Hydrogeological risk and mitigation measures. Best practices

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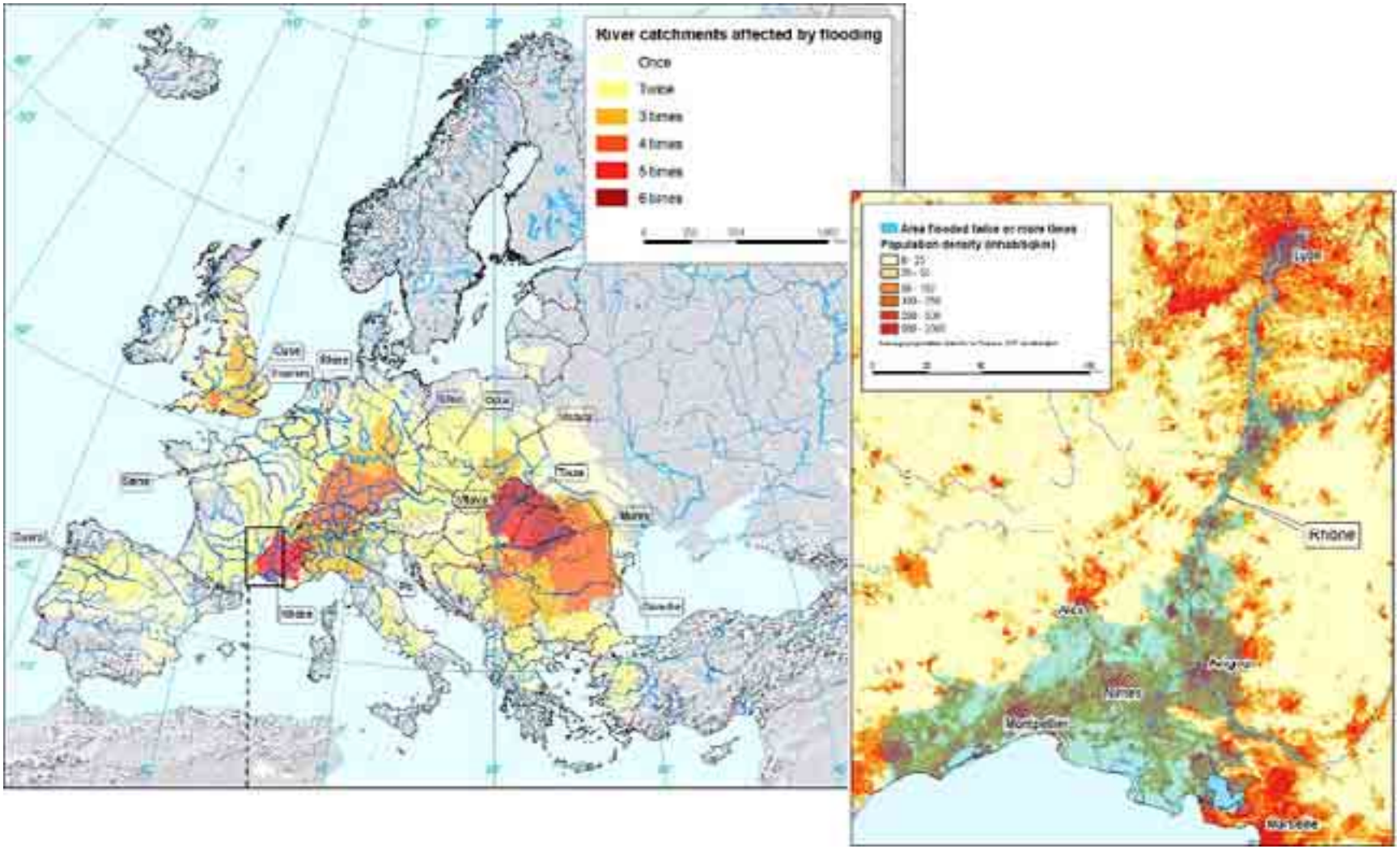
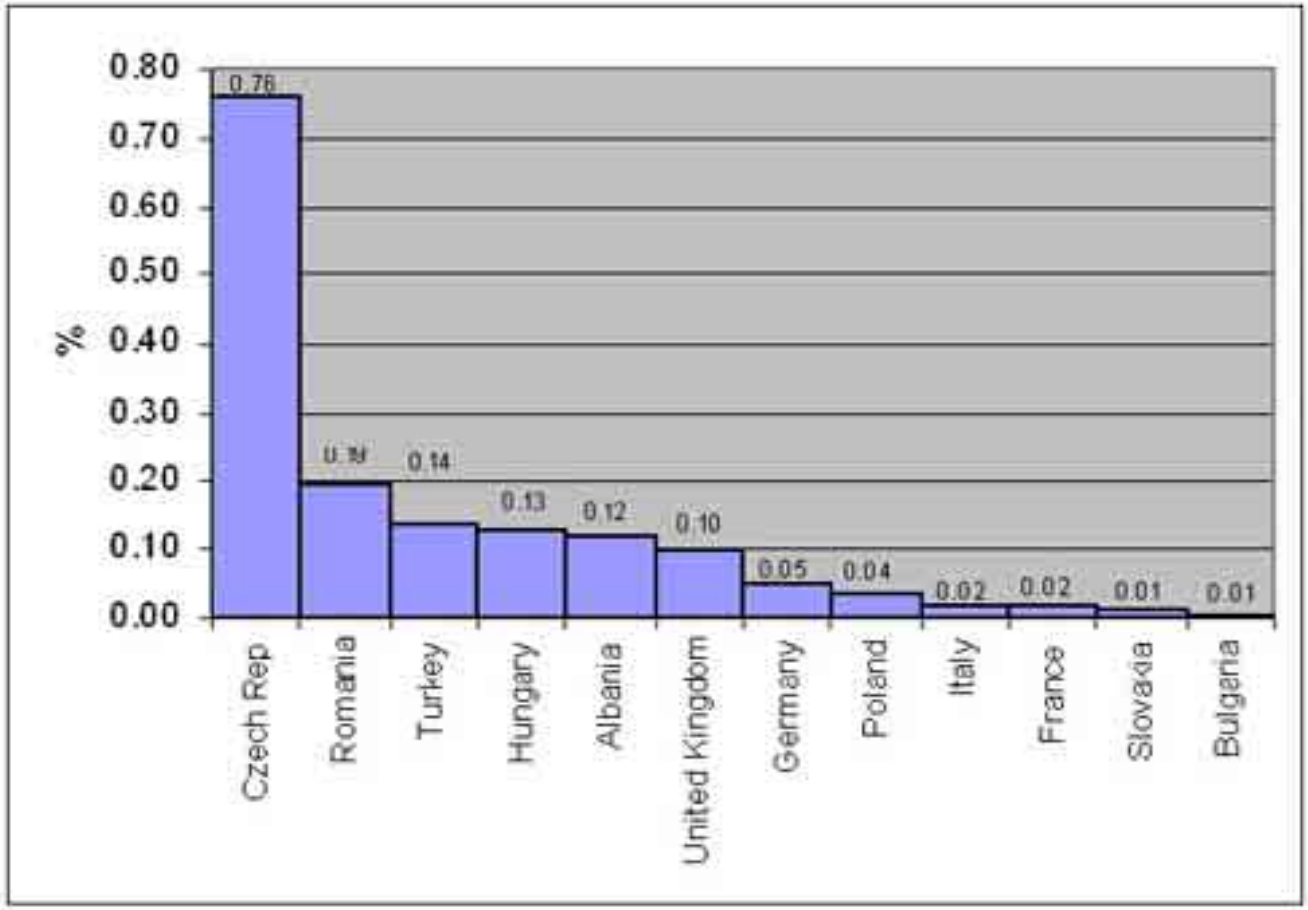
The hydrogeological risk

The hydrogeological risk is represented by events such as landslides and floods, that produce measurable damages to people and belongings

The hydrogeological risk maps are developed in those areas where the hazard maps together with information on land use and a vulnerability assessment show that potential risks from landslides, floods or avalanches are significant.
They **aim at** showing how risk varies in terms of potential economic damages, potential number of people at risk and adverse consequences for the environment.

Landslides and Floods


River catchments affected by flooding
Once
Twice
3 times
4 times
5 times
6 times
Area flooded twice or more times
Population density (inhab/sqkm)
Rhone



Annual average cost of the flood damage as percent of GDP (Gross Domestic Product) for the most affected European countries (1998–2002)

Type of damages:

(A) civil buildings;

(B) public buildings;

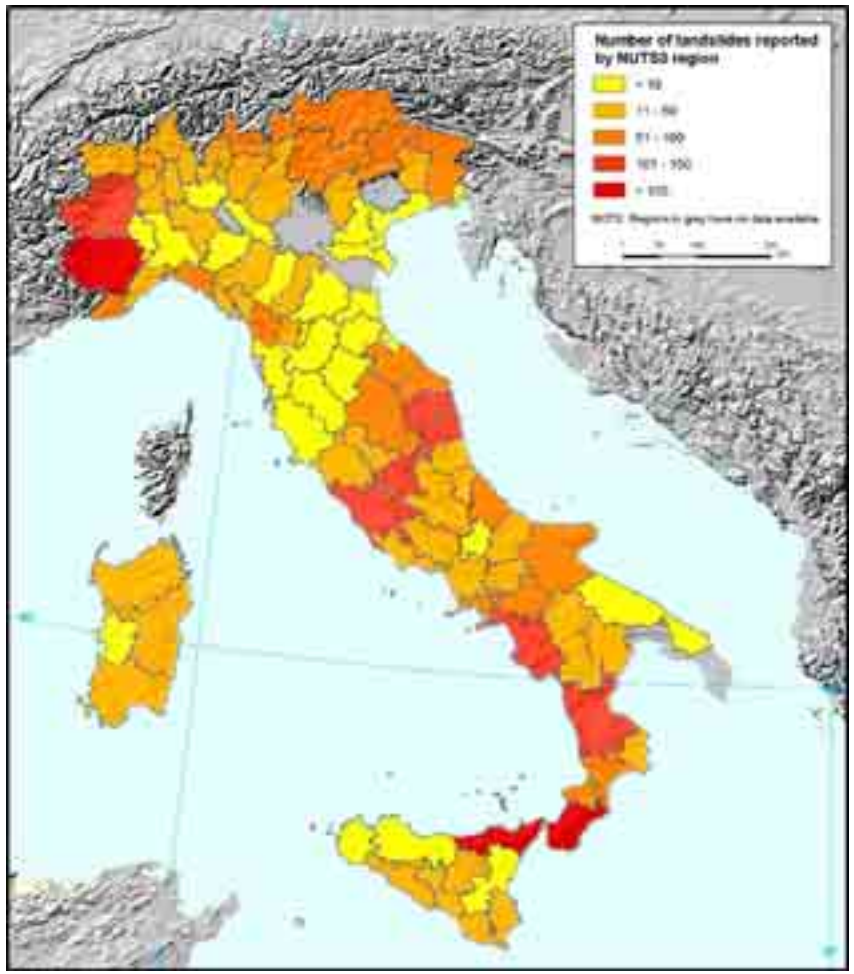
(C) industrial firms;

(D) hystorical-artistic monuments;

(E) public infrastructures;

(F) roads and railways;

(G) network infrastructures.



