WATER MANAGEMENT SCHOOL
1° International Training Course
URBAN WATER RESOURCES MANAGEMENT for AFRICA
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Hydrogeological Risk Management

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SOGESID

Presentation Outline

0. Overview
1. Physical features of Italy and hydrogeological risk status
2. Legislative evolution of hydrogeological risk management
3. Links beetween Flood Management and Water Management
4. Green Infrastructures

Floods are natural (yet disastrous) phenomena.

Italy has a very long history of disasters caused by floods that not only damage business and properties but also cause loss of human lives.

Florence 1966

Genova 1970

Versilia 1996

Sarno 1998

Piemonte 2000

Puglia 2005

Messina 2009

Sardegna 2013

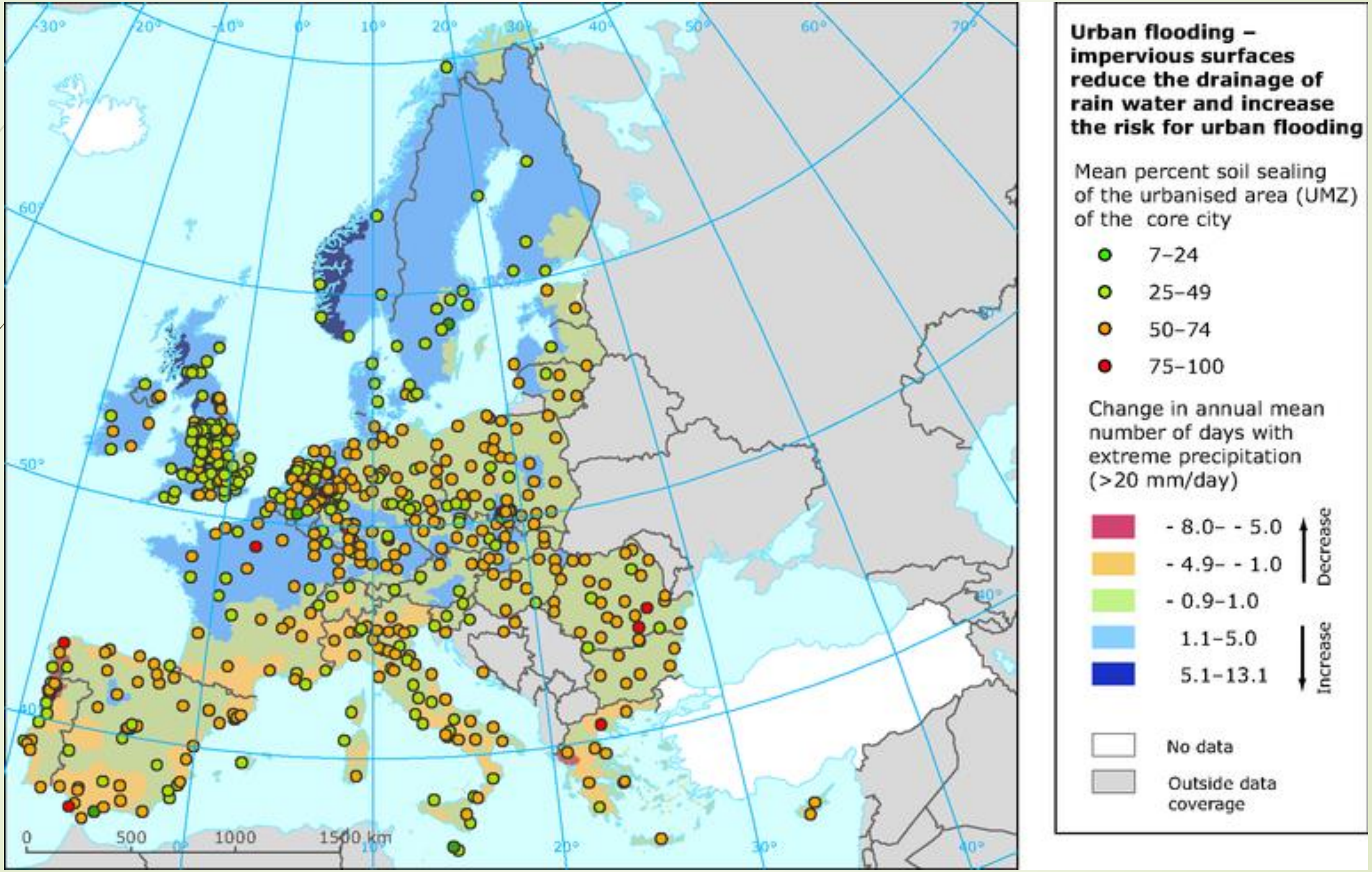
Not just Italy…

Fast moving floods and landslides are ravaging the globe

Overall flood risk

Source: WRI Aqueduct 2014

Hydrogeological Risk – Increasing factors



Source: EEA (2012)

Hydrogeological Risk – Increasing factors

PHYSICAL FACTORS

CLIMATE CHANGE

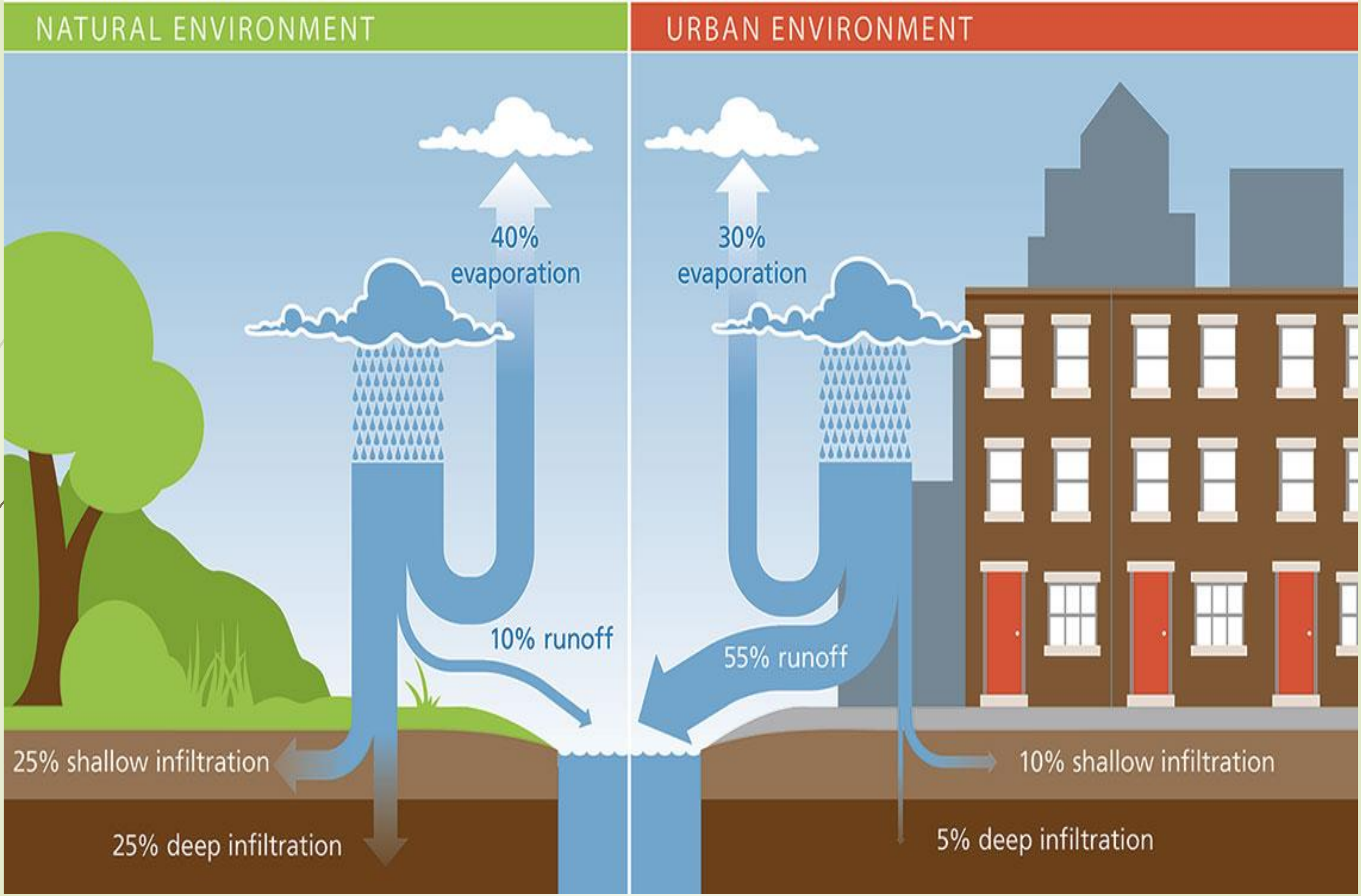
- Extreme events of rainfall
- Reduction of permafrost
- Desertification
- Increasing of rapid landslides, such as *mud* and *debris* flow;
- Decreasing of slow landslides and increasing of dormant landslides;
- Increasing of rock falls and topples;
- Increasing of soil erosion;
- Increasing of *flash floods*.

