LIFE08 ENV/IT/436

# PROJECT ACT
## ADAPTING TO CLIMATE CHANGE IN TIME

# *Climate change, geological and hydrological impact assessment and adaptation policy*


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***Rome 19 July 2010***

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## *Outline*

- General framework and logical path
- Risk areas 2010 – Italy example
- Land use planning and future urban trend
- Climate change and downscaling problems
- Specific effects on geological and hydrological hazard
- Adaptation policy
- Adaptation plan proposal for the project

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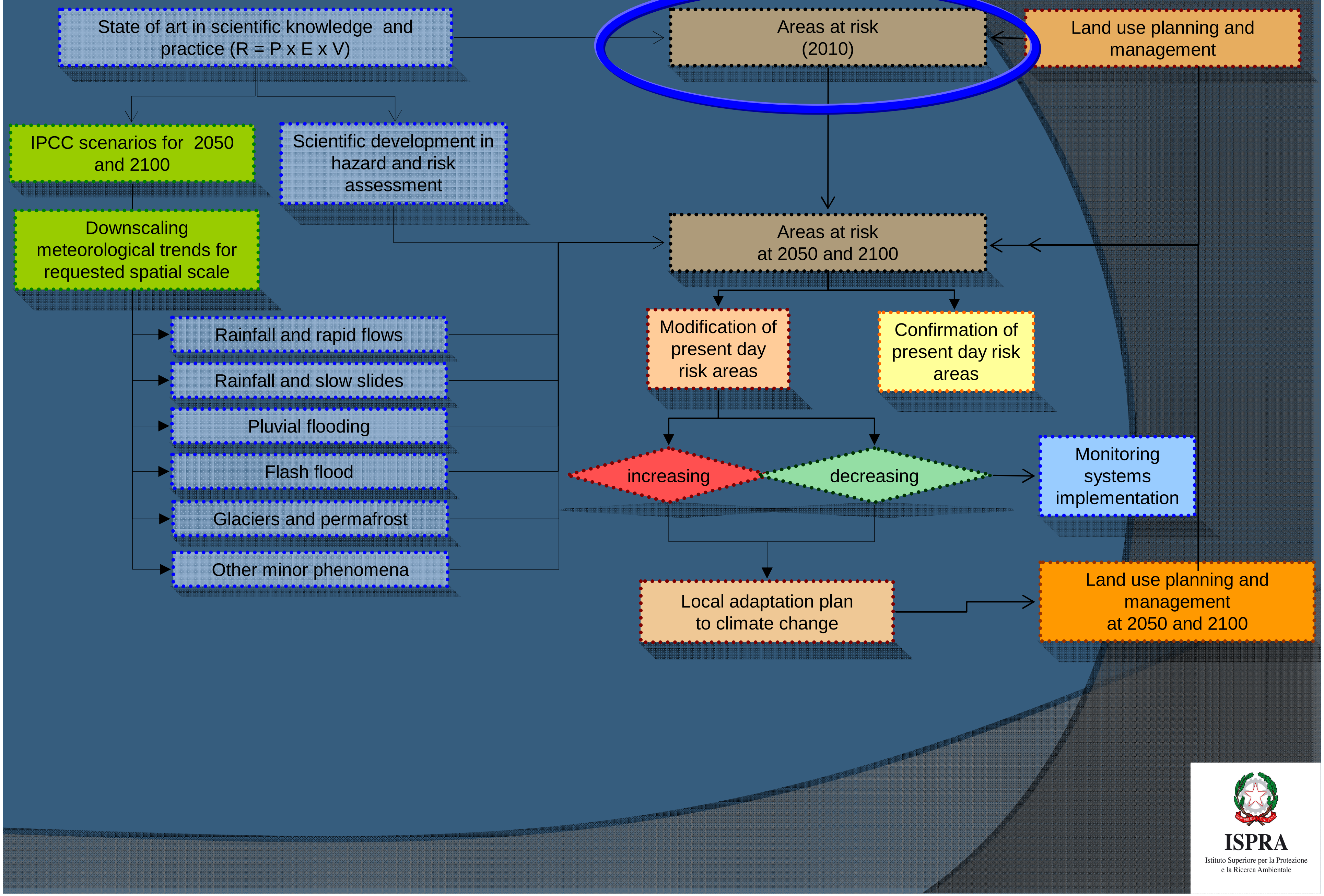
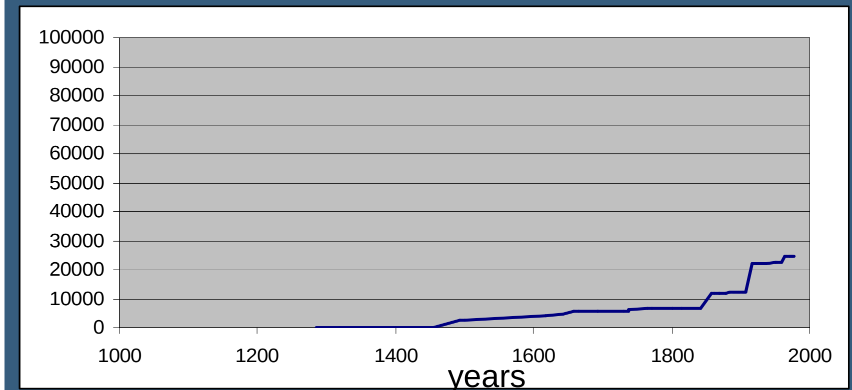
# The logical path Climate Change, geo-hydrological hazard



# *Victims for landslides and floods in Italy – historical data*

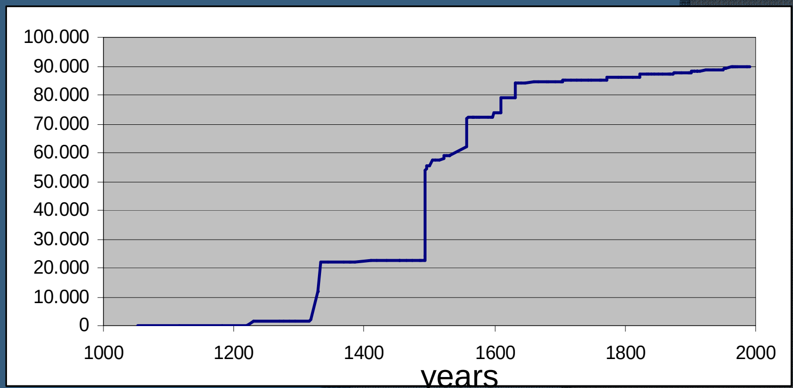
**Landslides:**

**1279 – 2002: 13,8 victims per year (source CNR)**




**Floods:**

**1279 – 2002: 49,6 victims per year (source CNR)**
**1951 – 2005: 31 victims per year (source ISPRA)**

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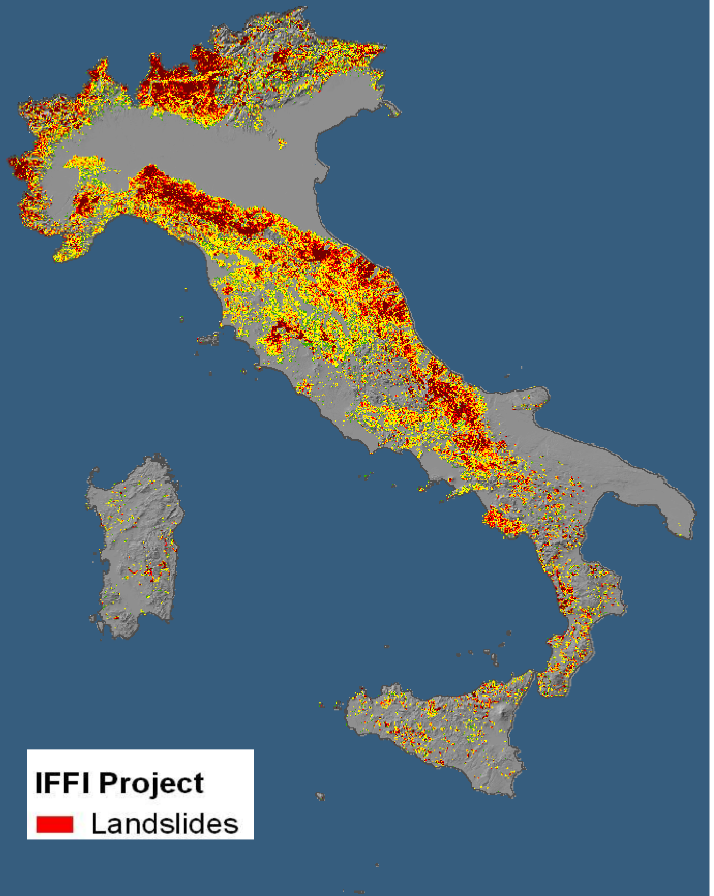
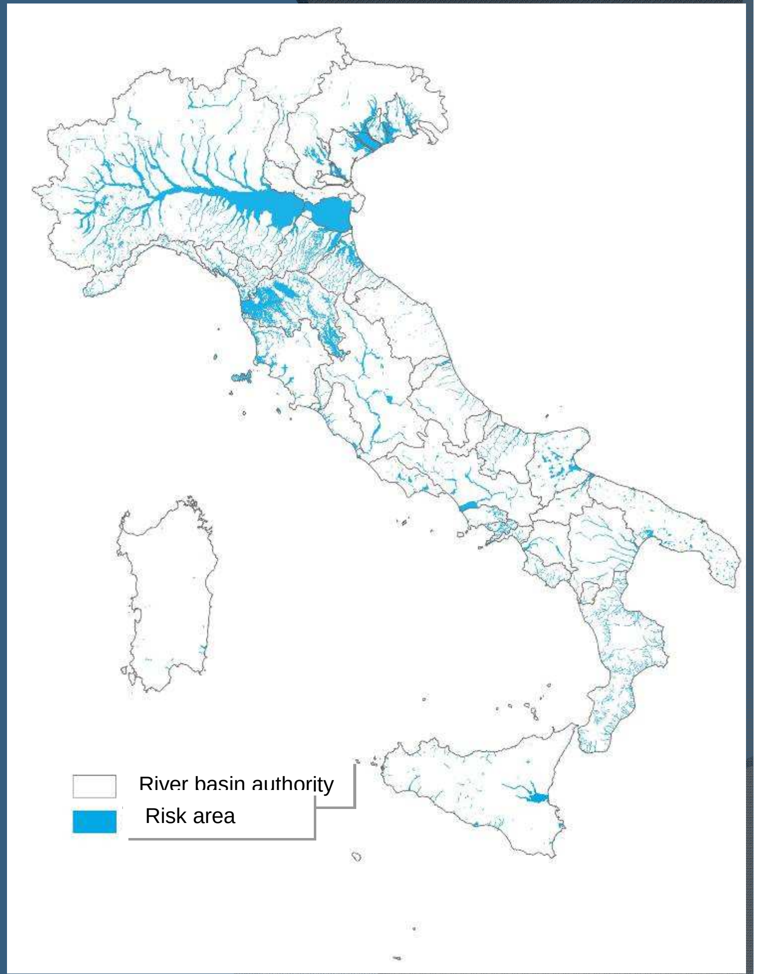
# *hazard and risk maps in Italy - 2010*