In most part of Regions civil buildings (A) and roads (F) have been often involved by landslides or floods.

LEGISLATIVE FRAMEWORK OF SOIL PROTECTION IN ITALY

- The soil defense in Italy has been regulated by:
  - Law 183 of 1989
    - divides the Italian territory in river catchment basins
    - appoints the Rivers Basin Authorities
    - requires the preparation of Basin Plans
  - Law by decree 180 of 1998 and amendments thereof
    - Establishes the Extraordinary Plans and the Hydrogeological Management Plans (PAI), which impose to River Basin Authorities risk zoning and limits land use for risk mitigation
    - Finances urgent interventions for risk mitigation

Law 183 of 1989

- In 1989, were laid the basis of reorganization of Soil Protection in Italy
- The law 189, subdivided the territory in territorial reference units, constituting National, Interregional and Regional Basin Authorities and, in particular, cerated the Basin Management Plan, a technical operational tool for physical system protection and safeguard.

Distribution of Basin Authorities

- **THE BASIN AUTHORITIES IN ITALY**
  - **National level (6)**
  - **Pilot (experimental) (1)**
  - **Interregional level (13)**
  - **Regional level (18)**

The Sarno catastrophe in 1998

The Sarno catastrophe in 1998

Law by decree 180 of 1998

- In 1998, following heavy rains, several mud flows abruptly hit Sarno and other small settlements near Naples, causing over 150 casualties.
- A few months after that tragic event, the law decree 180 was issued, aimed at speeding up the process of hydrogeological risk reduction and, in particular, the carrying out of the basin management plans foreseen by the law 183 of 1989.

The extraordinary plans

By 1999, the **Extraordinary Plans** according to the "Sarno" decree were prepared and approved by the River Basin Authorities.

They preliminarily identified and defined the zones at highest hydrogeological risk (9,200 areas in 2220 municipalities were mapped as "very high risk-prone areas" due to landslides, floods and snow avalanches), imposing them severe land use restrictions, aimed at

1) protecting human lives and goods,
2) avoiding any further increase of critical situations,
3) reducing the risk level by structural measures financed with additional funds

THE HYDROGEOLOGICAL MANAGEMENT PLAN (PAI)

The Hydrogeological Management Plan (PAI), which is part of the Basin Plan, is particularly aimed at soil defense. It:

1) organizes the mapping of the areas exposed to landslides, avalanches and floods, classified by level of risk

2) provides measures to limit land use in order to not increase the risk level

3) identifies the main protection actions to reduce or to remove the hydrogeological risk

PAIs are under continuous upgrading through the updating and implementation of events, scenarios and consequent countermeasures.

1) 18 PAI approved
2) 7 PAI adopted
3) 8 projects of PAI adopted
4) 5 projects of PAI ready for approval or under preparation

Preparation of PAI

The basin management plan is based on 3 steps:

1) *Preparation of a preliminary plan project*
2) *After discussion with, and possible changes proposed by, local public and private stakeholders, adoption of the plan*
3) *Final approval and application*

Presently there are:

1) *18 PAI approved*
2) *7 PAI adopted*
3) *8 projects of PAI adopted*
4) *5 projects of PAI ready for approval or under preparation*

Map of hydrogeological hazard

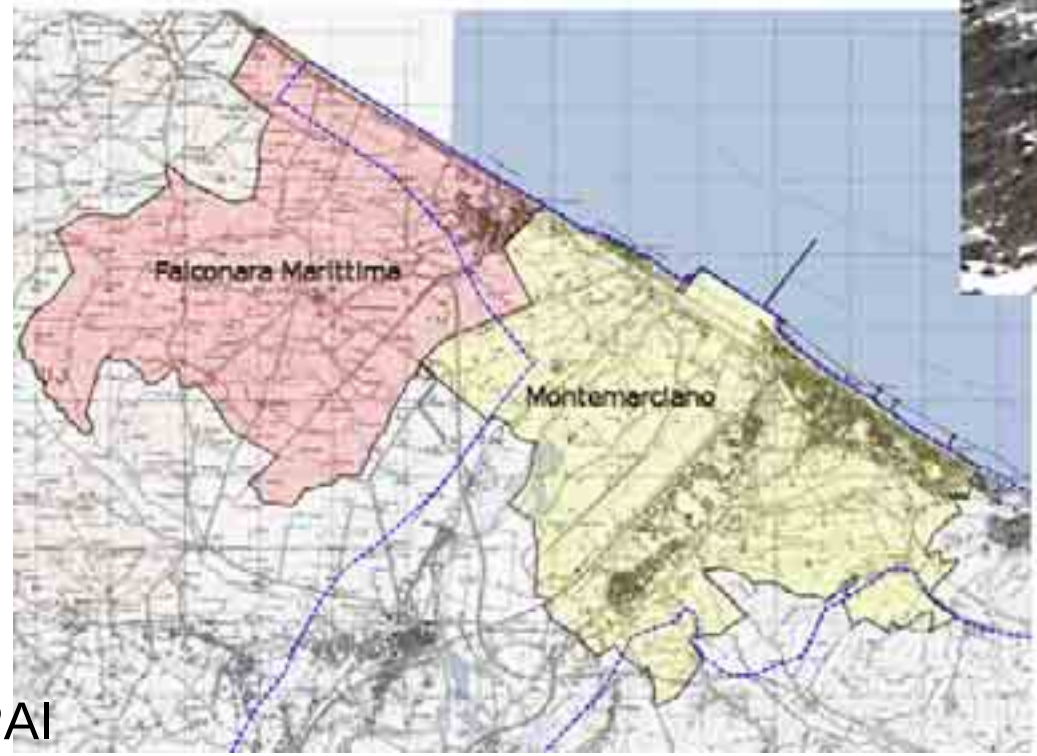
The MATT has acquired and mosaiked the risk-prone areas in all the PAIs prepared by the Basin Authorities, with the following results:

1) *over 500,000 critical situations. New dykes are necessary for 800 km of the Po river*
2) *Over 6,600 municipalities (81% of Italian municipalities) include zones at high risk from land slides, floods and avalanches.*
3) *Total affected surface 28,000 km^2 (10% of Italian territory) → 16,000 km^2 from landslides and avalanches, 12,000 km^2 from floods.*

Mitigation measures

Mitigation refers to policies and activities that reduce an area's vulnerability to damage from future disasters. These structural and nonstructural measures are in place before a disaster occurs.

WORKS



PAI

Structural and non structural interventions for hydrogeological risk mitigation

1) *The PAIs recognize over 11,000 interventions as necessary to achieve acceptable safety conditions in the basins, with a foreseen cost of ca. 40 billion euro.*

2) *The central government finances the realization of most of the structural measures to mitigate risk*

3) *The implementation rules of PAIs give precise restrictions to land use and forbid new settlements in the high criticality areas, which are the 10% of the whole territory. Over 6,600 municipalities (81% of Italian municipalities) include zones of high risk from slope instabilities, flood or avalanche*

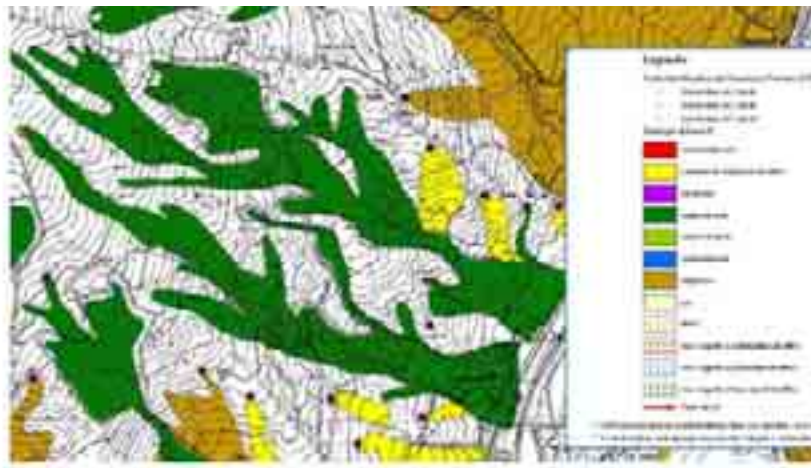
4) *Another non structural measure is the financial help to remove settlements located in very hazard-prone areas*

THE PROJECT OF HYDROGEOLOGICAL RISK REDUCTION

APAT, THROUGH THE SOIL DEFENSE DEPT.-GEOLOGICAL SURVEY OF ITALY, CONTRIBUTES TO THIS PROJECT BY MAINTAINING THE FOLLOWING BASES OF DATA:

***The slope instabilities*: IFFI**

(Inventory of landslide phenomena)



***The planning*: PAI**

(Hydrogeological Management Plans)