Hydrogeological Risk – Increasing factors

ANTHROPOGENIC FACTORS

- Impermeable surfaces: roads, excavation, buildings and other concrete structures, typical of urban areas, that do not allow water to permeate back into the soil;
- Bridge constriction: bridges that have been built over rivers can sometimes slow the discharge of water and reduce the river's capacity to hold more water;
- Flood embankments: that are intended to increase the water-holding capacity of rivers can potentially prevent flood water from draining back into the rivers during large precipitation events;
- Deforestation: which is associated with reduction in soil infiltration rates, enhanced drainage and greater sediment generation;
- Climate change: due to an increased level of human-produced greenhouse gases in the atmosphere.

Basically anything that reduces infiltration and increases surface runoff


NATURAL ENVIRONMENT
URBAN ENVIRONMENT
40%
evaporation
30%
evaporation
10% runoff
55% runoff
25% shallow infiltration
25% deep infiltration
10% shallow infiltration
5% deep infiltration

1. Physical features of Italy and hydrogeological risk status

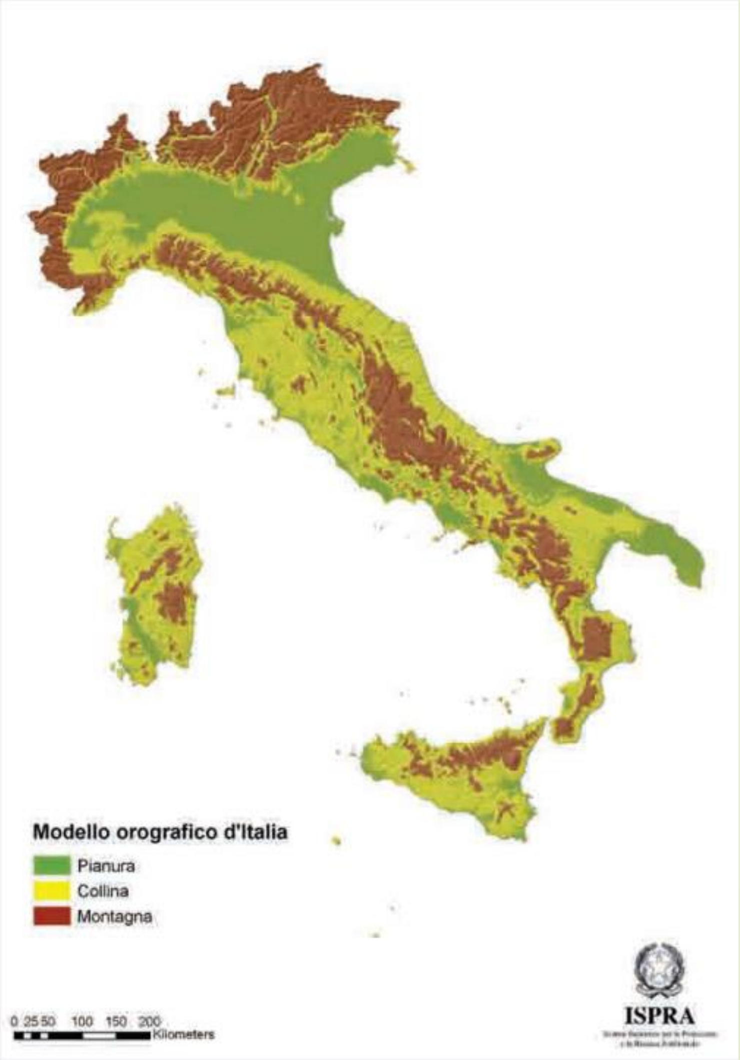
Geographical structure of Italy

Italy has a total surface of about 300.000 sq km and a population of 60 million inhabitants.

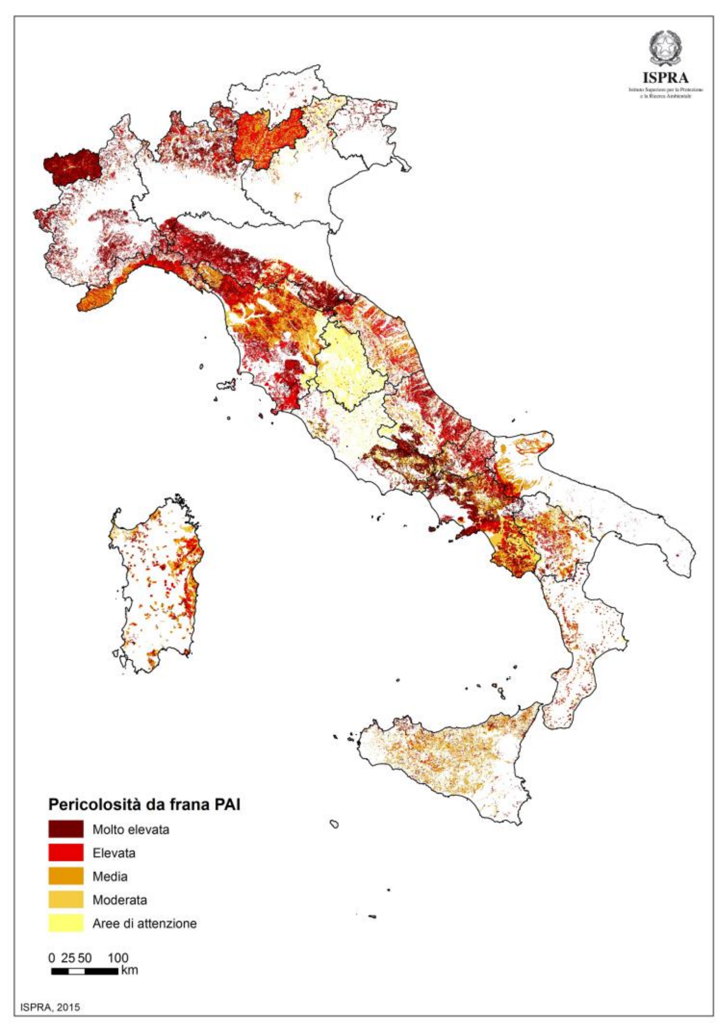
It is represented for 32.5% by mountains, 41.6% by hills, and 23.2% by plains.

About 20.3% of the population lives in urban areas, while 36.5% is in rural areas. The highest share is therefore in intermediate areas, with a percentage 43.1%.

Compared with other EU countries, Italy presents the highest levels of artificial covering of the soil (7.8%).