Areas at risk in Italy
(2010)

landslides

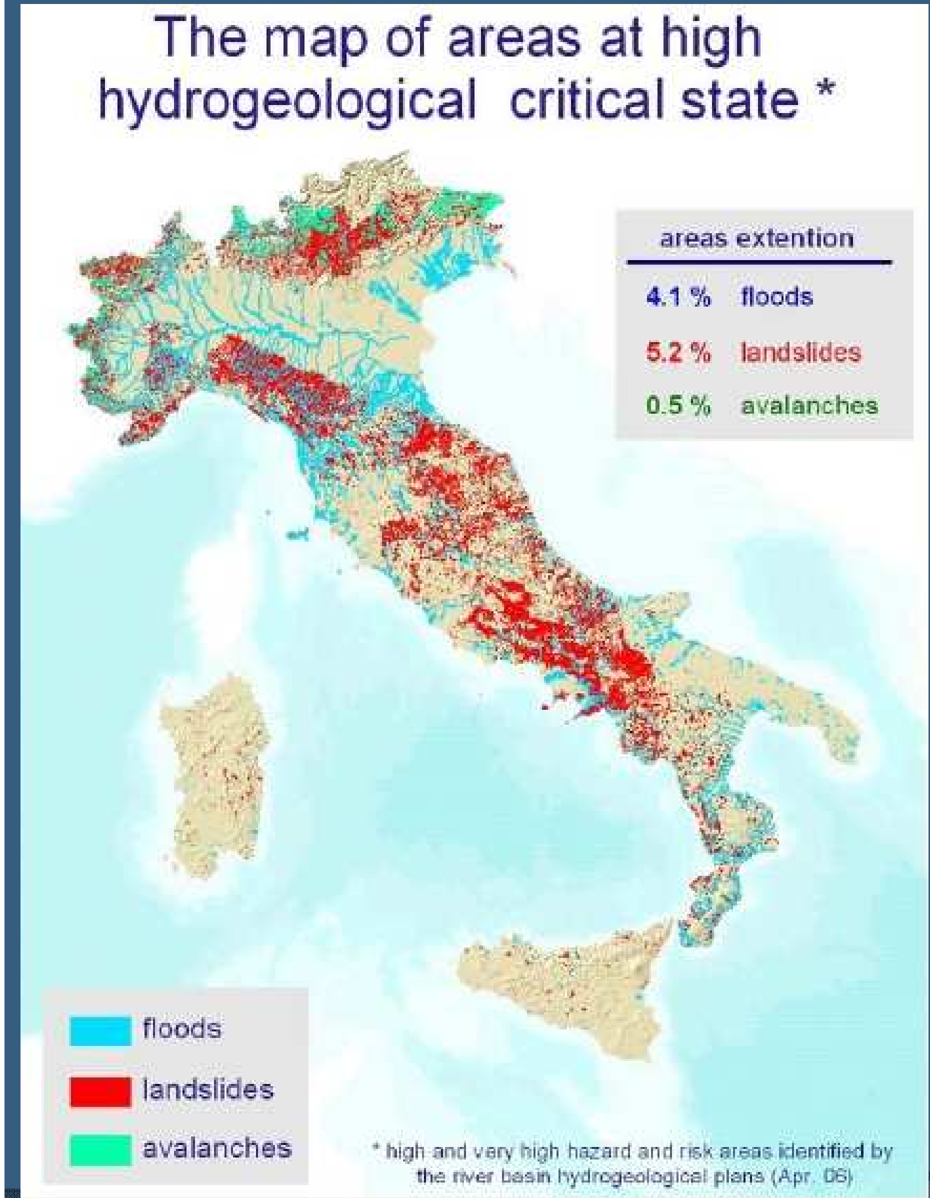



floods



# risk maps in Italy

Areas at risk in Italy (2010)




Needs (*in present day conditions*):
44 Billion € (Source Ministry of Environment, 2006)

- 2,385 Billion € in the period 1998 - 2008 **(only DL 180/98 and 179/02 law) mitigation measure;**

- Public works: (environmental protection, hydro geological protection, water resources) 9,4 Billion € in the period 2000 - 2005 **(Source: Authority for the Supervision of Public Contracts)**

Direct and indirect cost after disastrous event:

- Floods: 16 Billion € in the period 1951-2005, with a yearly average of 0,293 Billion €/year that become 0,773 Billion €/year in the period 1990 – 2005 **(ISPRA annual report, 2009);**

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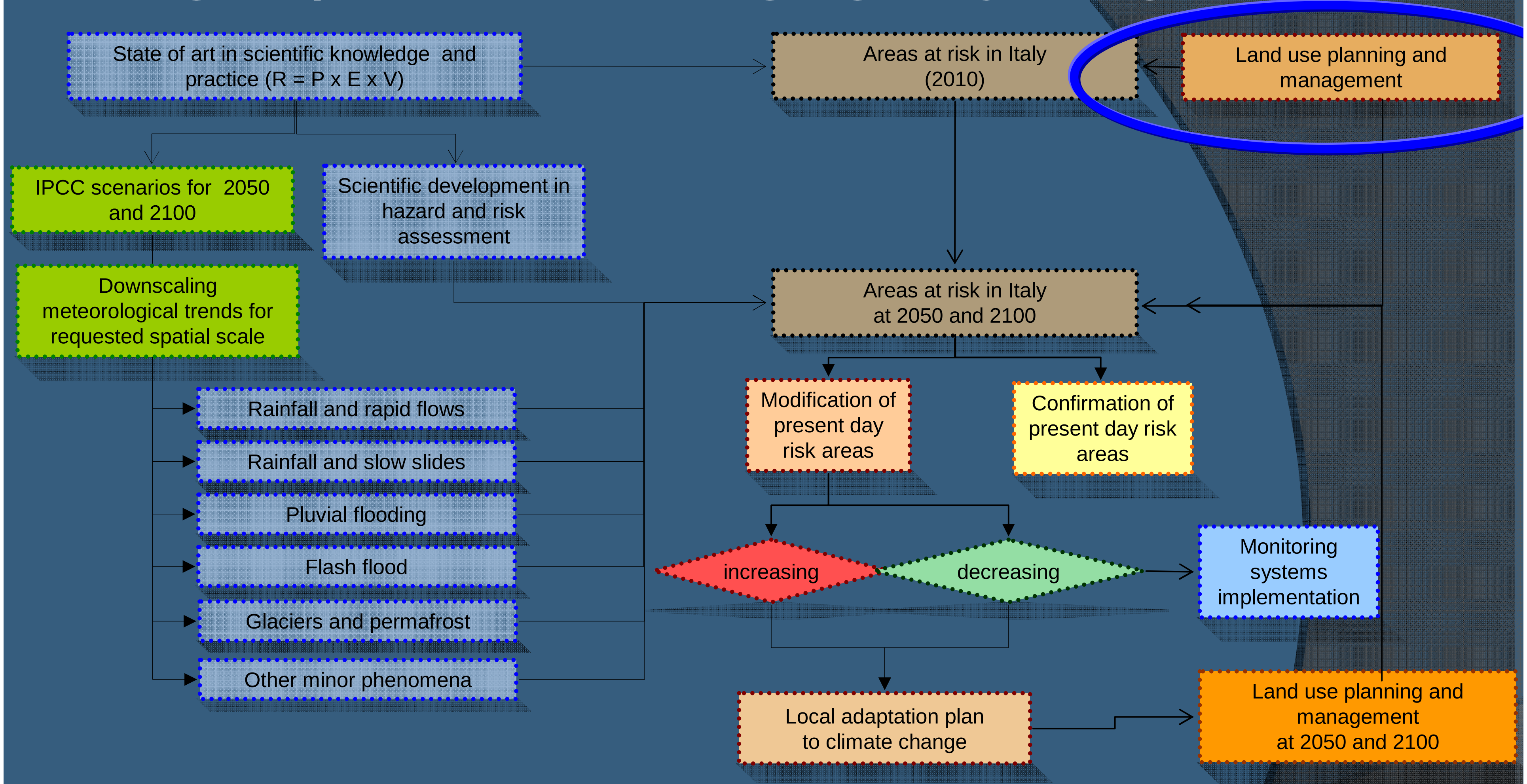
# *The logical path Climate Change, geo-hydrological hazard*