***The answer*:**

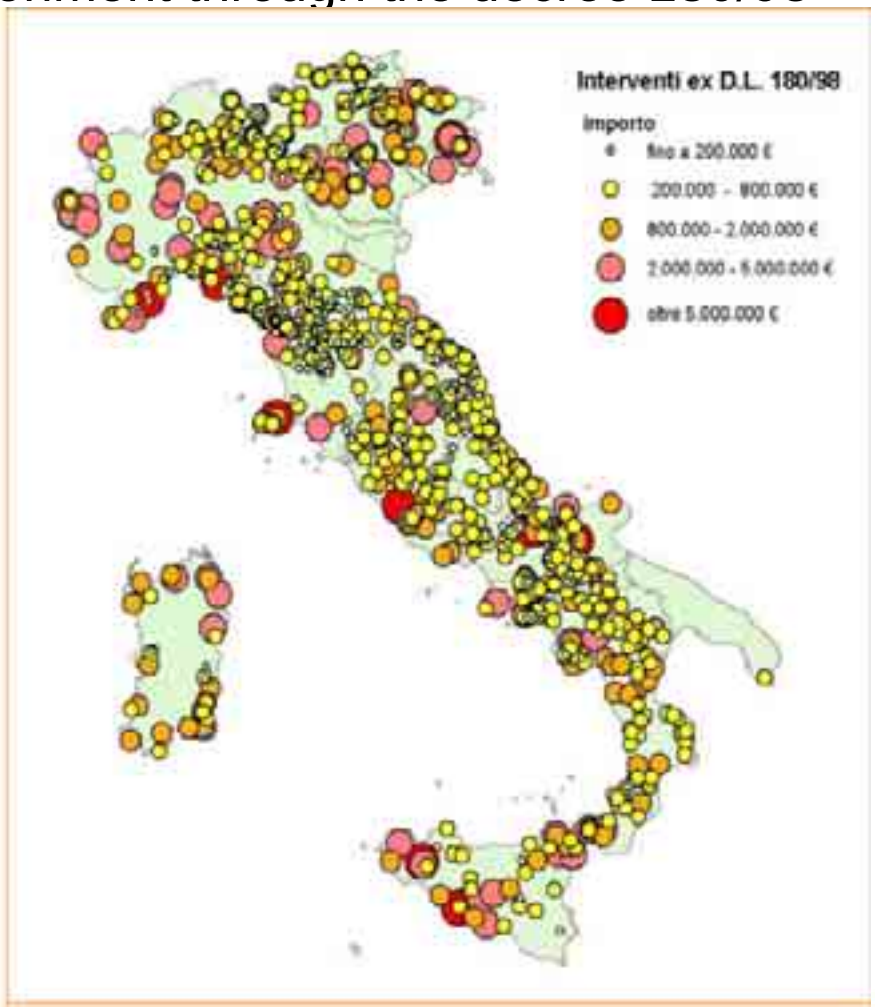
Structural works (dbase ReNDiS)

and non structural interventions

(restrictions to urban and infrastructural development)

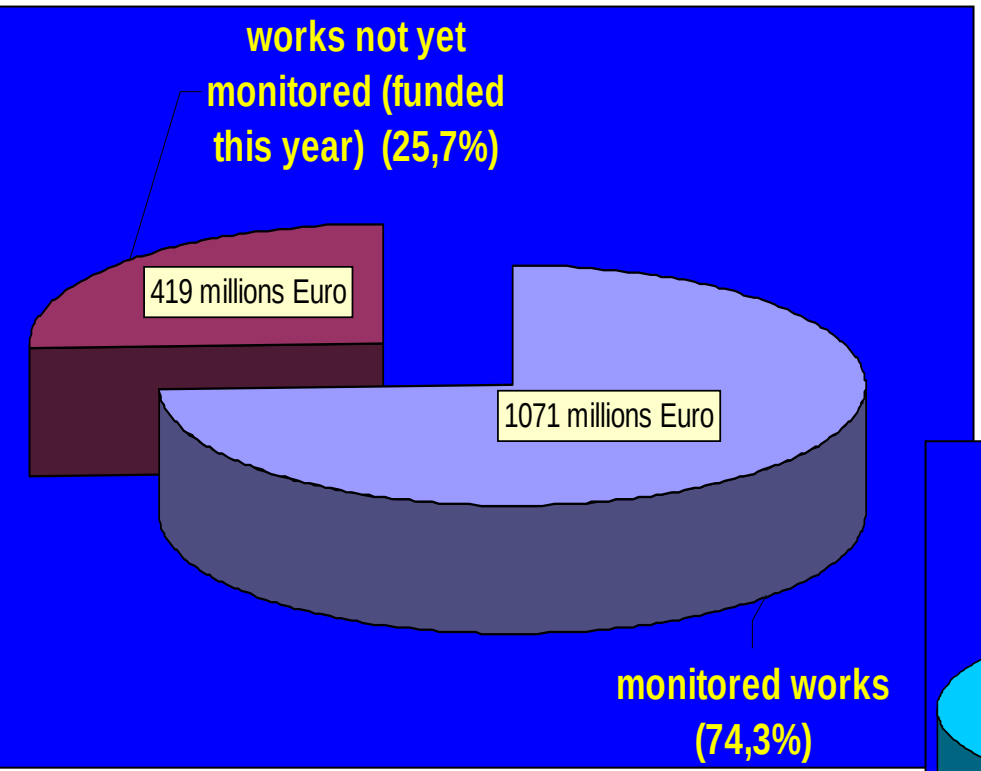
ReNDiS (Italian archive of soil defense works)

Database summarizing the monitoring action carried out by APAT on the works financed by the Ministry of the Environment through the decree 180/98



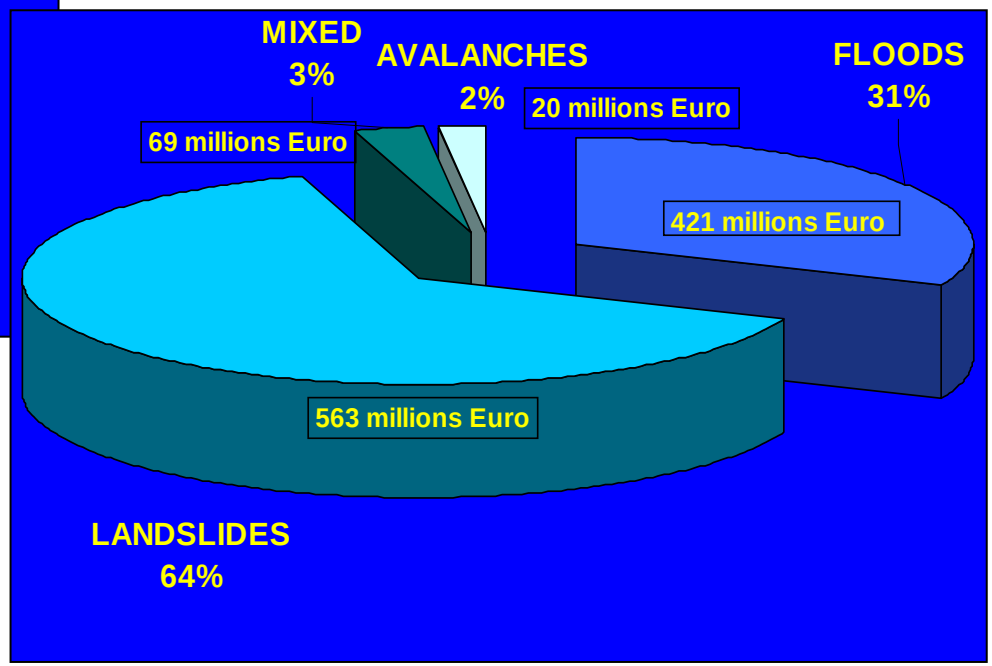
IFFI → >400,000 landslides mapped by Regions with standardized format and included in a database managed by APAT