Landslide hazard in Italy

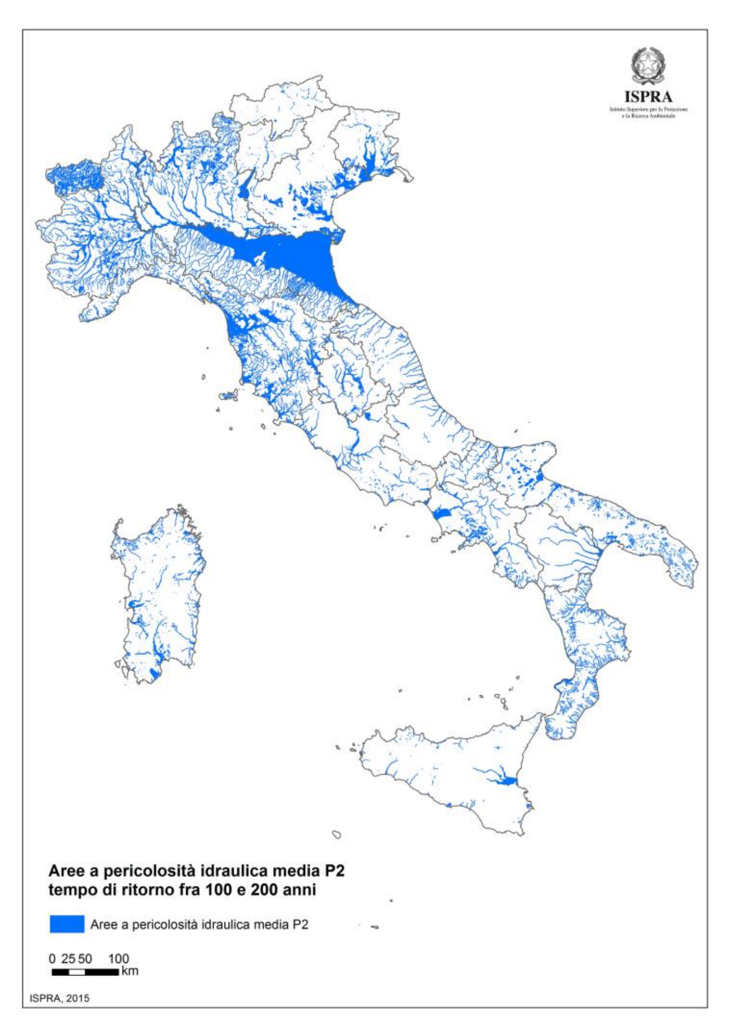


Italy is one of the European countries most affected by landslides, with 614,799 landslides recorded.

In terms of area, the total surface of the areas in danger of landslides and areas of attention in Italy amounted to 58 275 sq km, 19.3% of the national territory.

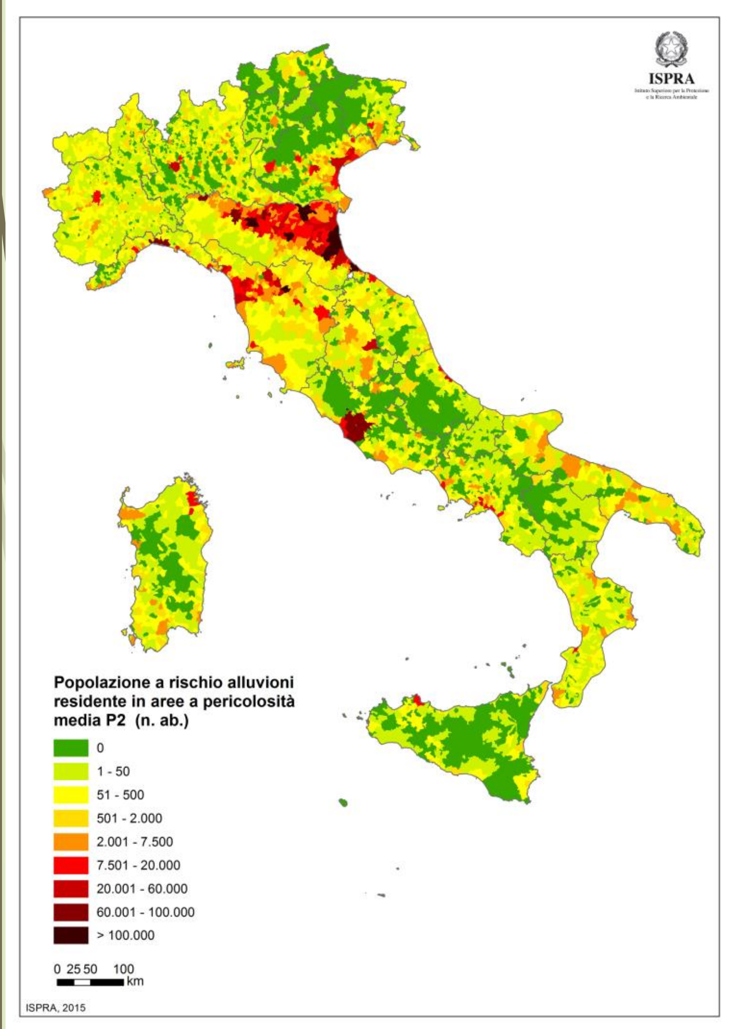
If we consider just zones most prone to landslide risk - high and very high P3 P4 – which are subjected to a restrictive land use, the surface area amount to 23,929 sq km, 7.9% of the national territory.

Flood hazard in Italy

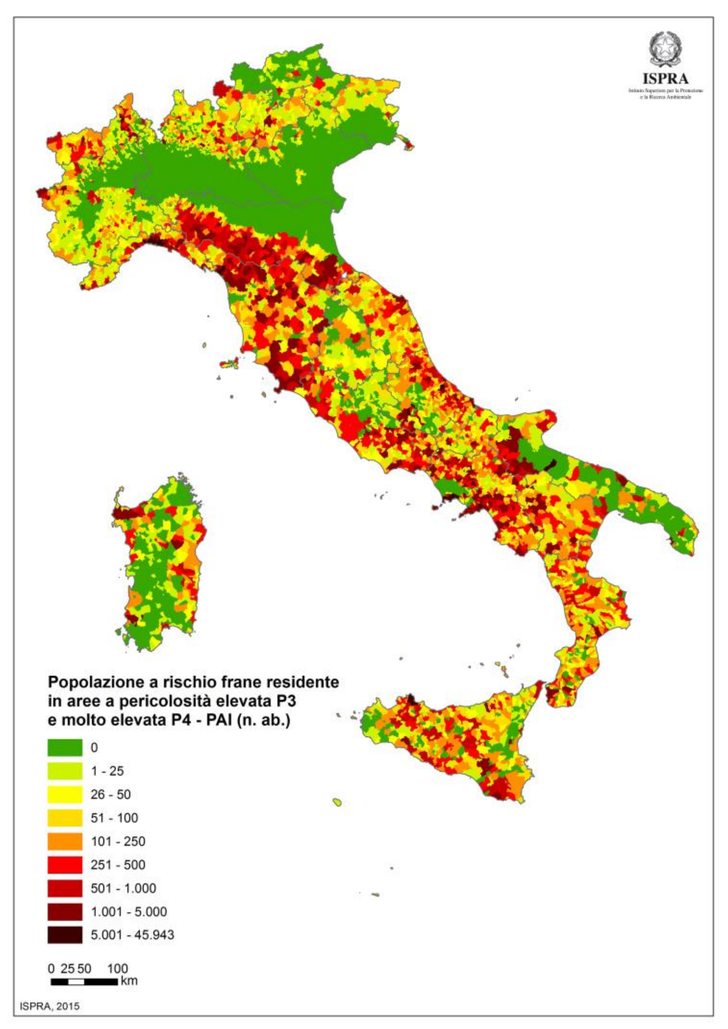


The areas subjected to high hydraulic hazard, amount to 12,218 sq km (4% of the national territory), the medium hazard areas amount to 24,411 sq km (8.1%), those with a low hazard to 32,150 km2 (10.6%).
5 Regions have the highest values of surface with average hydraulic hazard P2. In particular, Emilia-Romagna resulted the Region with thw highest surface at flood risk because of its artificial drainage channels.