*The past is the key to the present (C. Lyell); what about the future?*

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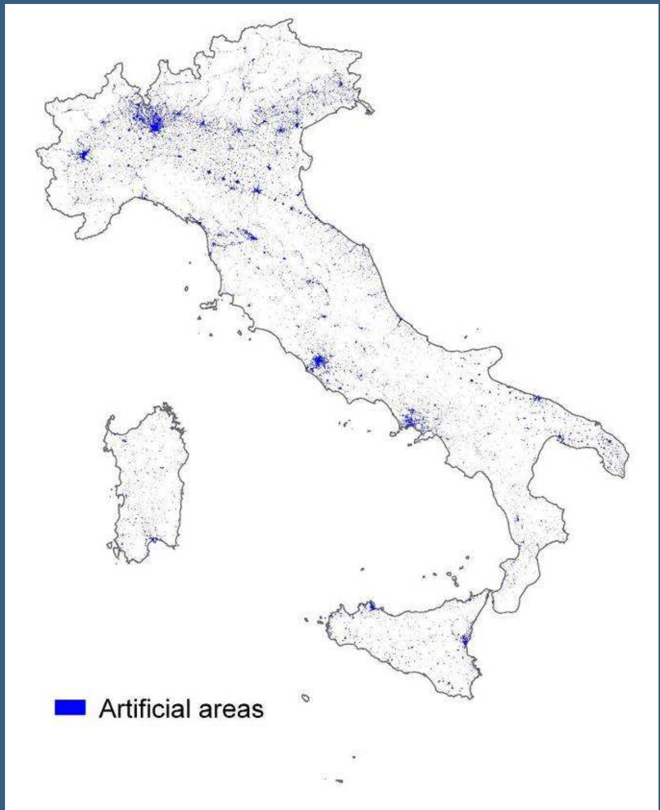
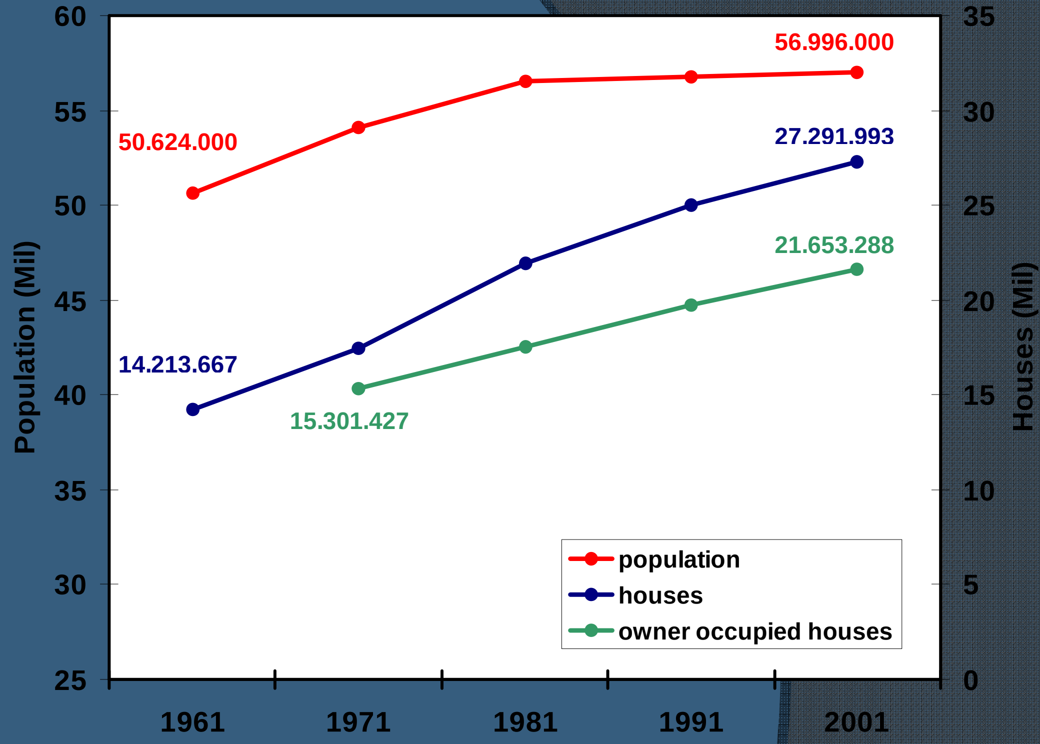
# *Future urban trends?*




| | |
|---|---|
| *59,459*<br>*(17,929 km$^2$, 5.9 %)* | *urban settlements* |

**In the past 50 years, urban areas in Italy underwent a strong increase; the urban surface has more than doubled.**

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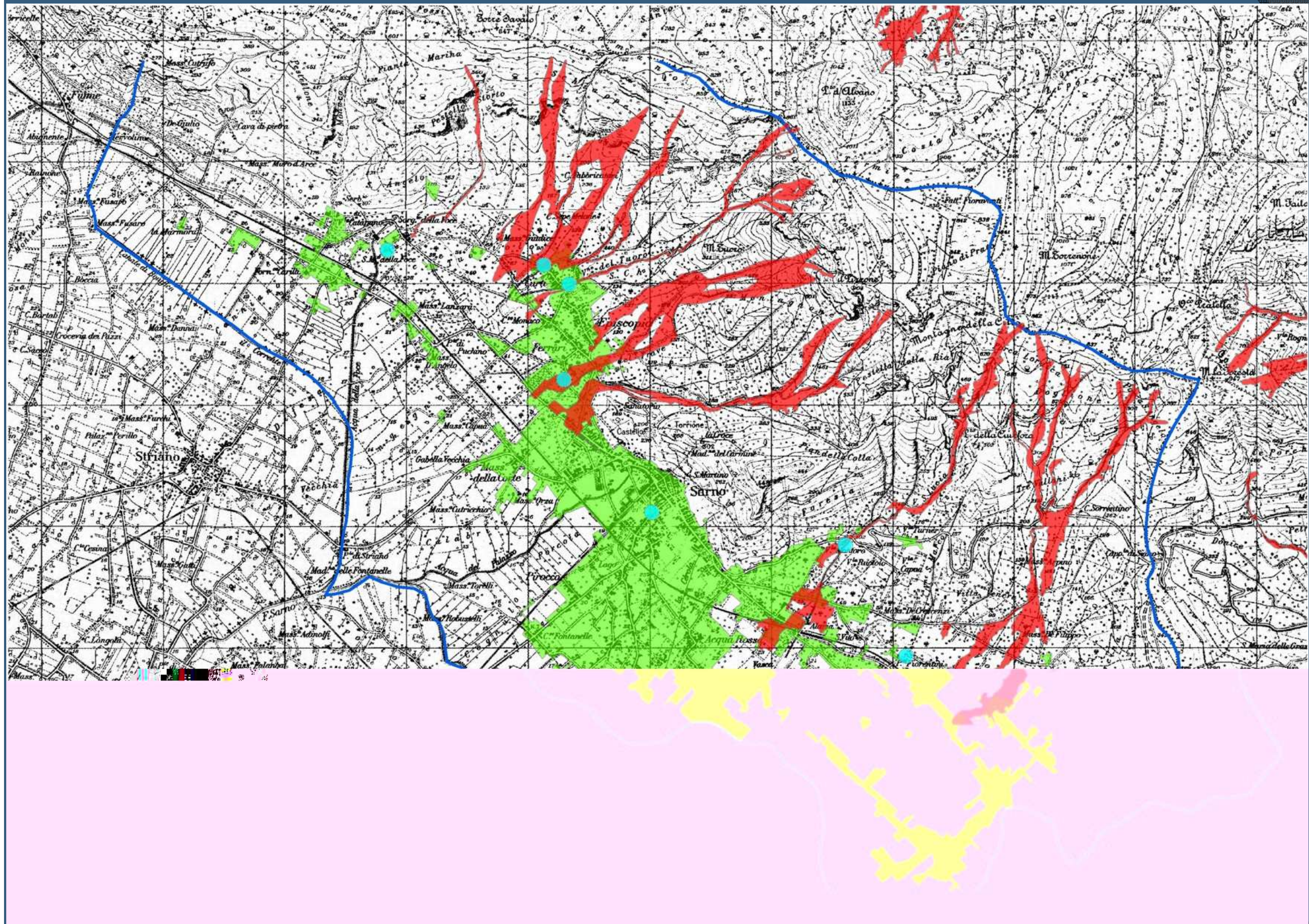
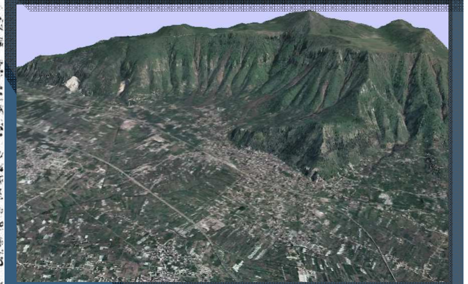
# *Future urban trends?*

Land use planning and management at 2050 and 2100



**05-06/05/1998: extremely rapid debris flows with 160 casualties.**

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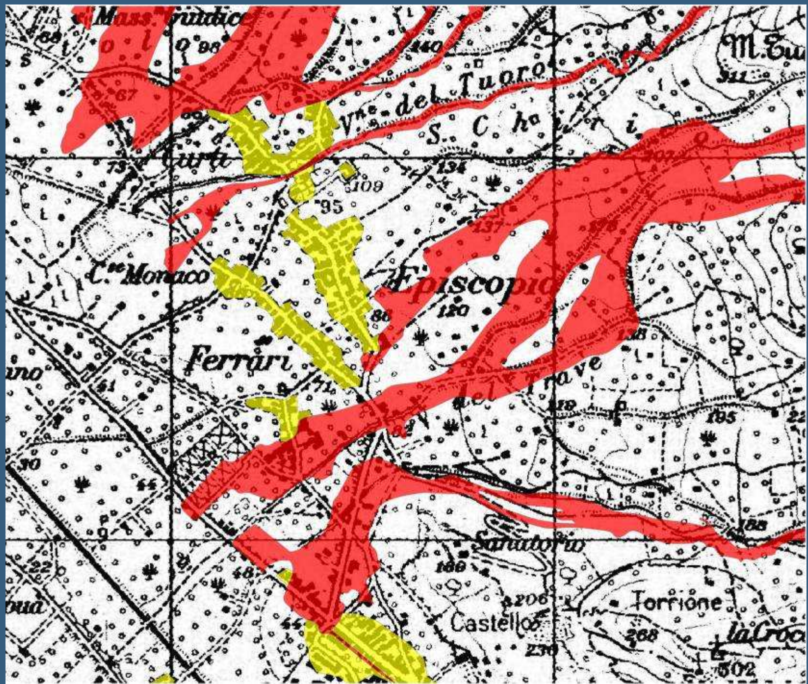
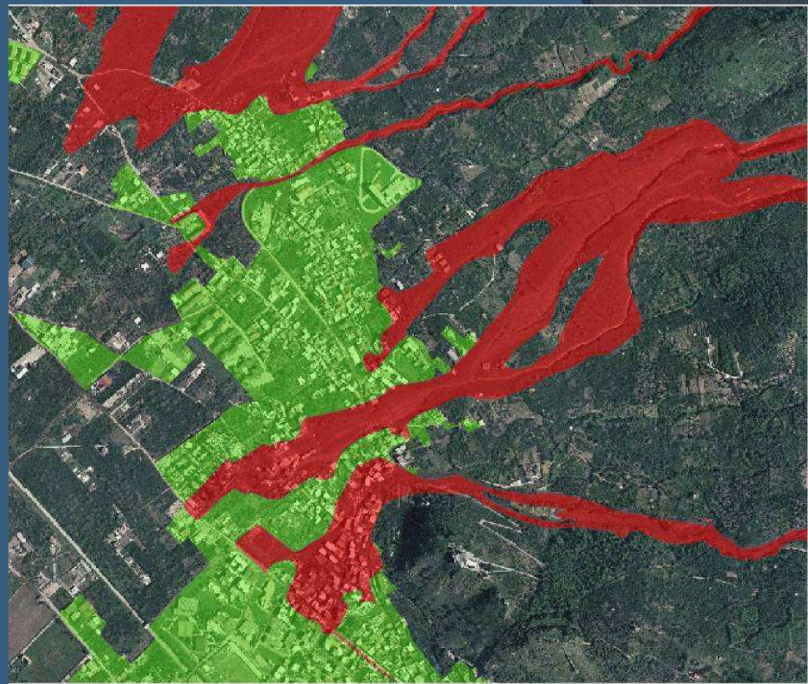
# Future urban trends?