http://www.sinanet.apat.it/progettoiffi

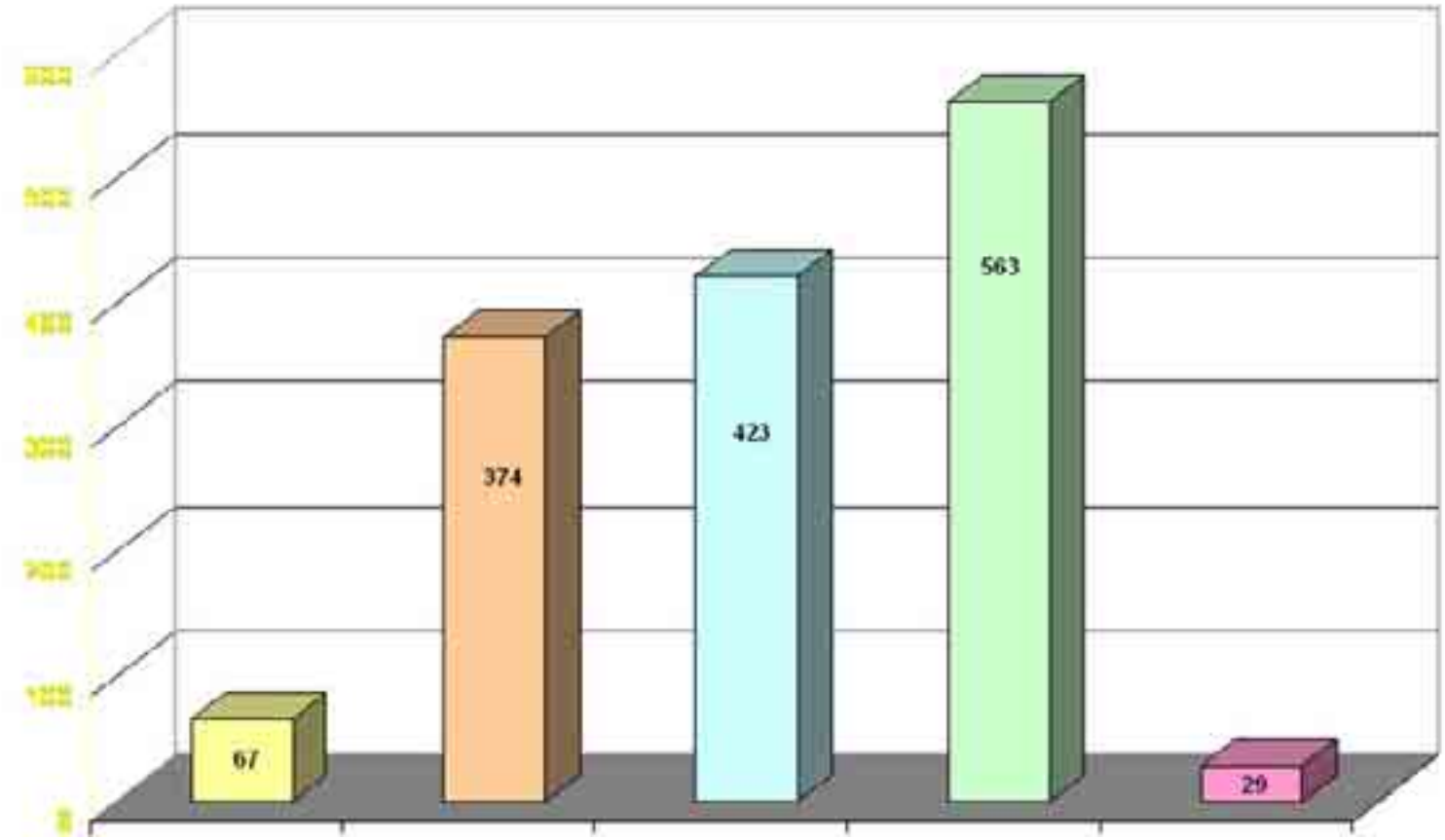


WORKS FUNDED BY MEANS OF THE DECREE 180/98

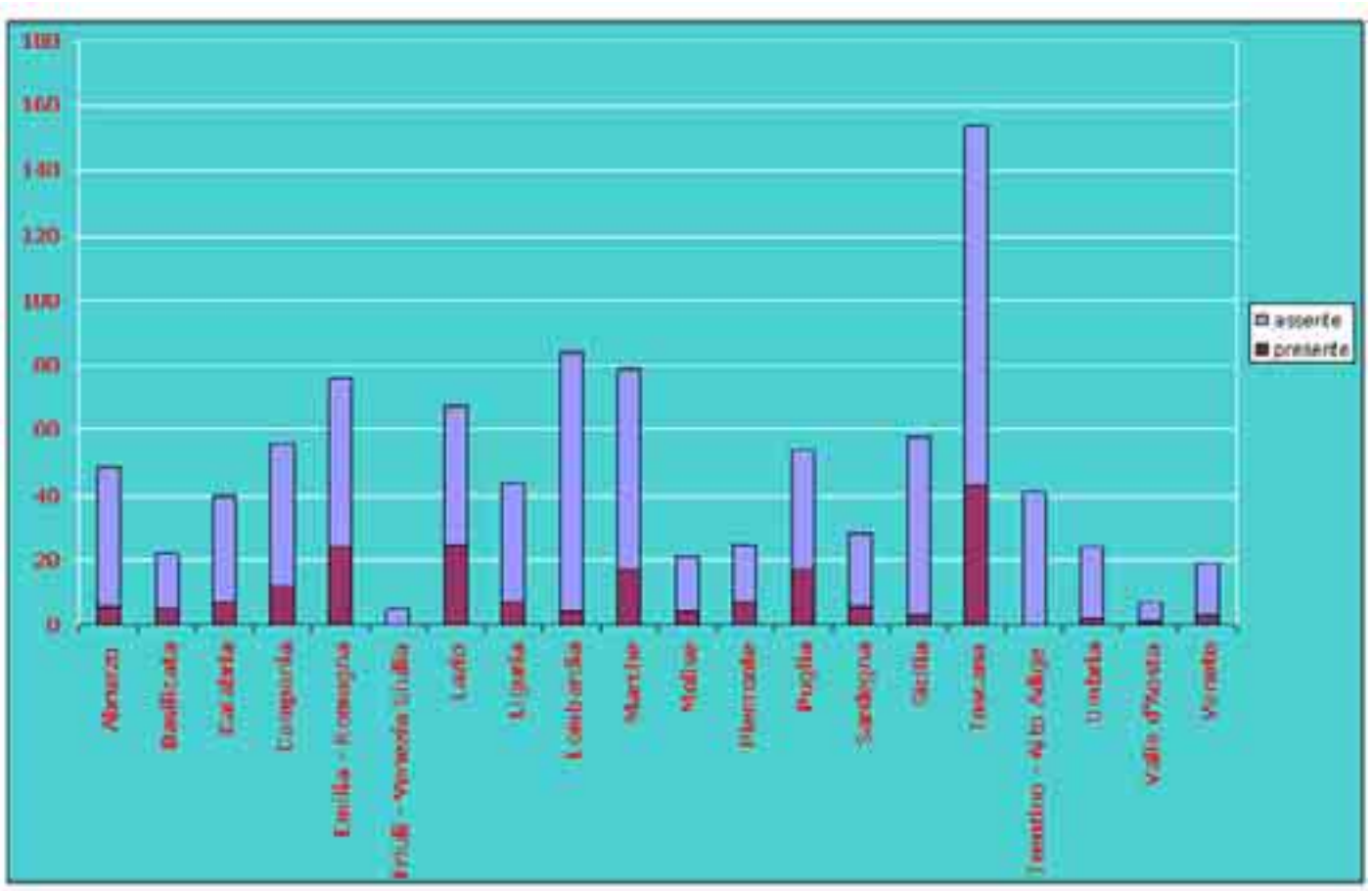
monitored by APAT



WORKS MONITORED BY APAT (1456 items in RENDIS database)



Works realized with soil bioengineering techniques (953 projects)



Restoration and Stabilization Works

National Alert System hydrogeologic and hydraulic risk

NETWORK OF FUNCTIONAL CENTRES (Centri Funzionali)

The Functional Centres are regional support offices aimed at the storage, extraction and immediate processing of meteo and hydrologic data, in order to support the activities of prevention and emergency intervention.

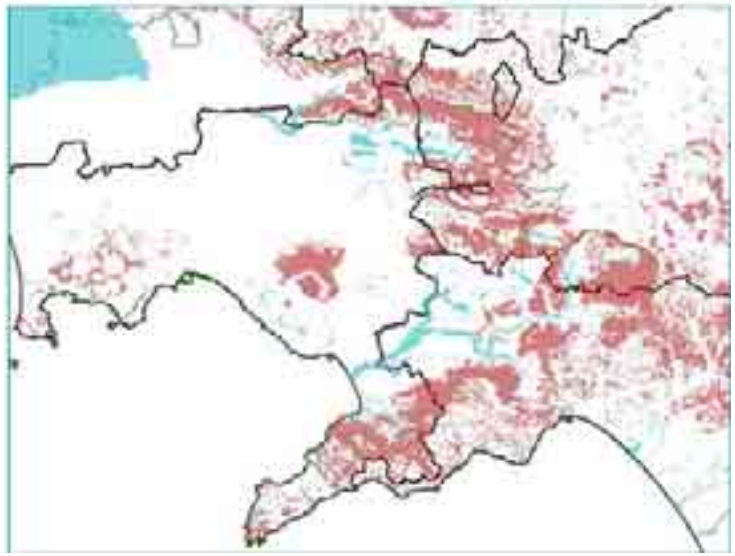
The Alert system is managed by the Department of Civil Protection and by the Regions. Many Centres of Competence contribute to the functioning of this network

The network is maintained and coordinated by the Chief Functional Centre, based in the headquarters of the Civil Protection in Rome

CONTINUOUS MONITORING

The relevant meteorological and hydrological parameters are continuously recorded by a network of mainly digital stations and downloaded in nearly real-time to the Functional Centres by telephone or radio

Such parameters are automatically compared to the threshold (critical) values of rain and drainage flows assessed for each watershed.



GIS tools allow a rapid overlap of estimated water level and saturation to the flood and landslide-prone areas identified in the PAIs (hydrogeological management plans) supplied by the Ministry of the Environment

WEATHER FORECAST AND CRITICAL STATE WARNING

- The regional Functional Centres and the Chief Functional Centre:
- Issue daily weather forecasts
- Evaluate for each *meteo surveillance zone* the likelihood to exceed a critical state and, in case, issue a specific warning and alert the involved prefectures and centres of competence

The *meteo surveillance zones* are interregional areas where a homogeneous daily amount of rain is expected.

The national territory is divided in 125 ***ALERT ZONES***

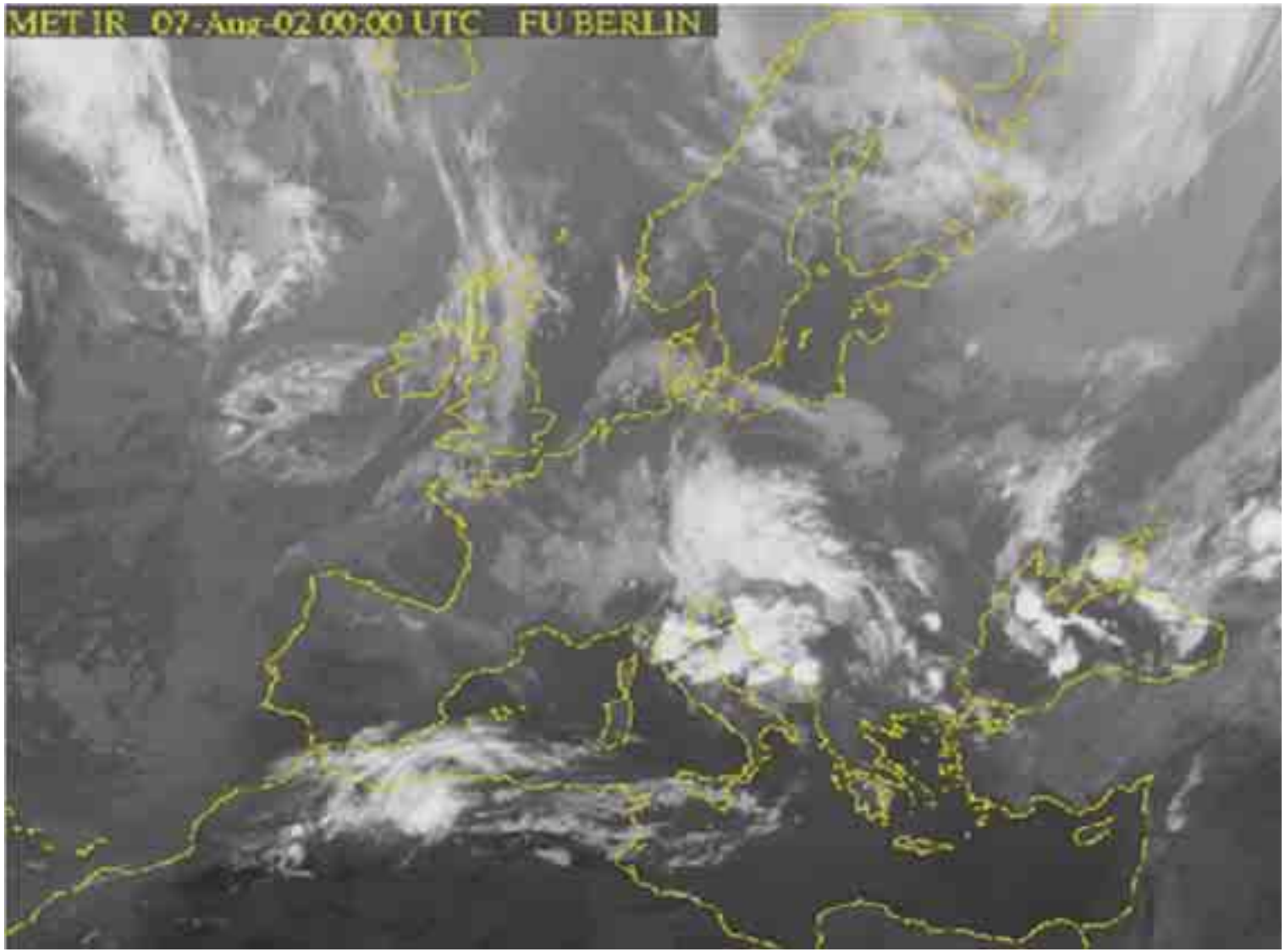
Such subdivision is based on criteria of homogeneity of severity and typology of expected hydrogeological and hydrological effects following a severe meteorological event

