehensive public database of soil protection works and therefore ReNDiS is designed to be easily implemented (including by services *wms*) with databases operated by other entities. The database allows you to share data and information between the different administrations and improve the cognitive framework to support planning activities for the protection from hydrological risks. Finally promotes the transparency of public administration through the publication of data on the web on the measures financed.

## 5. Case study: Interruption and insulation of small communities

### 5.1 Choice of case study

The case study relates to the Province of Lucca for the particular level of hydrogeological instability in this area. The historical analysis [6] shows that the territory of Lucca is particularly affected by superficial landslides and floods associated with heavy rainfall events. There have been major floods in 1774, 1885, 1902. The flood of 1996 is quite comparable to that of 25 September 1885. In particular, in the last 10 years (2003 -2012), in the province of Lucca, events often referred to as exceptional have become almost annual, with four serious floods in terms of impacts respectively in November 2009, October 2010, November 2011 and October 2012 [7].

## 5.2 Method of analysis

The methodology adopted for the study of the interaction between hydro-geological risk and road network needs an estimate of the segments of minor road network exposed to risk Hydraulic and landslides, through the analysis of spatial GIS platform of the information layers below.

The various road segments encoded in TeleAtlas ®, taken together, constitute the elements exposed, whose characterization is a key step in the risk analysis. Concerning the vulnerability parameter, it must be said that in the absence of specific vulnerability curves, this parameter has been conservatively considered constant and equal to 1, assuming that, in the specific context, the mere presence of the element will automatically determine the maximum vulnerability.

Inventory of landslides in Italy (IFFI Project): the data on landslides come from the Italian landslide Inventory (IFFI project), realized in 1997 by ISPRA (Institute for Environmental Protection and Research), the Regions and Autonomous Provinces of Italy.

Hydraulic Hazard areas: the hydraulic hazard areas considered and adopted in this study are derived from the hydraulic hazard areas produced by *Serchio* River Basin Authority.

Road graph TeleAtlas ® 2009 : with regard to exposed elements in the Province of Lucca, codes FRC 6 (local roads), 7 (Importance of minor local roads), 8 (other minor roads) of the road graph TeleAtlas updated to 2009 have been considered.

Table 3 - Base layer adopted for the spatial analysis

| | | |
|---|---|---|
| Province of Lucca | Total area [$km^2$] | 1772 |
| Landslides IFFI | Total area [$km^2$] | 102.8 |
| TeleAtlas | Total length [km] | 5563 |
| | length FRC 6 [km] | 556 |
| | length FRC 7 [km] | 3282 |
| | length FRC 8 [km] | 37 |
| | Total 6+7+8 [km] | 3875 |
| Huydraulic hazard areas | P1 [$km^2$] | 7.3 |
| | P2 [$km^2$] | 15.7 |
| | P2a [$km^2$] | 9 |
| | P3 [$km^2$] | 11.7 |
| | Total P1+P2+P3 [$km^2$] | 43.7 |

## 5.3 Analysis and implementation of data

The minor road segments (codes 6, 7 and 8) of the graph of TeleAtlas road of the Province of Lucca, were subjected to buffer analysis (buffer 3 meters) in order to give physical reality to exposed elements and quantify the width of the roadway. It was not considered necessary in this first case study, to differentiate the categories of smaller roads with different values of buffers.

The road elements thus obtained were then spatially intersected with the polygons of landslides obtained from IFFI, around which it was created a buffer of 20 m to take into account possible evolution of the phenomenon of instability in any direction. It's been possible to obtain a first estimate of the segments exposed to landslide risk. In this way, its been possible to identify 290 km of roads exposed to landslide risk equal to 5.2% of the entire road graph of the province and 7.5% of the minor road network (codes 6, 7 and 8).

As for the hydraulic risk, by the same procedure previously described (overlapping of road graph and hydraulic risk areas by Serchio Basin Authority in a GIS environment) it was possible to identify, in the Province of Lucca, 162 km of local roads exposed hydraulic risk equal to 3% of the entire provincial graph and 4.2% of the minor road network (codes 6, 7 and 8). The results of this spatial analysis are reported in the following table.

Table 4 - The results of spatial analysis

| Code TeleAtlas | Length [km] | L. landslides risk [km] | L. flood risk [km] |
|---|---|---|---|
| 6 | 555.75 | 35.70 | 27.15 |
| 7 | 3282.24 | 254.28 | 128.19 |
| 8 | 37.27 | 0.15 | 7.13 |
| TOT | 3875.26 | 290.13 | 162.46 |

## 6. Conclusions: economic impacts of interruptions and/or methodologies or policies that can be implemented

In front of significant economic impacts for the damage and business interruption, Italian regions are working to prevention. The Tuscany Region has allocated one billion euro for three years to defend the mountain, to retain the services, ensure the residences and protect the land and natural resources. More than € 878 million have been allocated (€ 376 million, or 42.8%, are regional, € 142 million are statal, and 192 million euro from the European funds allocated to EAFRD, ERDF and ESF). The sectors affected by these budget appropriations are those of the "*Mobility and infrastructure*" with 163 million euro invested (18.6% of the total), "*Agriculture and Forests*", with a total amount of € 147 million (equal to 16.7% of the total), "*Natural Resources*" with 138 million investment for interventions related to water resources, and "*Soil and homeland security*" with nearly 110 million investment (12.5%) of which the half of regional origin. [8]. The investments relate to the road infrastructure and soil conservation, strategic sectors for the whole region and not just for the mountains, and also the support of the economy (industry, trade, tourism, agriculture) and services (social, health, educational). The monitoring of mountainous areas for the prevention of hydrogeological risk is crucial. The mountains, rural areas, minor and isolated, are to be protected with regular maintenance and with a serious and specific mitigation plans which need to take into account hydraulic and hydrogeological risks that may affect these territories.

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## *Useful links*

CNR-GNDCI web site: The AVI project URL: http://avi.gndci.cnr.it/welcome_en.htm

Civil Protection Agency of the Friuli Venezia Giulia Region URL: http://www.protezionecivile.fvg.it

EM-DAT: The OFDA/CRED international DisasterDatabase - Università Catholique de Louvain - Brussels – Belgium www.emdat.be

ICL –International Consortium on Landslides URL: http://iclhq.org/Europe.htm

Italian Landslide Inventory – IFFI Project URL: http://www.sinanet.apat.it/progettoiffi