Land use planning and management
at 2050 and 2100

- **Landslide risk in Sarno municipality:**




*Scenario: landslides (1998), urban area (1956)*



*1998 Sarno event: landslides & urban area*

| | 1956 | 1998 | Δ % |
|---|---|---|---|
| Urban area (Km$^2$) | 0.875 | 5.292 | 505 |
| Urban area affected by landslides 1998 Scenario (Km$^2$) | 0.029 | 0.289 | 897 |
| Urban area affected by landslides (%) | 3.31 | 5.46 | |

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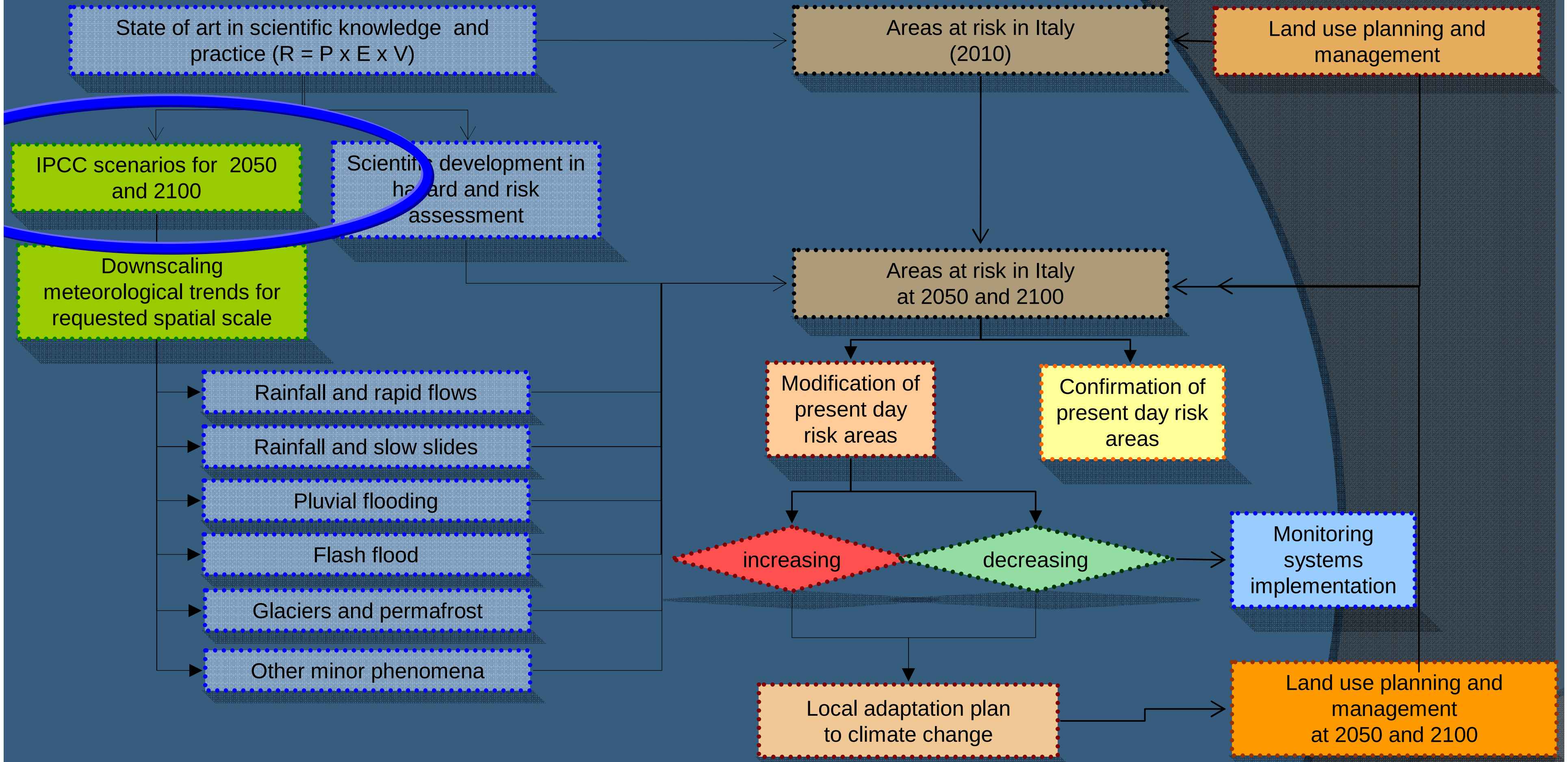
# The logical path Climate Change, geo-hydrological hazard




*The past is the key to the present (C. Lyell); what about the future?*

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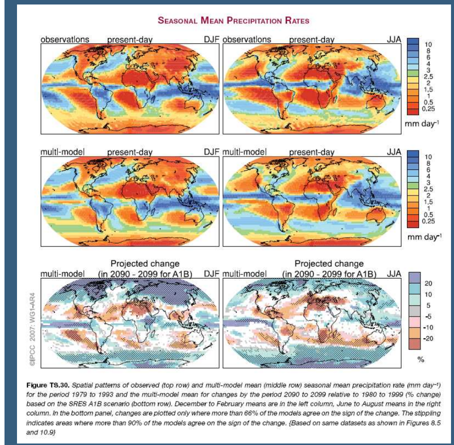
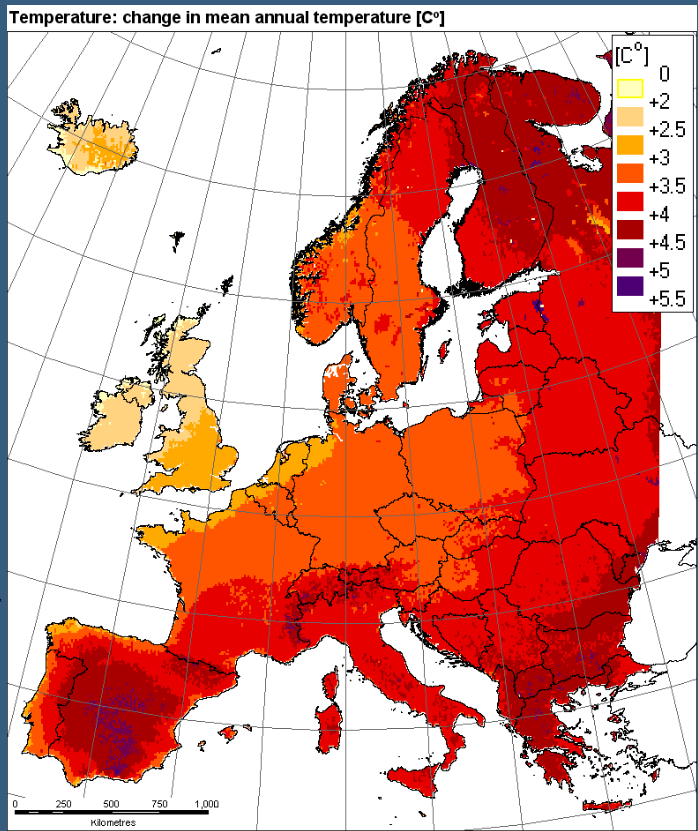
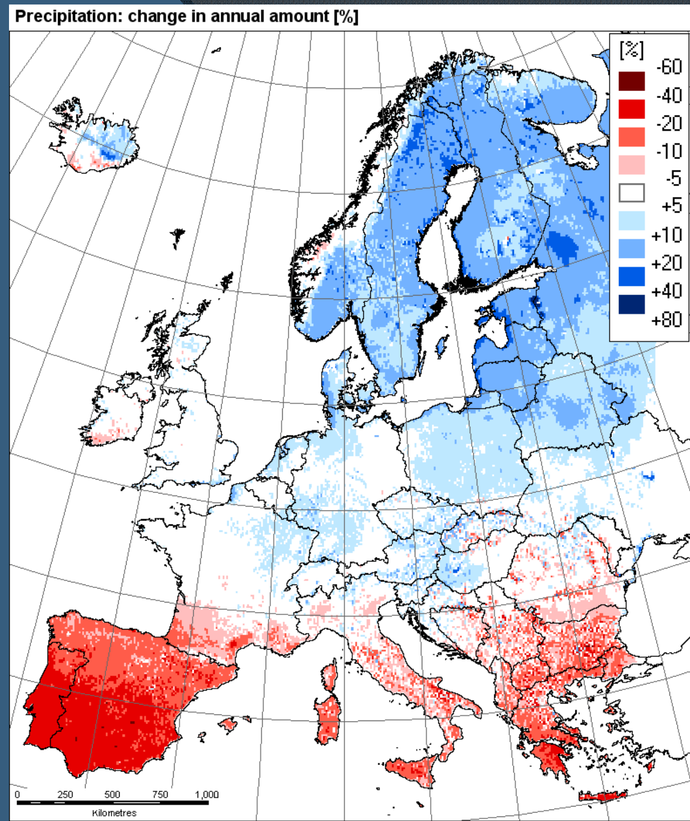
# Climate change at European scale




IPCC scenarios for 2050 and 2100

***EU green Paper (A2 scenario in special report (SRES – IPCC). T and P impacts scenarios estimated for the 2071 and 2100 using series data 1961 – 1990. Maps are based on DMI/PRUDENCE (http://prudence.dmi.dk) data and has been elaborated by CCR for the PESETA project (http://peseta.jrc.es).***

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# Climate change at European scale



## Impacts of Europe's changing climate — 2008 indicator-based assessment Joint EEA-JRC-WHO report

…..the global mean **temperature** has increased by 0.8 ℃ compared with pre-industrial times for land and oceans, and by 1.0 ℃ for land alone. Europe has warmed more than the global average (1.0 and 1.2 ℃, respectively), especially in the south-west, the north-east and mountain areas. Projections suggest further temperature increases in Europe between 1.0–5.5 ℃ by the end of the century, which is also higher than projected global warming (1.8–4.0 ℃)…..