Hydrogeological risk in Italy



The number of Italian municipalities at risk landslides and floods amounted to 7,145 municipalities (88.3% of the total). Of these 1,640 have their territory classified as high danger landslide areas P3 and very high danger landslide areas P4,1,607 as areas of medium hydraulic hazard P2, while 3,898 have in their territory both both areas at risk of landslides and floods. Seven Regions (Valle D'Aosta, Liguria, Emilia-Romagna, Tuscany, Marche, Molise and Basilicata) have 100% risk municipalities, such a hazard areas represent 15.8% of the country.



2. Legislative evolution of hydrogeological risk management

Today: floods risk management and water resources protection is a central theme of action of the Italian Government.

Yesterday: Law n.183/1989 laying down “Standards for the organizational and functional order for soil protection”

all-embracing approach to spatial planning

- Ensure soil protection and water preservation, to be extended in other environmental sectors, such as the regulation of mining activities, the natural recovery, civil protection, coastal protection and erosion of sea water.
- Ensure the collaboration and cooperation of all public authorities (the State, regions, provinces and municipalities) in order to carry out programming and planning of actions

Law n.183/1989

In order to guarantee an organic approach to phenomena such as landslides and floods the Law introduce the principle that **soil protection must occur at river basin scale**

Hydrogeological Management should be carried out at the most appropriate physical and geographical scale: this is the *catchment scale*.

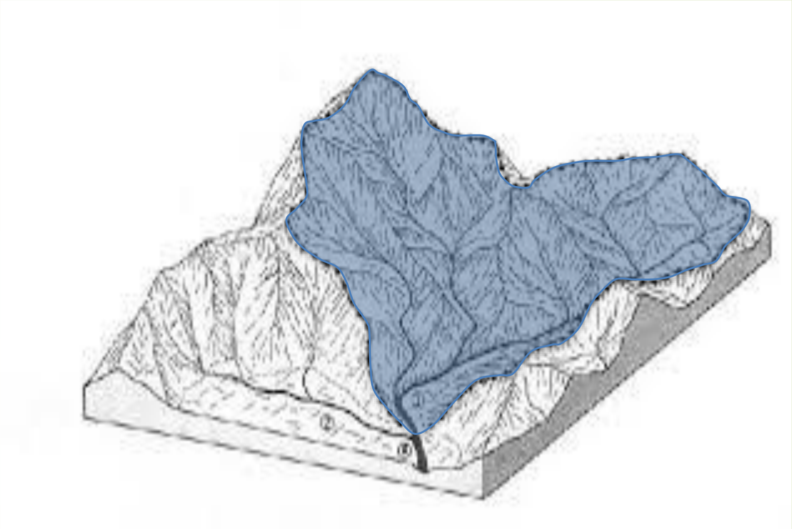
NEW planning scale, **regardless to administrative boundaries**

- Appointed of River Basin Authorities, equipped with overriding power to all the others public authorities, at least with regard to the interventions for soil protection.
- Required the preparation of Basin Plans, that covered all aspects of the physical environment of the river basin of economic development and land use, for the purpose of coordination with the planning instruments, in order to adapt them to the requirements of the Plan

River Basin Approach

River Basin

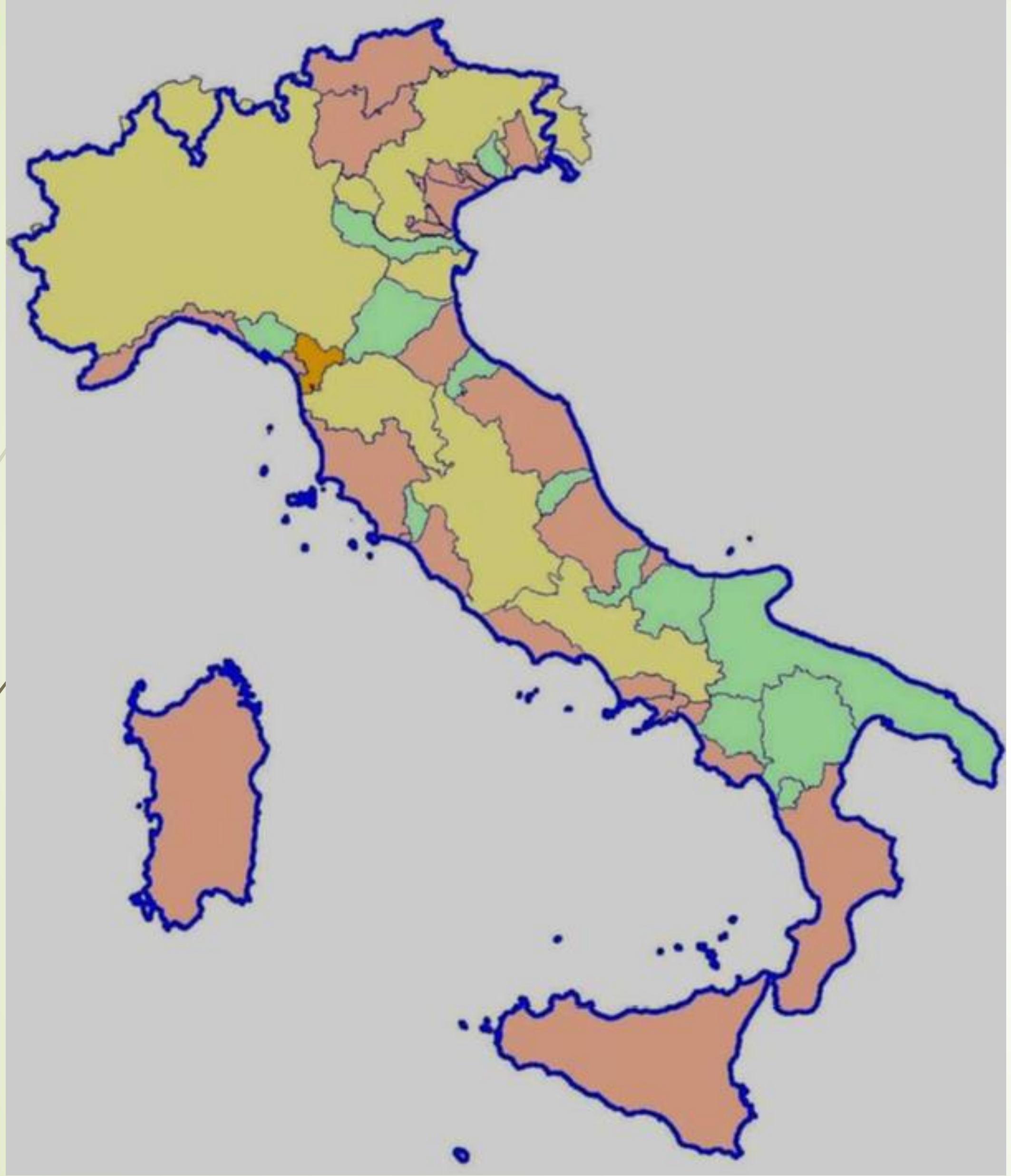
the entire geographical area drained by a river and its tributaries; an area characterized by all runoff being conveyed to the same point (lake or a river confluence) and fall in a water course



River Basin Authority

Territorial unit: one or more neighboring river basins and their associated groundwater and coastal waters, which is the main management unit of the river basins.