Spatial and Temporal Data

Rainfall forecasting (especially for floods)

Physical-meteorological Processes

- Radiation
- Vertical Diffusion
- Cloudiness
- Precipitation (stratiform / convective)
- Orographic forcing
- Surface processes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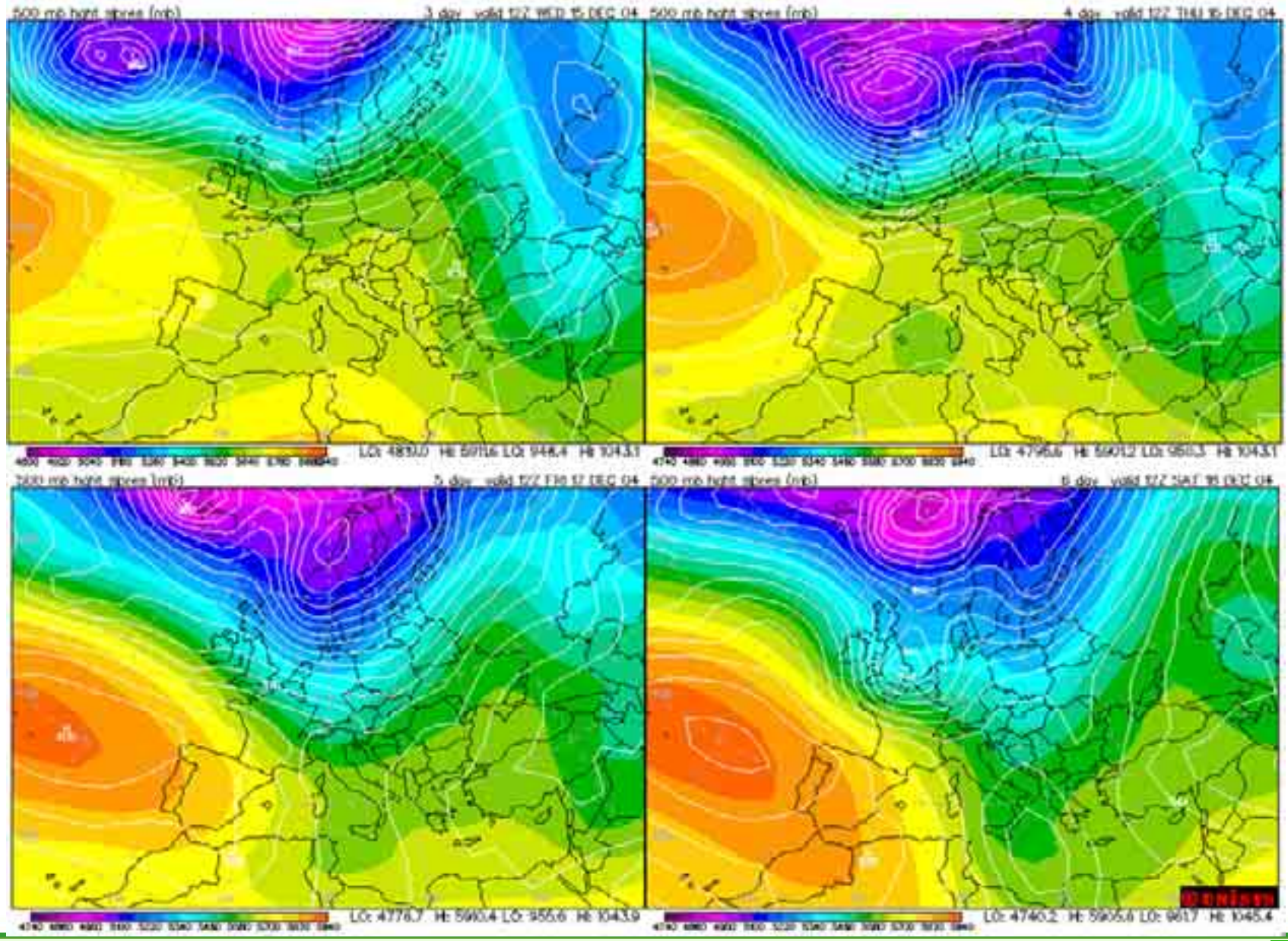
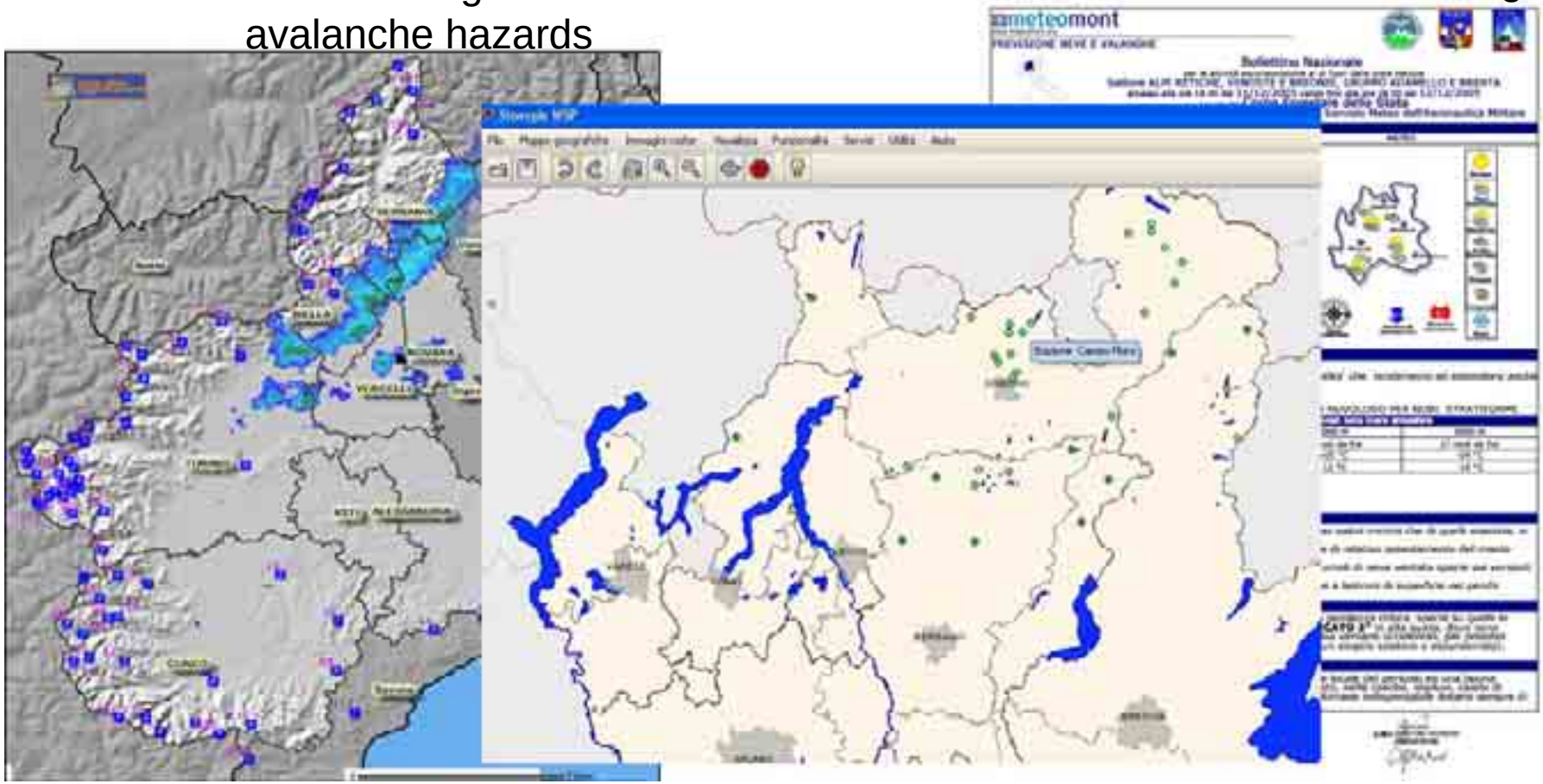


SNOW AND AVALANCHE RISK

Some regions run their own monitoring networks, issue daily bulletins and are basically autonomous in the management of snow and avalanche hazards

In the Civil Protection website bulletins prepared by Meteomont can be downloaded for each region



SNOW THICKNESS MONITORING SYSTEM

- Monitoring is aimed at timely forecast or identification of:
- Critical conditions in the road and railway network due to intense snowfalls
- Critical discharge peaks due to rapid melting of thick snow coverage

Most of the measuring stations are now seen by the Chief Functional Centre in Rome

ADVANTAGES AND DISADVANTAGES

Structural Mitigation Measures

Structural mitigation reduces the impact of hazards on people and buildings via engineering measures. Examples include designing infrastructure, such as electrical power and transportation systems, to withstand damage. Levees, dams, and channel diversions are all examples of structural flood mitigation.

However, structural mitigation projects have the potential to provide short-term protection at the cost of long-term problems.

Non-structural Mitigation Measures

Nonstructural mitigation measures are nonengineered activities that reduce the intensity of hazards or vulnerability to hazards. Examples of nonstructural mitigation measures include land use and management, zoning ordinances and building codes, public education and training, and reforestation in coastal, upstream, and mountain areas.

Nonstructural mitigation measures can be implemented by central authorities through legislating and enforcing building codes and zoning requirements, or by the private sector in providing incentives to take loss-reducing measures.

The four elements of a complete and effective early warning system

Knowledge of the risks faced by communities	*Technical monitoring and warning service*	*Dissemination of useable information*	*Knowledge and capacity to act*
Risks arise from both the hazards and the vulnerabilities that are present – what are the patterns and trends in these factors?	Is there a sound scientific basis for predicting the risks faced? Are the right things being monitored? Can accurate warnings be generated in timely fashion?	Do the warnings get to those at risk? Do people understand them? Do they contain useful information that enable proper responses?	Do communities understand their risks? Do they respect the warning service? Do they know how to react?