………Changes in **precipitation** show more spatially variable trends across Europe. Annual precipitation changes are already exacerbating differences between a wet northern part (an increase of 10 to 40 % during the 20th century) and a dry southern part (a decrease of up to 20 % in some parts of southern Europe).

**The intensity of precipitation extremes such as heavy rain events has increased in the past 50 years, and these events are projected to become more frequent. Dry periods are projected to increase in length and frequency, especially in southern Europe……..**

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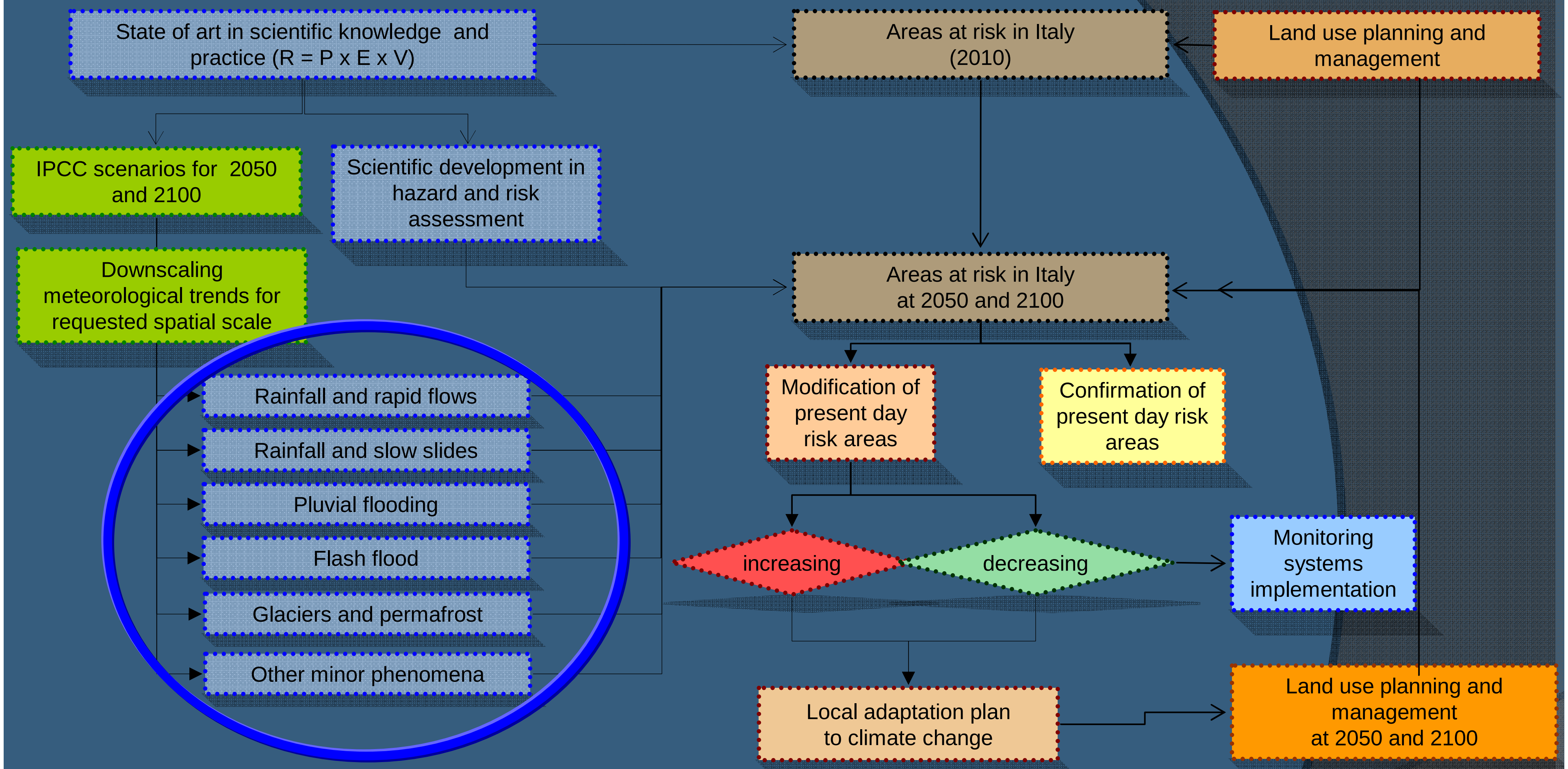
# *The logical path - some specific effects*




*The past is the key to the present (C. Lyell); what about the future?*

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# *Rainfall and rapid/slow slide*

…..slight decrease in the annual cumulated precipitation but, at the same time, a potential increase in the intensity of single rainfalls due to a decrease in the number of rainy days….

Highly pervious materials characterized by high permeability (coarse-grained soils, and fractured rock)

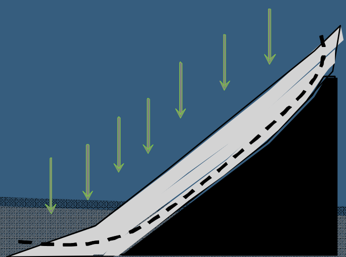
***detrimental effect***

***Increase of rapid shallow landslide***

low permeability materials (fine-grained soils, clay).

***beneficial effect***

***quiescence period for slow landslide ?***



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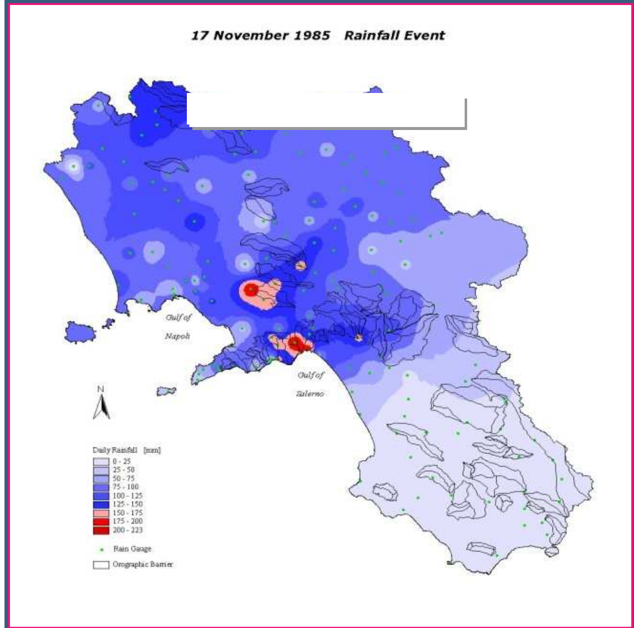
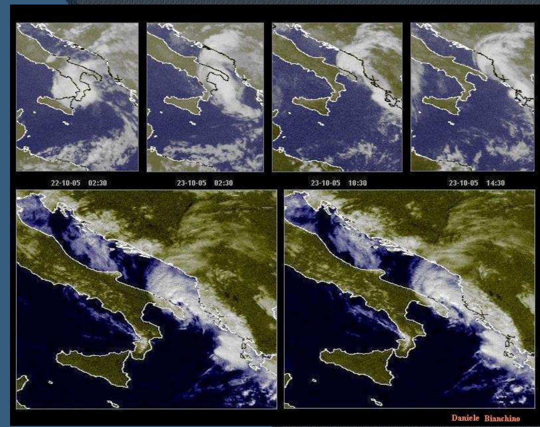
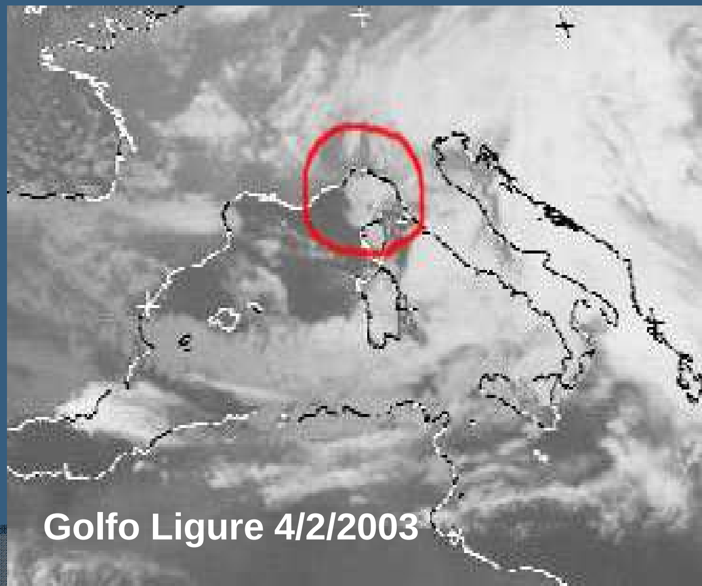
# *flash flood and tropical cyclones in southern Europe ?*




Napoli 17/11/95
(Longobardi e Villani, 2007)