Law n.183/1989



THE BASIN AUTHORITIES IN ITALY

- National level (6)
- Pilot (experimental) (1)
- Interregional level (13)
- Regional level (18)

Law n.183/1989 – Key points

- First **comprehensive** discipline concerning soil protection, both in terms of regulatory and organizational point of view
- Soil and aquatic compartments have started to be indissolubly linked, defining an **unique** thematic and management environment
- Every action has to be considered within a **planning** activity.
- The achievement of soil conservation cannot be reached only at local level but within the **river basin**

Sarno 1998

- 300 millimeters of rain in 72 hours
- 160 victims
- 1 municipal fraction erased
- EUR 290 million for protection and risk prevention measures
- EUR 45 million for the recostruction

Law Decree n. 180 of 1998

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.

Extraordinary Plans
All approved by 1999

Identified and defined the zones at highest hydrogeological risk, imposing severe land use restrictions, in order to avoid any further increase of critical situations

Hydrogeological Setting Plans (PAI)
Adopted and approved between 1999-2006

- organize the mapping of the areas exposed to landslides, and floods, classified by level of risk
- provide measures to limit land use in order to not increase the risk level
- identify the main protection actions to reduce or to remove the hydrogeological risk

Hydrogeological Setting Plans (PAI)

HAZARD

is the probability of occurrence of a potentially damaging flood or landslide event.
The hazard expresses the probability that a damaging event of a given severity occurs in a given timeframe (return period Tr).
The return period is statistically defined as an inverse function of the probability, which can be consequently identified by the frequency of the flood event:

$$T_r = \frac{1}{P} \Rightarrow P = \frac{1}{T_r} = f$$

where
P = probability of flood event occurrence
Tr = return period
f = frequency (the number of the occurring events in a given timeframe)

- When for instance we estimate that the return period of a flood event in a given area is 30-50 years, the probability of occurrence of such event is high; consequently this area can be defined a "high hazard area".
- Vice versa, the probability of a flood occurrence with an estimated return period of 300-500 years is low; consequently the area affected can be defined a "low hazard area".

RISK

is the damage expected to people, properties, the environment, infrastructures, industrial activities, considered as the combination of the hazard (probability of a flood/landslide) and of the damage to human health, the environment, the infrastructures and the economic activity associated with a calamitous event.

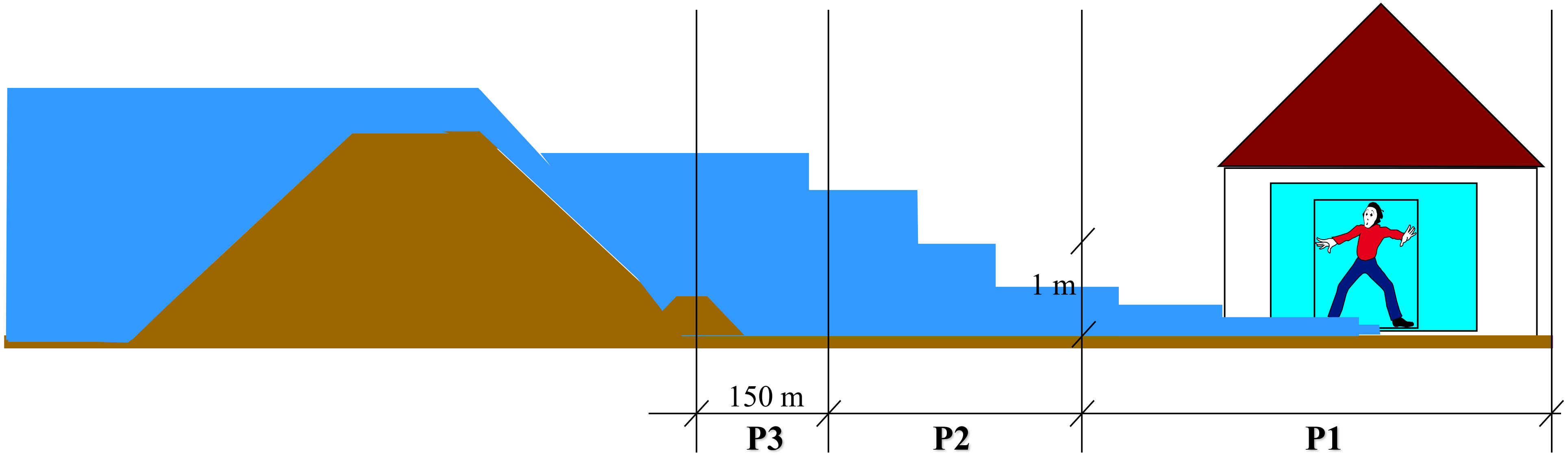
$$R = H \times E \times V = H \times D \qquad \text{(Varnes, 1984)}$$

where
R = risk
H = hazard
E = elements at risk (habitants, public and private properties, that may be affected by the event)
V = vulnerability associated with each type of risk element with the occurrence of the event
D = damage

The analysis of the flood and landsilde risk therefore requires the acquisition of the following data:

- localization of the possible, ongoing or expected phenomena of their type, their respective intensity and probability of occurrence;
- identification of all the elements at risk present in the area and their grouping in homogeneous categories;
- evaluation of the degree of loss produced by each phenomenon of given intensity on each element at risk.