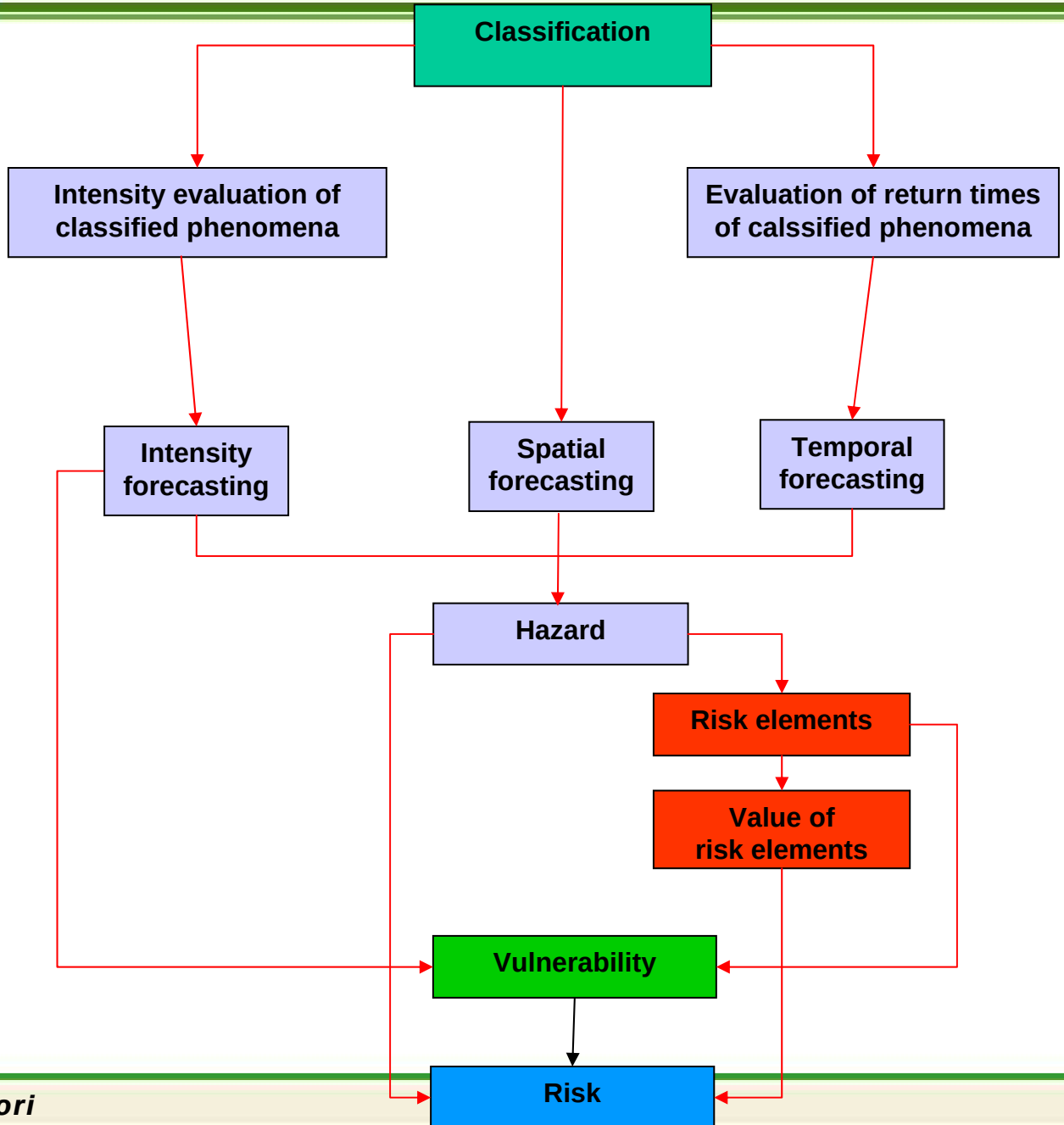
Good Early Warning Systems have strong linkages between the four elements.

From ABCHIR, 2005

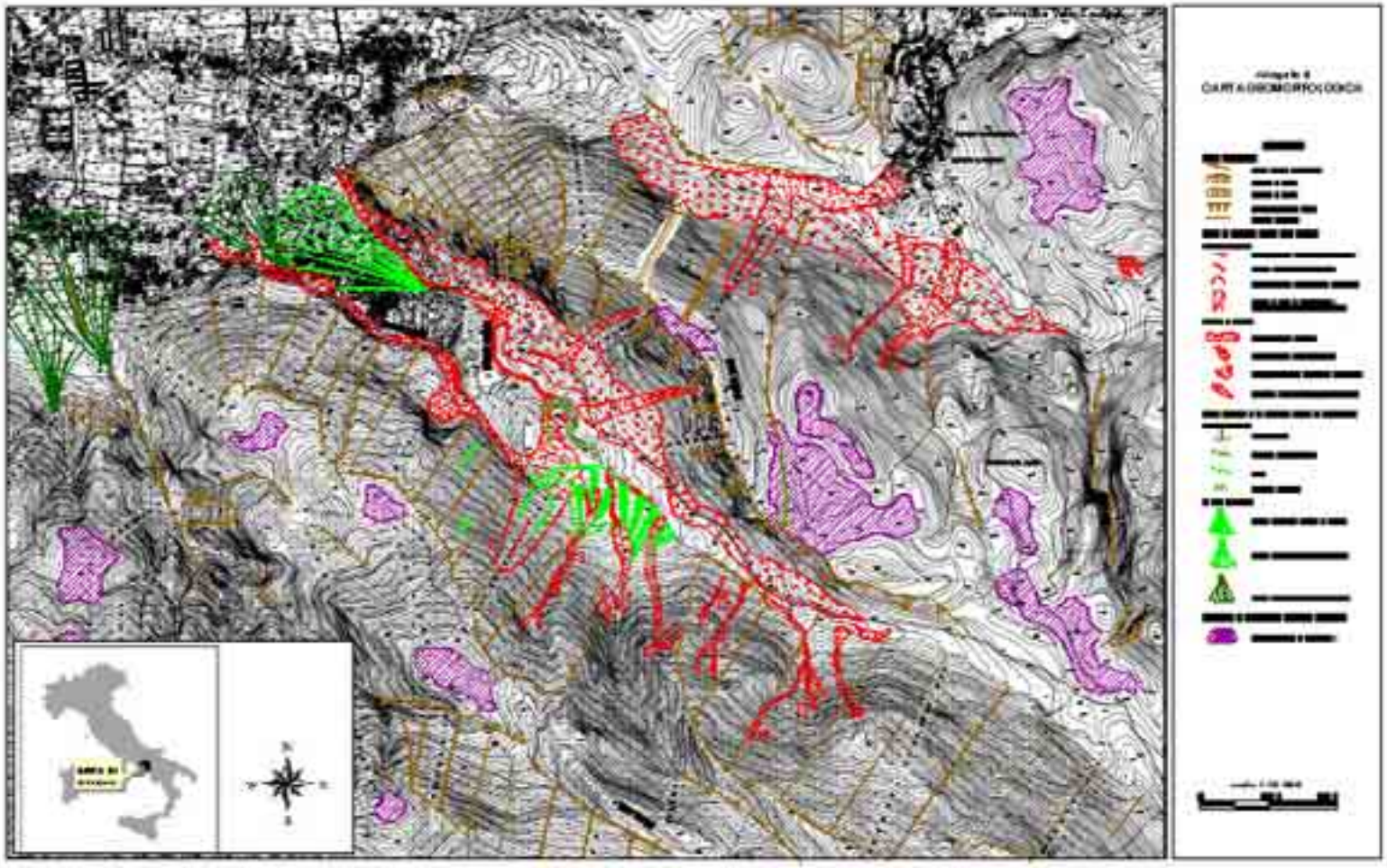
Barrikaden aus Sandsäcken gegen das Oderwasser in Reitwein. Die Gemeinde südlich von Frankfurt (Oder) traf die Jahrhundertflut am härtesten. Hier stieg der Pegel auf 6,05 Meter an. Foto: Reuter

PRAGUE FLOOD – August 2002

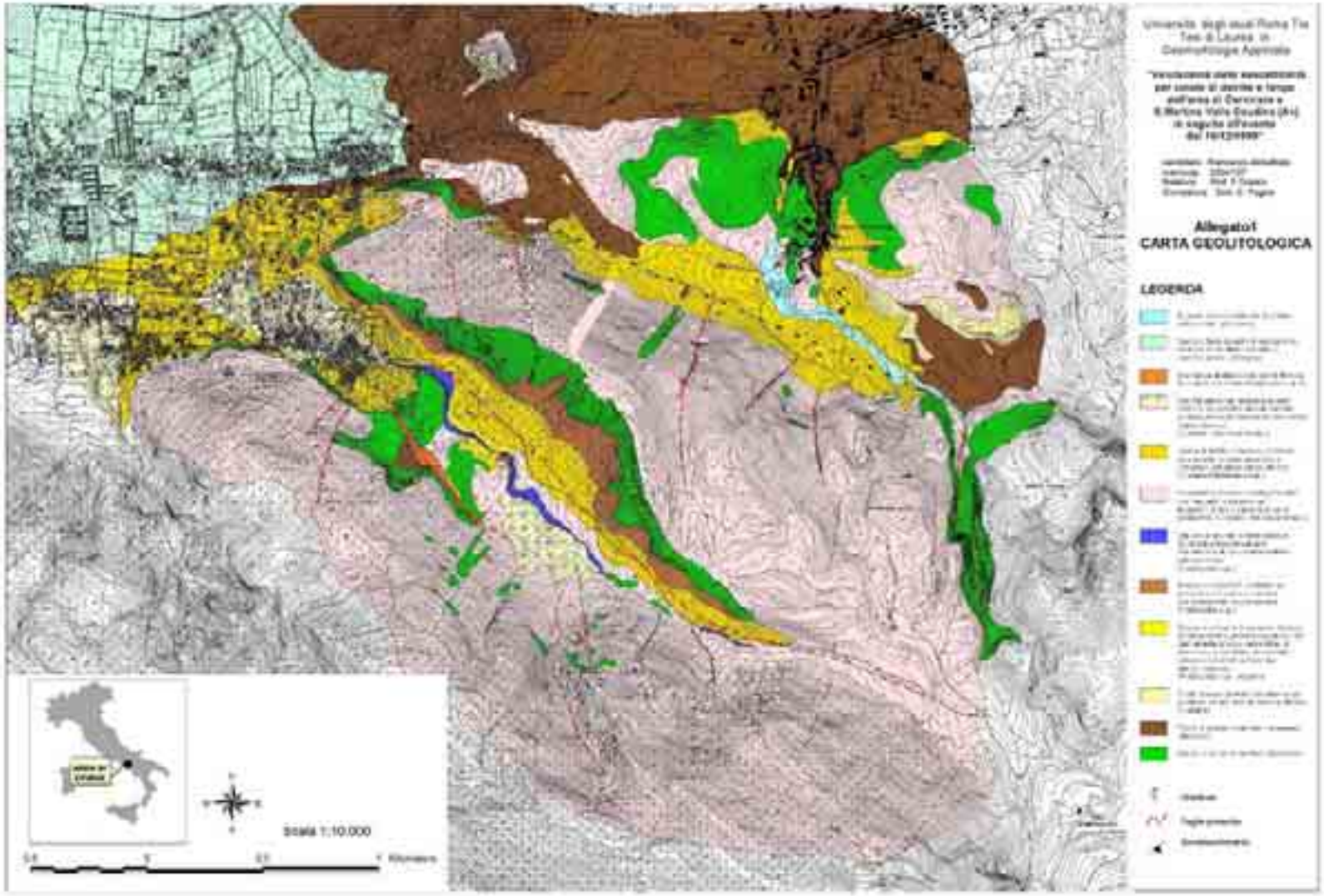
Landslside Classification


Classification
Intensity evaluation of classified phenomena
Evaluation of return times of calssified phenomena
Intensity forecasting
Spatial forecasting
Temporal forecasting
Hazard
Risk elements
Value of risk elements
Vulnerability
Risk