Bari 23/10/2005

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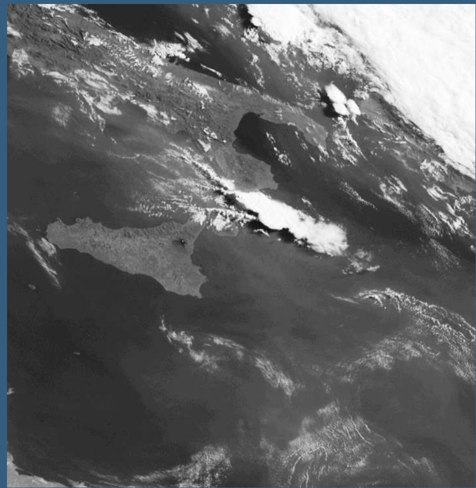
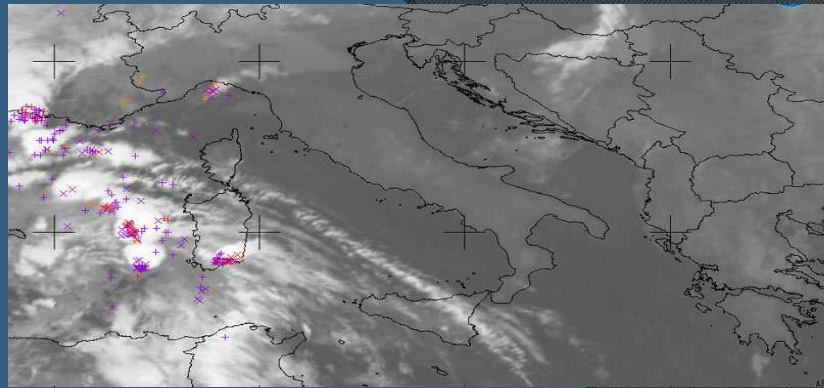
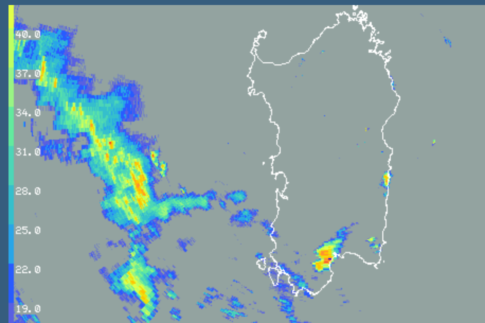
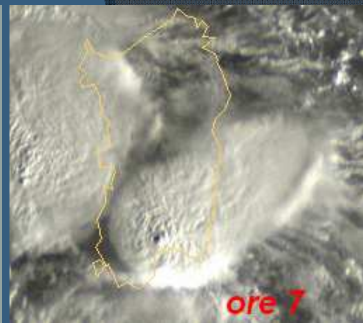
# …. few but intense storm?

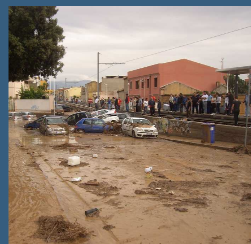
*Vibo Valentia*
*3/7/2006*

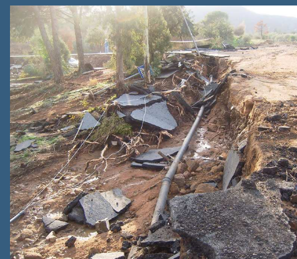








*Cagliari*
*22/10/2008*

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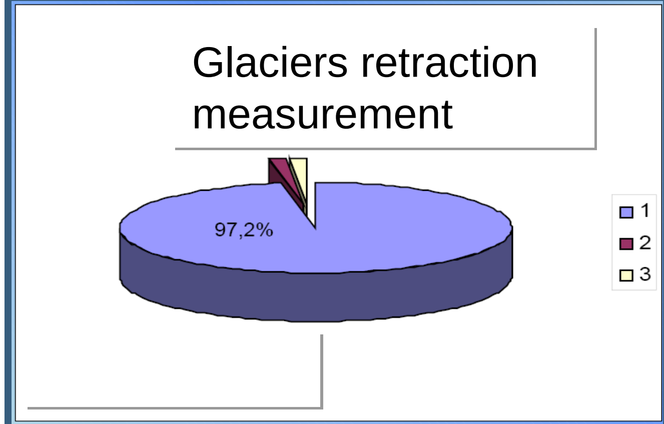
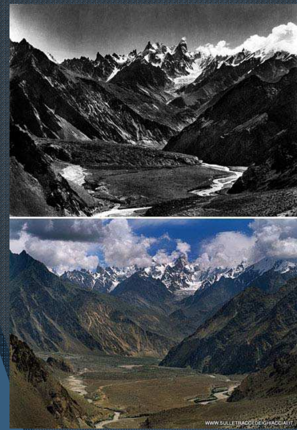
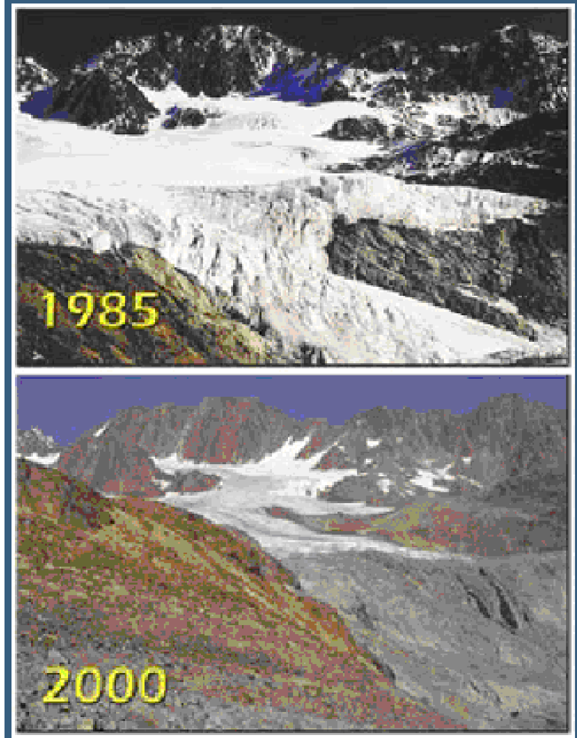
# Glaciers and permafrost

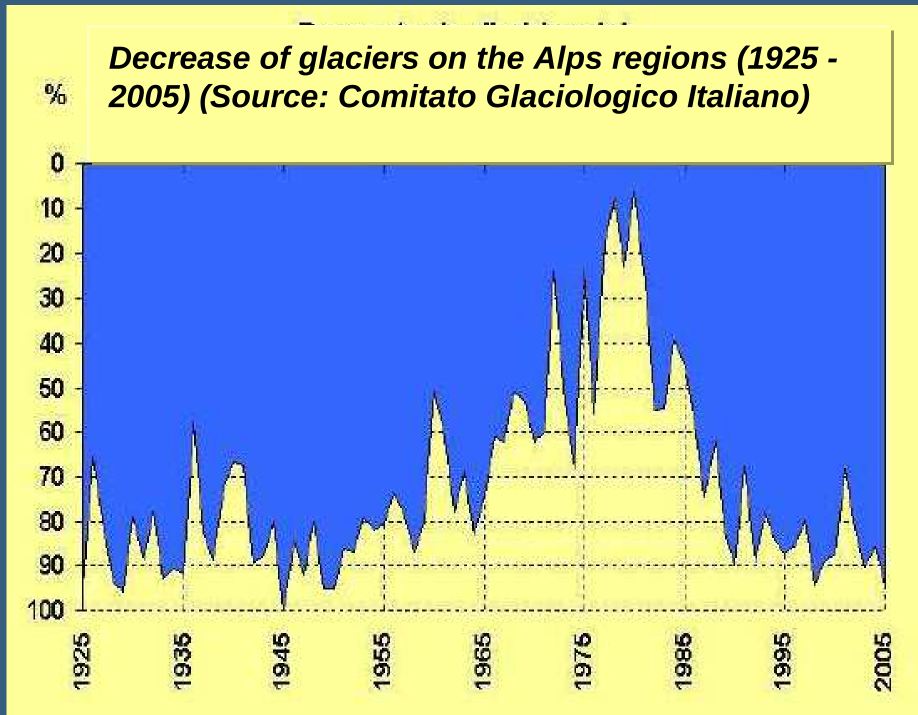
*Source :* G. Mortara, 2007

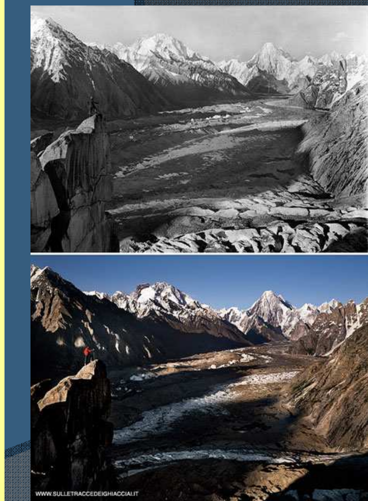








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# Adaptation policy

## The "hazard" scenario

The increasing of high concentrated precipitation might increase rapid slope movements, as well as soil erosion as consequence of the rising of temperature and aridity index;

Slow slope movements, since they are triggered by prolonged rainfall, could exhibit a quiescence period;

The increasing of concentrated high intensity rainfall could generate, in mountain and hill-mountain areas, the increasing of flash flood;

Increasing of temperature is decreasing the permafrost; as consequence an increasing of slope movements is expected in these areas even at no modified precipitation. In detail it is possible to expect:

- Increasing of rock-fall in areas presently stable because above the permafrost line;
- Increasing of slow slope movements in areas today interested by permafrost;
- Fall and debris flow due to collapse of temporary lakes caused by retraction of glaciers;
- Debris flow in the moraine outcropping as consequence of glacier reduction;
- Rock fall due to thermoclastism;

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## *Adaptation policy*

# *The "risk" scenario*

Urbanisation seems to be, together with meteorological phenomena and seismicity, one of the causative factors for mass movements in terms of increase of exposure and vulnerability; extremely important for risk assessment is illegal urbanisation. Built up new houses in hazardous areas, susceptible to rapid slope movements, is actually the main cause of damage.

There will be a high channelling of water stream, especially in hill - mountains sites that. Reducing the capacity of storage of river bed, might increase the velocity of water flow, likely increasing the risk, even in a general rainfall reduction scenario.

Increasing of temperature and prolonged dry period might produce (and already produced) volume contraction of typically clay soils with consequent damage to buildings located over these soils.