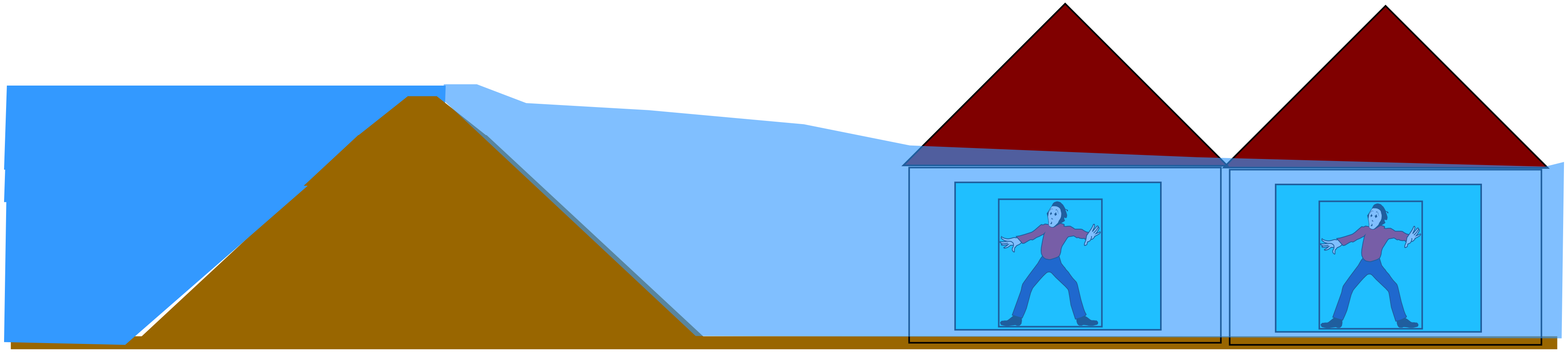
HAZARD/RISK MAPS – RISK CLASSES



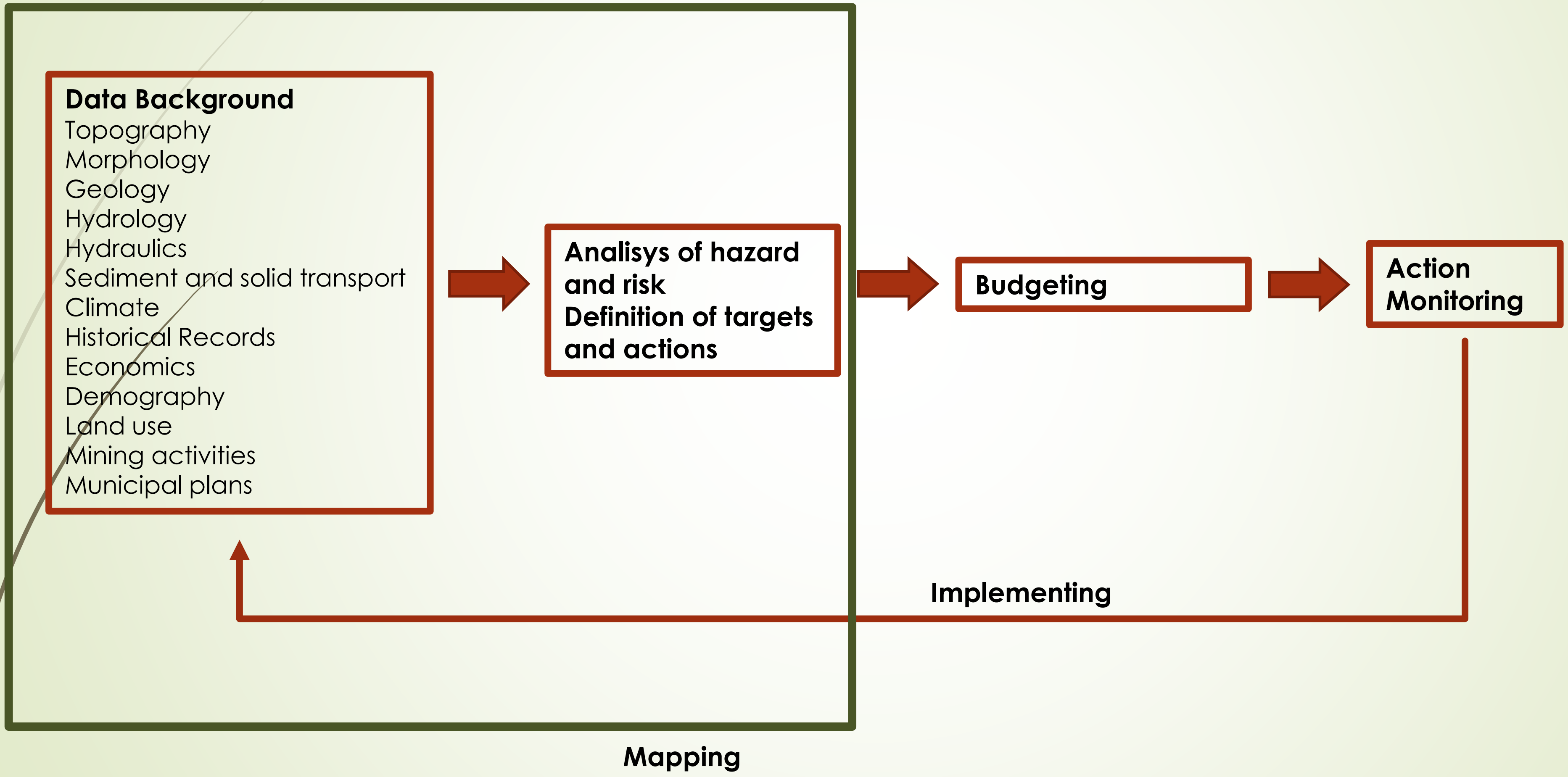
CLASSE DI RISCHIO	EFFETTI	MISURE DI SALVAGUARDIA: INTERVENTI PERMESSI
P4	perdite vite umane gravi danni edifici e patr. amb. distruzione attività economiche	Demolizioni senza ricostruzioni. Manutenzione ordinaria. Manutenz. ord. e str. OO.PP. Opere sistemaz. frane.
P3	problemi incolumità persone danni edifici e patr. amb. interruzzione attività economiche	Tutti i precedenti. Ristrutturazi. edilizia senza aumento vol/sup e rischio. Ampliamenti per adeguamenti igienico sanitari.
P2	danni minori edifici e funzionalità attività economiche danni patr. amb.	Completamento previsioni urbanistiche, previa compatibilità idrogeologica. Escluse nuove espansioni urbanistiche.
P1	danni sociali, economici e patr. amb. (marginali)	Ricordarsi che tali aree sono andate sommerse. Fare le neces-sarie verifiche prima di utilizzare quelle aree.

FLOOD SAFETY paradox

$$R = H \times E \times V$$



Hydrogeological Setting Plans (PAI)



Hydrogeological Setting Plans (PAI) - MAPS

Hazard
Mapped for different scenarios based on different return periods

Build on data derived from hydraulic modeling and, where available, on historical records

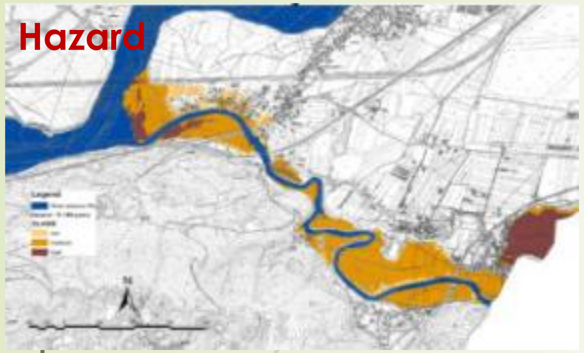
→ **Elements at risk From numerical cartography**

→ **Damage assessment for different scenarios**

→ **Risk Mapping**

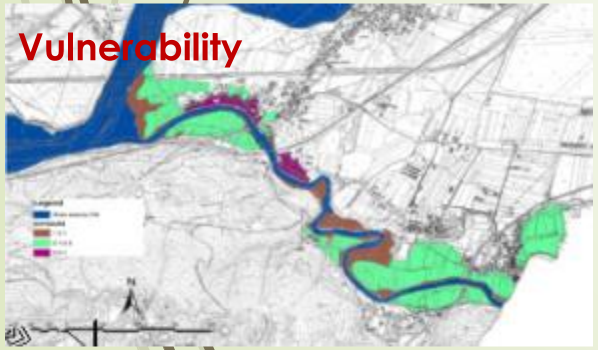
The current state of scientific knowledge and of the available databases allows to apply this schema only for a few areas

Hydrogeological Setting Plans (PAI) - MAPS



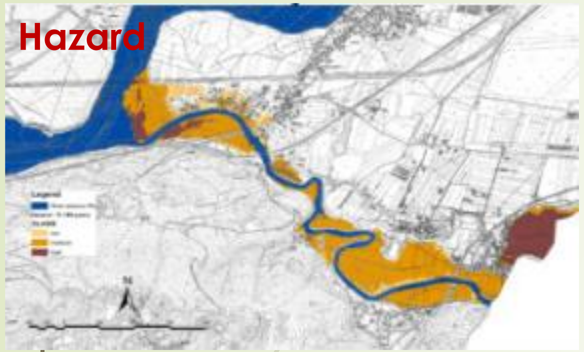
cover the geographical areas which have been flooded, which could be flooded with an indication of the probability, taking into account the existing flood defence structures.
These areas are shown according to different scenarios, related to the frequence of the flood event.