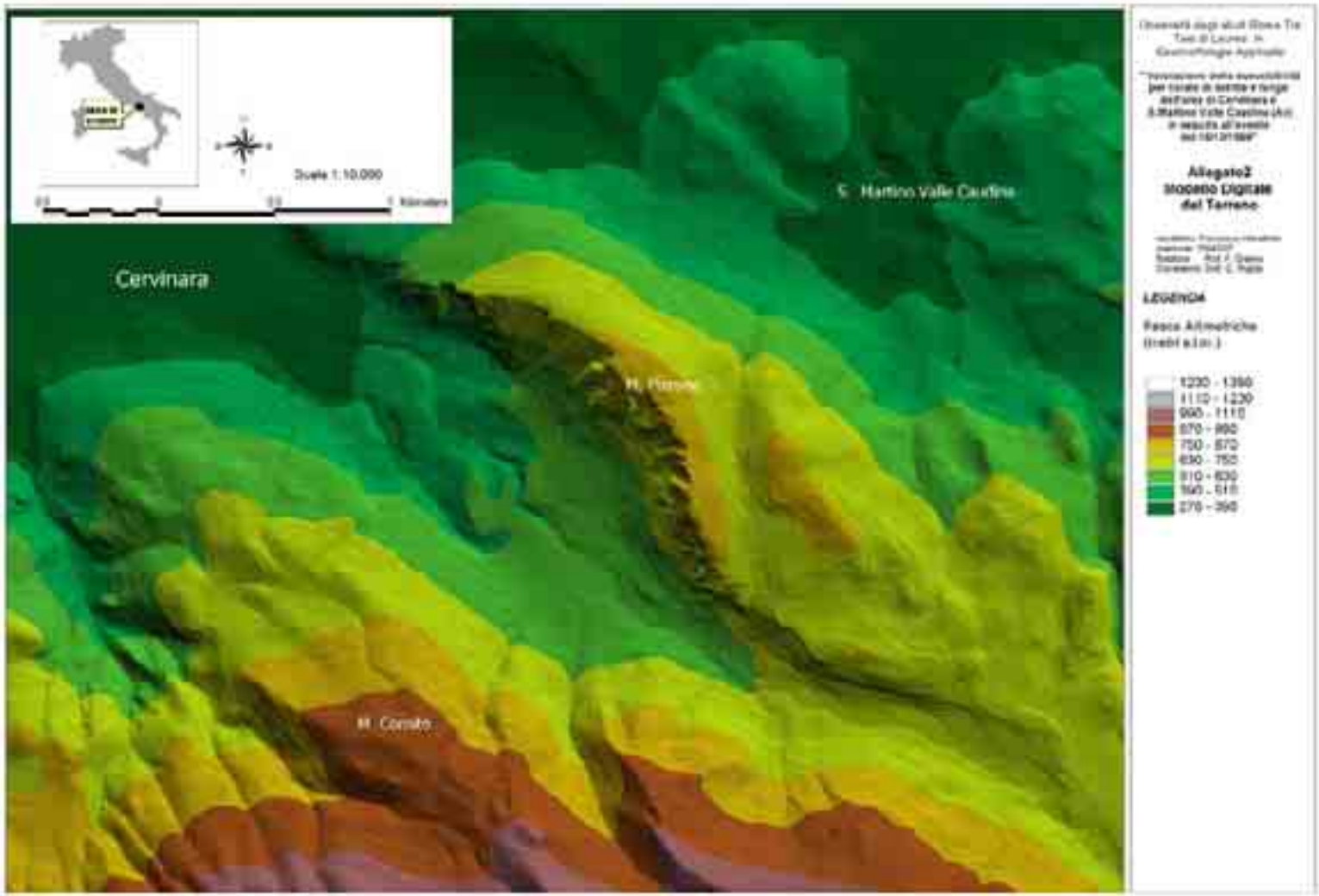
CERVINARA: A CASE STUDY FOR LANDLSIDE HAZARD EVALUATION



Geomorphological Map of Vallone Castello area (Cervinara, Italy)

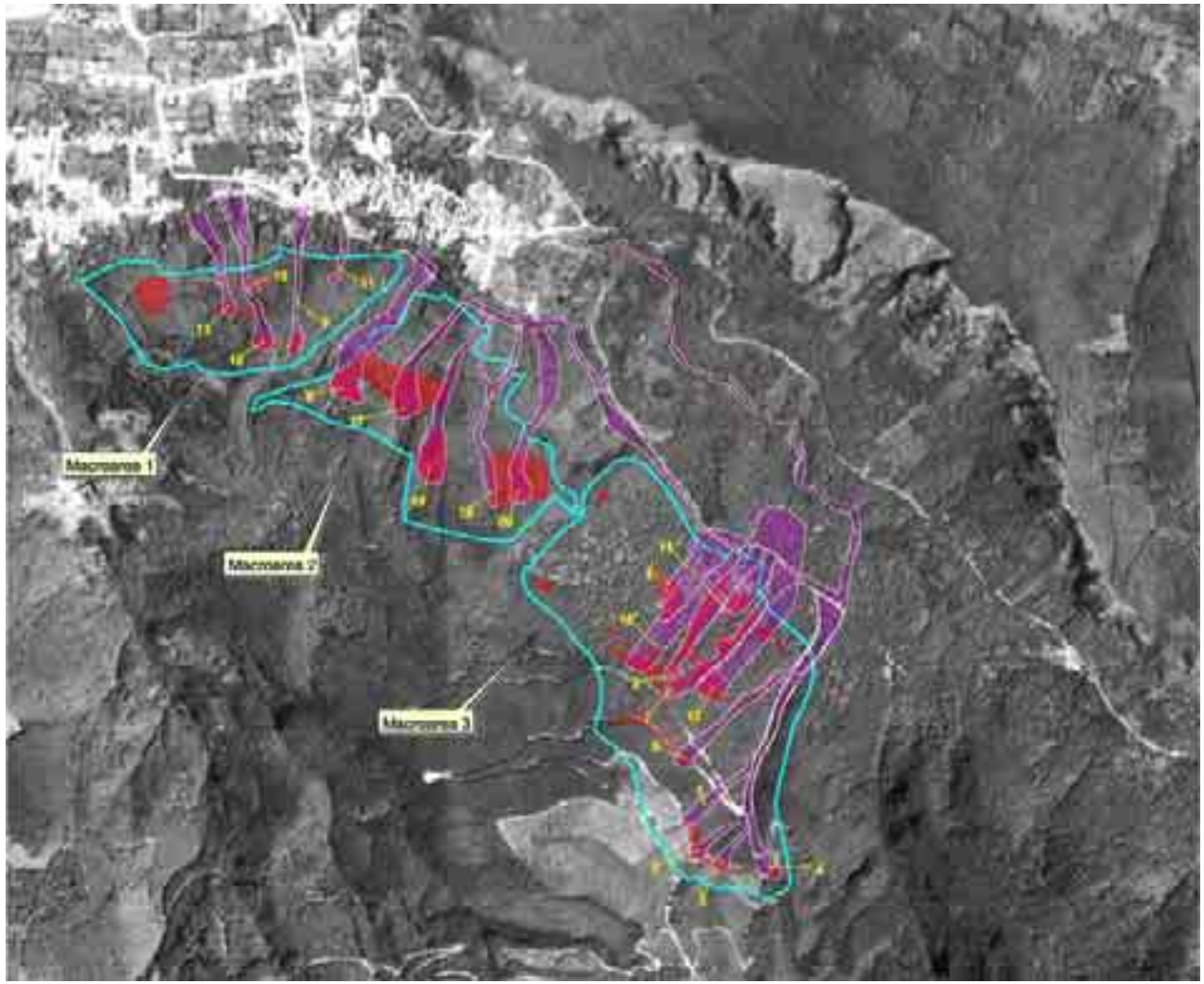


Geological Map of Vallone Castello area (Cervinara, AV)