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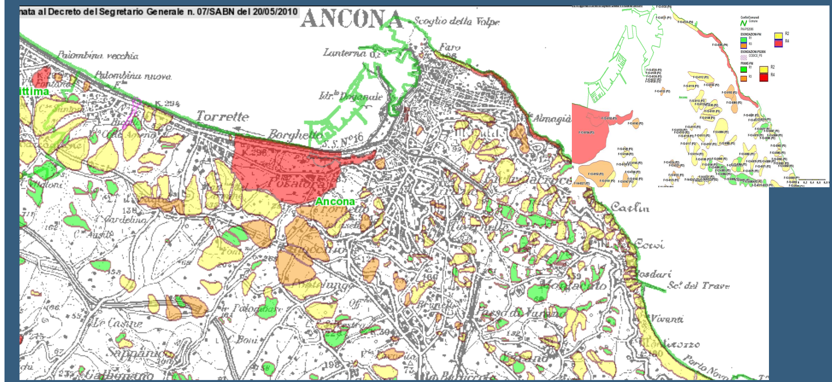
# • *Adaptation* plan proposal for LIFE ACT project

## Ancona Municipality case study

### *2010 - hydrological and geological risk situation*

- Collection of available dataset or implementation of new database;
- GIS processing of data (intersection and analysis);
- If landslide and hydrological risk is already available a simple costs analysis must be implemented, otherwise the intersection between *Hazard* an *Exposure* (e.g. population, public and private proprieties, infrastructures) should be implemented in order to perform a complete risk analysis



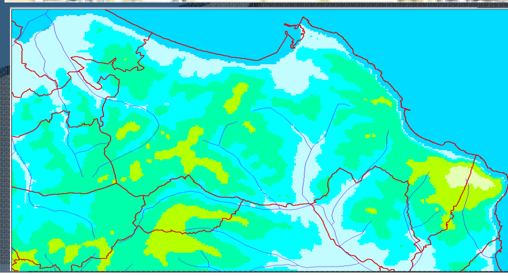

*Hydraulic and landslide Hazard/risk maps of Ancona Municipality (source: RbA_regionemarche)*

population

Urban settlement

infrastructures

Cultural heritage



*Geo-database implementation and geo-processing analysis*

*Simplified approaches for impacts assessments*

***•n°of casualties/km2 of hazardous area (referred to municipality);***
***•km2 of hazardous or risk area/ total area available (referred to municipality and classified by different land use)***

# • *Adaptation* plan proposal for LIFE ACT project

**Ancona Municipality case study** ***2010 – economic impacts assessments***

**Every single impact derived from landslide and hydrological events will be accounted at 2010 through economic update**

## *Global value*

$$W_G = [Rm*(Mm-Em)]\ Nab + Ned\ Ced + Cstr + Cmorf + C_{BBCC} + C_{ppa}$$

| | |
|---|---|
| *Rm* | is the medium income of the inhabitants; |
| *Mm* | is the medium age of dead of inhabitants; |
| *Em* | is the medium age of inhabitants; |
| *Nab* | is the number of inhabitants ; |
| *Ned* | is the number of buildings; |
| *Ced* | is the medium costs of buildings; |
| *Cstr* | is the costs of structures and infrastructures; |
| *Cmorf* | is the costs of morphological modifications; |
| $C_{BBCC}$ | is the medium cost of cultural heritage |
| $C_{ppa}$ | is the medium_of public and private area |

Rigorous definitions of risk, the total value W could be multiply to an appropriate index of vulnerability or vulnerability function in order to define the real:

**Global expected damage (direct and indirect cost)**

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# • *Adaptation* plan proposal for LIFE ACT project

## Ancona Municipality case study

## *Climate change trends and projections*

### Ancona temperature future trends

**Temperature**

| MODELS | MEAN TEMPERATURE Variation 2100 | | | | |
|---|---|---|---|---|---|
| | WINTER (DJF) | SPRING (MAM) | SUMMER (JJA) | AUTUMN (SON) | ANNUAL |
| ANCONA | | | | | |
| CNRM-RM+5.1 | **+2.8** | **+2.9** | **+5.7** | **+3.4** | **+3.7** |
| KNMI-RACMO2 | **+3.4** | **+2.8** | **+4.8** | **+3.6** | **+3.6** |
| SMHIRCA | **+3.3** | **+2.4** | **+3.9** | **+4.0** | **+3.4** |

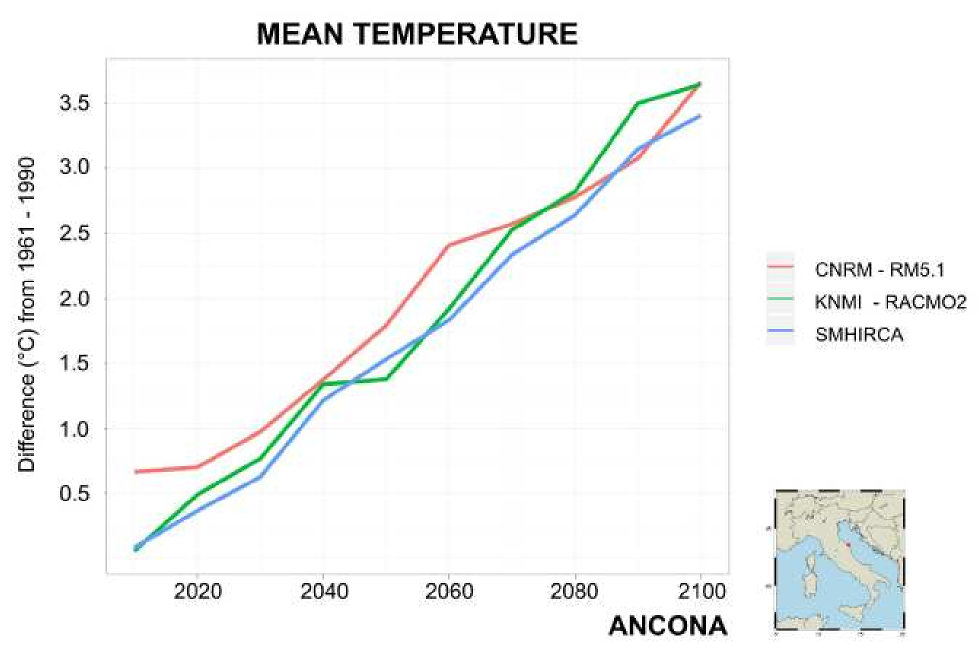


*Figure 2.1 Annual mean temperature variation predicted by RCMs ( °C)*

The three RCMs predict an increase of the mean air temperature at the end of the century between 3.4 °C (SMHIRCA) and 3.7 °C (RM5.1). The warming is more pronounced in summer (between 3.9 °C and 5.7 °C) and less in spring (between 2.4 °C and 2.9 °C). In the A1B scenario, the GCMs prediction of the intensity of the warming at the end of the century is lower than the RCMs (2.9 °C and 3.4 °C for INGV and CNRM models, respectively). In the A2 scenario, the GCMs predict a warming between 4.2 °C and 4.7 °C, while in the B1 scenario the global CNRM model estimates a warming of 2.1 °C. Therefore, the two opposite scenarios A2 and B1 introduce an uncertainty in the variation of the mean temperature of about 2.5 °C, which is likely to be wider when more GCMs are considered. With regards to the GCMs projections, the maximum increase for the mean temperature (6.3 °C) is predicted by the CNRM model in the A2 scenario, while the minimum increase (1.5 °C) is predicted by the INGV model in the A1B scenario and by the CNRM model in the B1 scenario.

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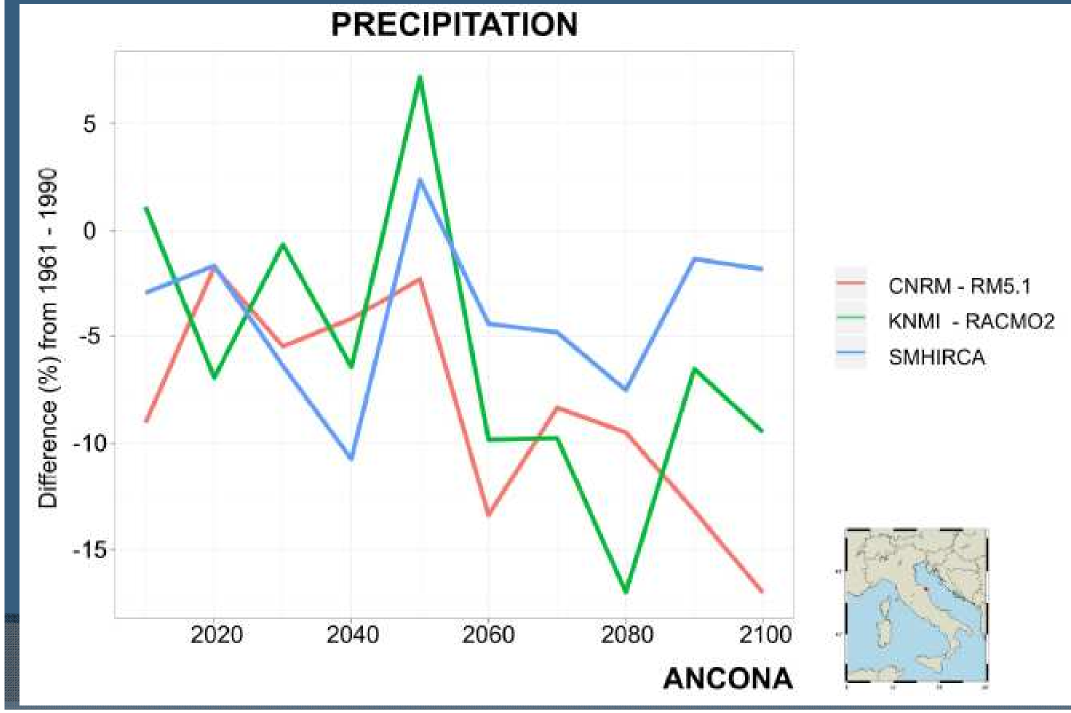
# • *Adaptation* plan proposal for LIFE ACT project