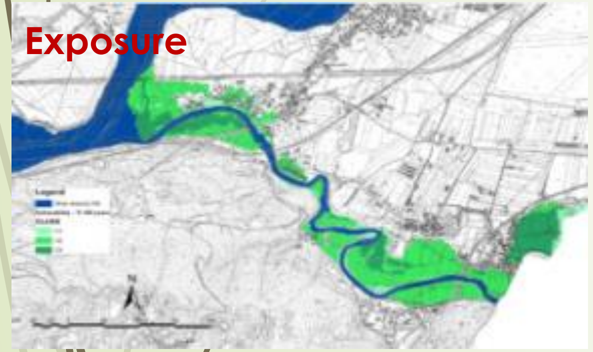
shows the properties identified within the “flood hazard areas”, as the properties exposed to flooding, since potentially affected by the event

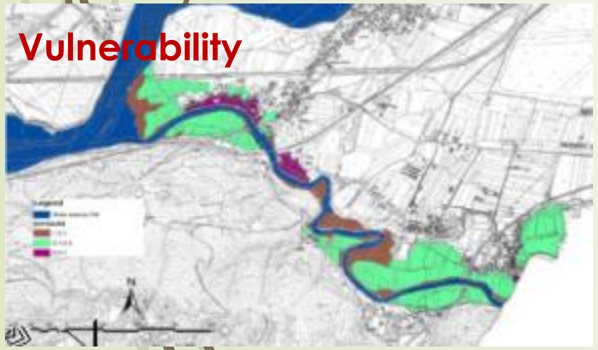


shows the capability of the properties to withstand the forces due to the event

Hydrogeological Setting Plans (PAI) - MAPS





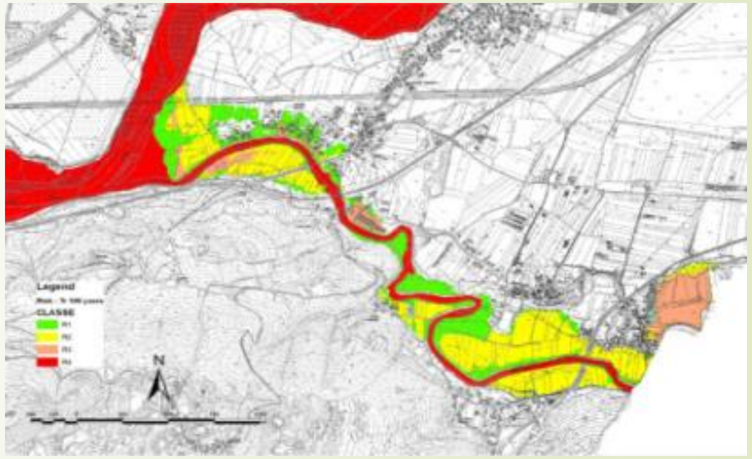


$$R = H \times E \times V$$

Risk Classes		Hazard Classes		
		P3	P2	P1
Damage classes	D4	R4	R3	R2
	D3	R3	R3	R2
	D2	R2	R2	R1
	D1	R1	R1	R1

Risk Intervals	Description	Risk Category
0.1 < R ≤ 0.2	**Moderate Risk** for which relative social economic and environmental damagese are negligible or nulls	R1
0.2 < R ≤ 0.5	**Medium Risk** for which are possible minor damage to buildings, infrastructures and environmental heritage that do not compromise people safety, building use and economic activities funcionality	R2
0.5 < R ≤ 9	**High Risk** for which are possible problems for people safety, functional damages to buildings and infrastructures, interruption of socio-economic activities and damages to environmental heritage	R3
0.9 < R ≤ 1	**Very High Risk** for which there are possible loss of human lives and serious injuries to people, serious damages to buildings, infrastructures and environmental heritage and the destruction of socio economic activities	R4

Flood Risk Map



Hydrogeological Setting Plans (PAI) – BUDGETING

The attention level and the priority actions are identified on the basis of the hazard degree determining the degree of risk.

Once the actions are prioritized according to the degree of risk is it possible to schedule allocation of financial available resources

Two types of actions:

- Structural measures: intereventions that requiers the application of engineering techniques to achieve hazard resistance and resilience (e.g. dams, flood levees, networks of micropiles, soil nailing)
- Non-structural measures: land-use planning laws and their enforcement through the implementing rules, which are a consistent part of the PAIs

European Regulations – Water Framework Directive

2000/60/EC

- Enhance the status and prevent further deterioration of aquatic ecosystems and, with regard to their water needs,terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems
- Promote the sustainable use of water use based on a long-term protection of available water resource
- Reduce pollution of water, especially by ‘priority substance’ and ‘priority hazardous substances’
- Ensure progressive reduction of groundwater pollution
- Contribute to mitigating the effects of floods and droughts

Legislative Decree n. 152 of 2006

European Regulations – Flood Directive

2007/60/EC

- establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community
- establish a process for producing flood hazard maps and flood risk maps in order to address the flood risk
- in the flood risk management plans address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin.

Legislative Decree n. 49 of 23 February 2010

Aim of the Directives

SIMPLIFY

Reduction of the of the actors involved in the decision making process

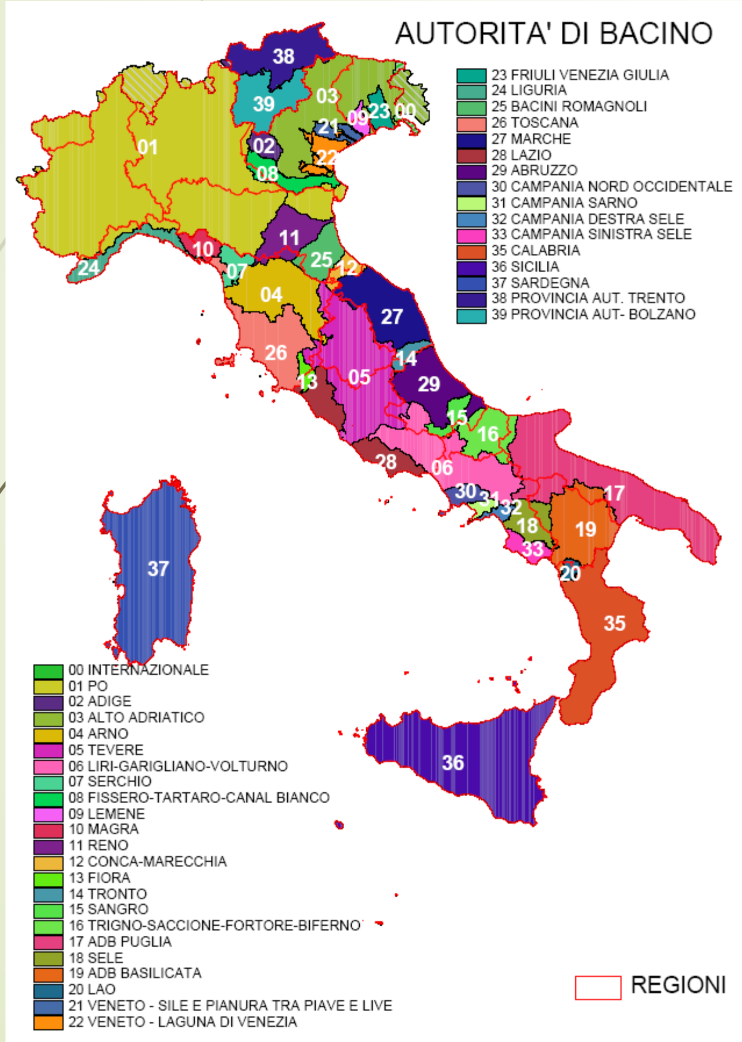
Rationalization of competences
WHO (River Basin Districts)
DOES (planning and programming)
WHAT (River Basin Management Plan and Flood Risk Management Plan)

Define the duties

- Ministry of Environment and Land Protection: coordinates, monitor and supports the implementation of the Directives
- River Basin Districts: plan
- Regions: implement the plans

Aim of the Directives

1989 → 2006



From River Basin Authorities to River Basin Districts

Aim of the Directives

Directs and Coordinates
(ex ante)

MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE

Monitors and Controls
(ex post)

River Basin Districts
Planning
(public non-economic entity)

Regions
Implementing

Flood Directive

The purpose of Directive 2007/60 / EC is to manage and reduce flood risk.
The instrument is the Flood Risk Management Plan (FRMP):

Risk Management (FRMP)	≠	**Full removal of risk (PAI)**

- new technical-operational tool through which the prevention, protection, preparation and response and recovery measures aimed at managing the risk are planned
- constitutes a territorial and functional section of the District Basin Plan
- represents the know-how, defines the objectives and the planning of the interventions, provides addresses not to increase the hydraulic risk and mitigate and "manage" the existing risk.