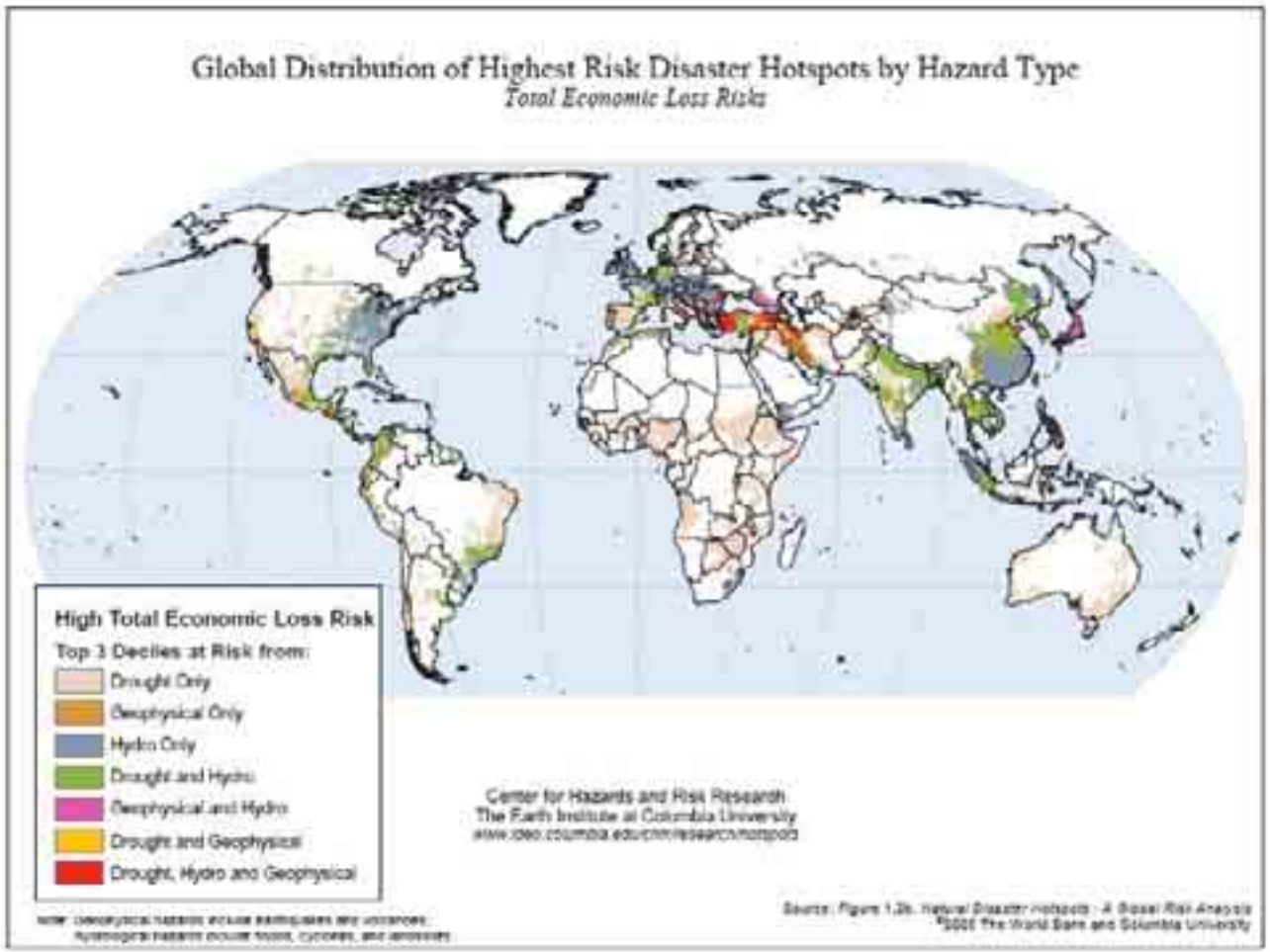


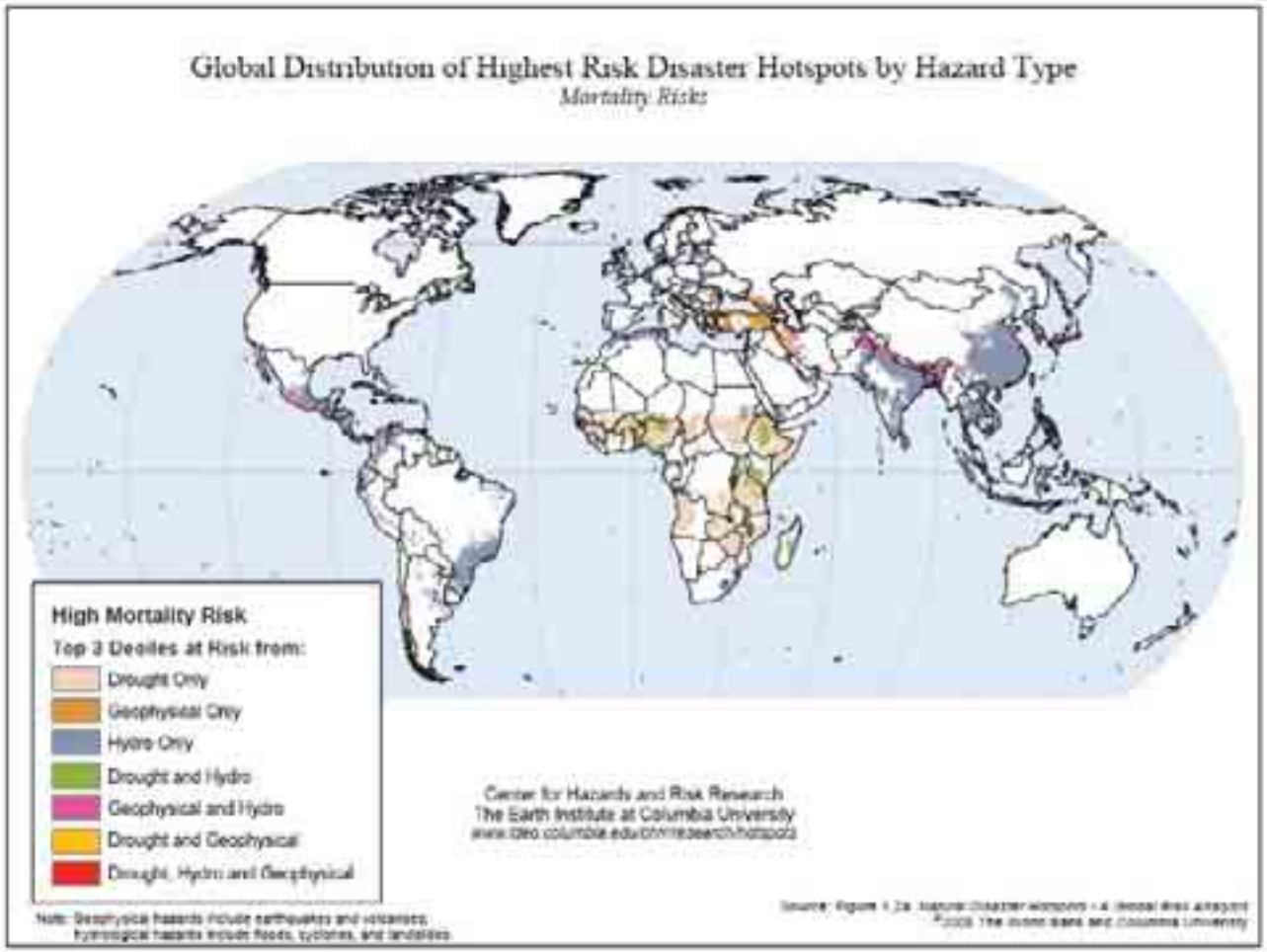
DEM (5X5m) of Vallone Castello area (Cervinara, AV)

Possible source areas and relative transport areas for landslides

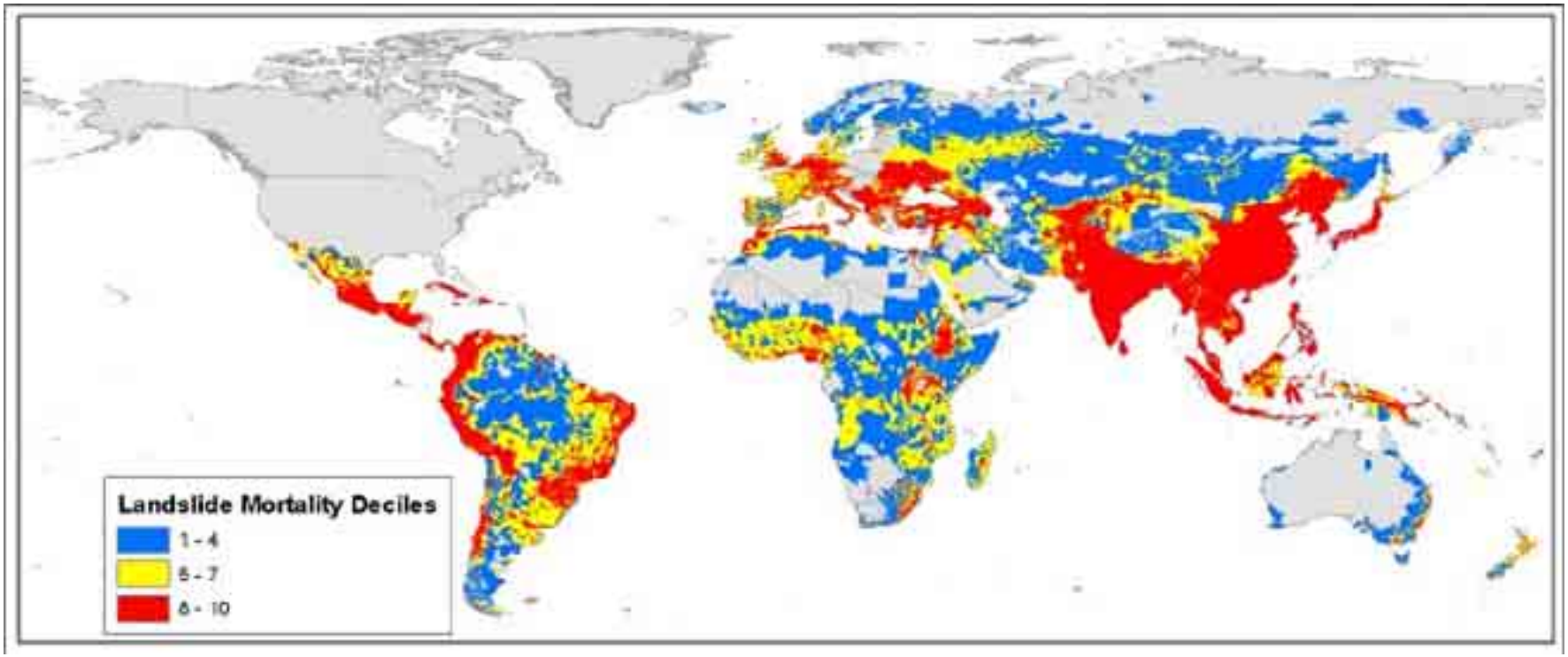


A GLOBAL RISK ANALYSIS




Global Distribution of Highest Risk Disaster Hotspots by Hazard Type
Mortality Risk
High Mortality Risk
Top 3 Deciles at Risk from:
Drought Only
Geophysical Only
Hydro Only
Drought and Hydro
Geophysical and Hydro
Drought and Geophysical
Drought, Hydro and Geophysical
Center for Hazards and Risk Research
The Earth Institute at Columbia University

Landslide disaster mortality risk hotspots



Flood disaster mortality risk hotspots