## Ancona Municipality case study

## *Climate change trends and projections*

### Ancona precipitation future trends

| Precipitation MODELS | PRECIPITATION Variation 2100 | | | | |
|---|---|---|---|---|---|
| | WINTER (DJF) | SPRING (MAM) | SUMMER (JJA) | AUTUMN (SON) | ANNUAL |
| ANCONA | | | | | |
| CNRM-RM+5.1 | **+8.8** | **-16.7** | **-41.0** | **-14.2** | **-17.0** |
| KNMI-RACMO2 | **-14.4** | **-20.2** | **-55.6** | **+42.9** | **-9.5** |
| SMHIRCA | **+6.0** | **-1.5** | **-45.0** | **+17.0** | **-1.8** |




The RCMs predict a reduction of the annual cumulated precipitation during the last 10 years of the century, ranging between - 1.8% (SMHIRCA) and - 17.0% (RM5.1). The relatively wide range of the variation along with the rather irregular behaviour over the decades, highlights that the uncertainty for the projections of precipitation is higher than the uncertainty for the temperature projections. Two models out of three predict a relative maximum of precipitation (higher than present) in the middle of the century. Summer is the only season whose precipitation has a quite regular decreasing tendency over the century, with a reduction of the seasonal cumulated precipitation in the last 10 years, ranging between - 41.0% and - 55.6%. Finally, two models out of three predict an increase of seasonal precipitations (in autumn: + 17.0% and + 42.9%; in winter: + 6.0% and + 8.8%). With regards to the GCMs projections, in the A1B scenario CNRM estimates the same precipitation reduction for the end of the century (- 16.8%) of the corresponding RCM, while the INGV model predicts a much drier (- 27.7%) climate. In the A2 scenario, the GCMs predict a drop of the annual precipitation between - 27.5% and - 33.6%, while in the B1 scenario the global CNRM model predicts a - 12.3% reduction.

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• ***Adaptation* plan proposal for LIFE ACT project**

**Ancona Municipality case study**

***2050 – 2100 hydrological and geological risk situation***

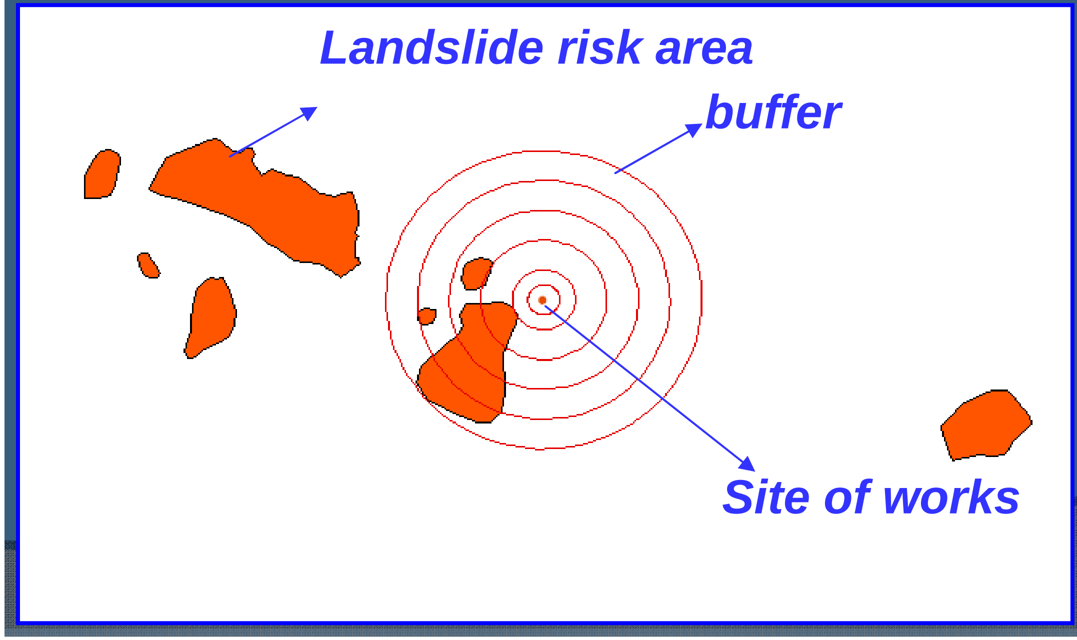
Landslide risk 2050 - 2010 trends and approaches

•**Slow landslide (low permeability material)** quiescent period;

•**Rapid landslide** (direct connection between climate input and triggering),

Direct proportionality useful to implement: buffer analysis for the hazard area

E.g.: 10% increase of extreme events the buffer will be realized of about 10% of the existing landslide area

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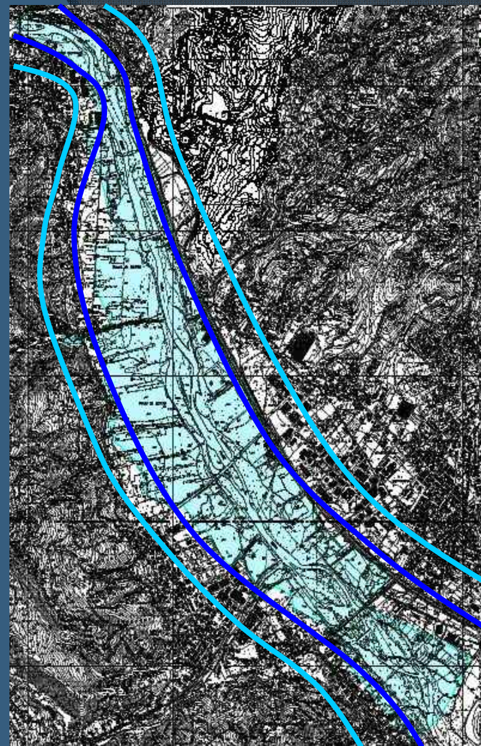
# • *Adaptation* plan proposal for LIFE ACT project

## Ancona Municipality case study

### *2050 – 2100 hydrological and geological risk situation*

Floods risk 2050 - 2010 trends scenario and approaches



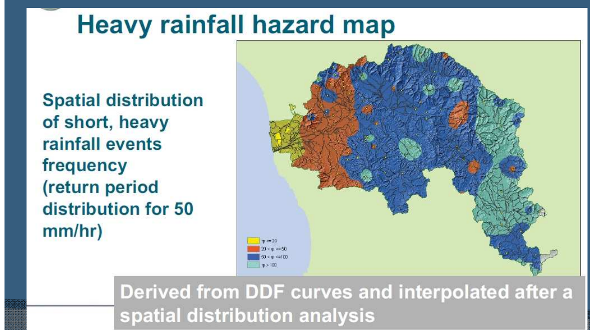
- For the high and very high hydraulic hazard area (Return Period > di 100 years) : buffer analysis and safety factor  - scenario analysis.

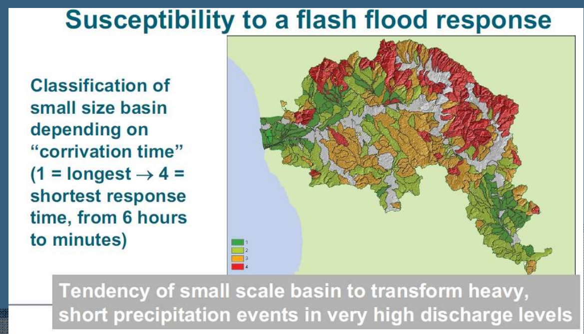
E.g.: 10% increase of extreme event with a specific return period we should increase the hydraulic surface at risk of about the same percentage;

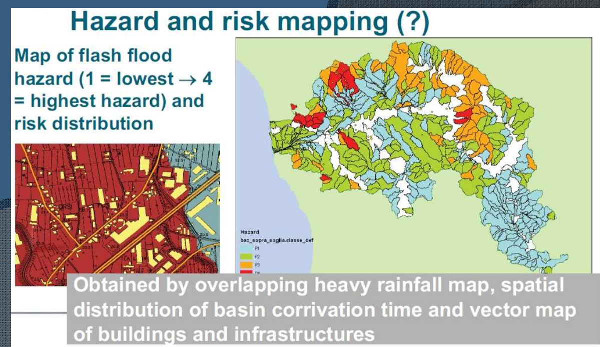
Flash Flood susceptibility map – we can applied a new methodologies developed by the Arno river basin Authorities 2010:

Classification of municipality by sub basin characterized by:

1. Small size (< 500 sKm or concentration time < 6 hours);
2. Heavy rainfall Hazard maps Spatial distribution of short, heavy rainfall events frequency (return period distribution for 50 mm/hr)



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**Ancona Municipality case study** ***2050 2100 – Economic Impacts***

**The same approaches adopted for the economic impact assessment and costs estimation at 2010 will be implemented for the futures scenarios (2050 – 2010) in order to evaluate and calibrate the economic sustainability of the adaptation options.**

**More in detail we will implement a cost benefit - analysis between impact costs and the adaptation benefit clean by the costs of the adaptation policies.**

**The involved municipality could be implement a medium long terms strategies (deferred time) using the adaptation plan together with cost benefit analysis**

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# Uncertainties and risk: what decision in an uncertain system?

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***2050 2100 – Local Adaptation Plan preliminary proposal***

**Landslides & Floods**

**Indicator** : Mitigation measure for soil protection;  adoption of non-structural measures in order to reduce exposure and vulnerability, especially trough illegal binding policy;

**Indicator**: implementing of data bases and knowledge;

**Indicator**: Weather forecasting system and early warning systems, weather radar implementation, especially for the forecasting of extremely rapid events and flash floods;

**Indicator**: implementing accurate satellite monitoring and early warning system, as prevention measures for rapid onset of disasters;

**Indicator**:  better understanding of relationship between physical processes Vs climate change in  floods and landslides topics (downscaling future meteorological trends and scenario at local scale);

**Indicator**:  better understanding of anthropogenic system response to occurrence of disasters;

**Indicator**:  better understanding of economic impact of climate change Vs geological and  hydrological  disasters;

**Indicator**: development of appropriate land use planning and management tools (conversion, changes in production, naturalisation and relocation settlements);

**Indicator**: raising thresholds for realisation of new buildings (relatively safe areas today, may be exposed to risks in the future);

**Indicator**: new approaches for designs mitigation works based on scenarios approaches more than  return period;

**Indicator**: hazard and risk maps carried out with more precautionary criteria, taking into account present and future climate scenarios;

# Thank you


ευχαριστώ για την προσοχή σας

gracias por su atención

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