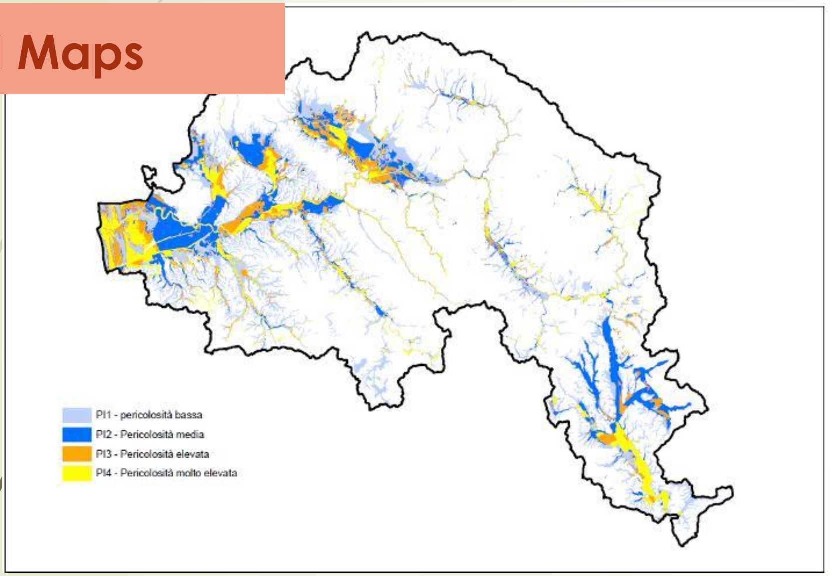
Flood Directive - Targets

- Environment:…
- Human Health:…
- Cultural heritage:…
- Economic Activities:…

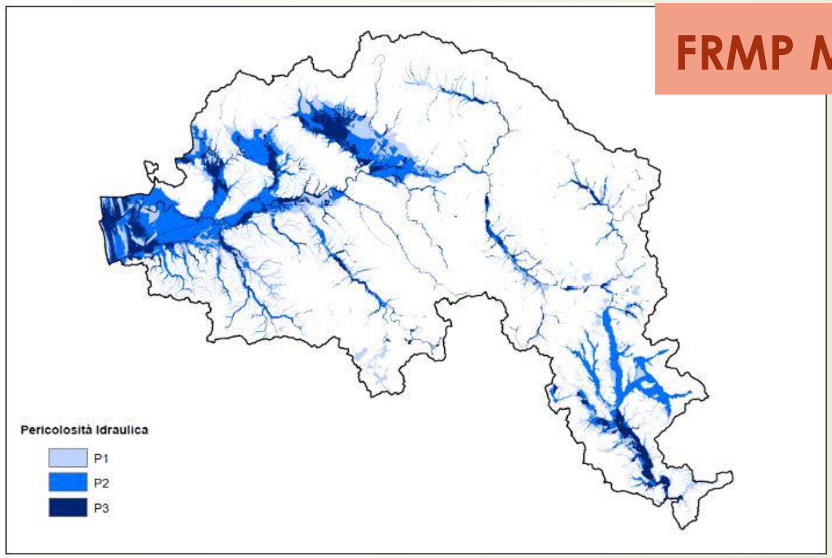
How do we manage risk? Through Maps

Italian PAI maps meet the requirements of the Directive as “preliminary flood risk assessment”

PAI Maps

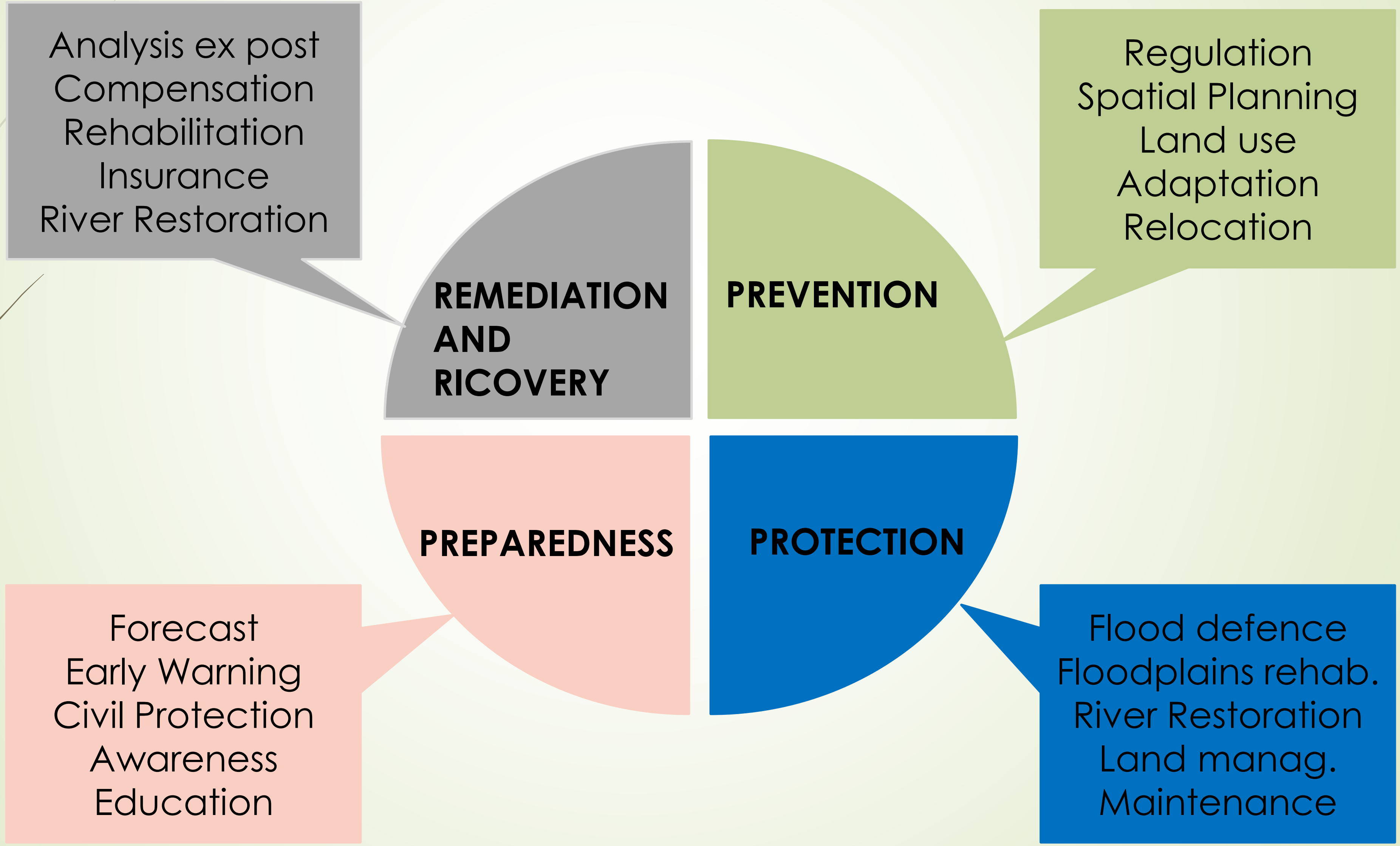


FRMP Maps



Coherence between the maps of the PAI and those of the FRMP, review of the actions of the plan, revision, simplification and integration of the rules and procedures.

How do we manage risk?
Through Measures



3. Links beetween Flood Management and Water Management

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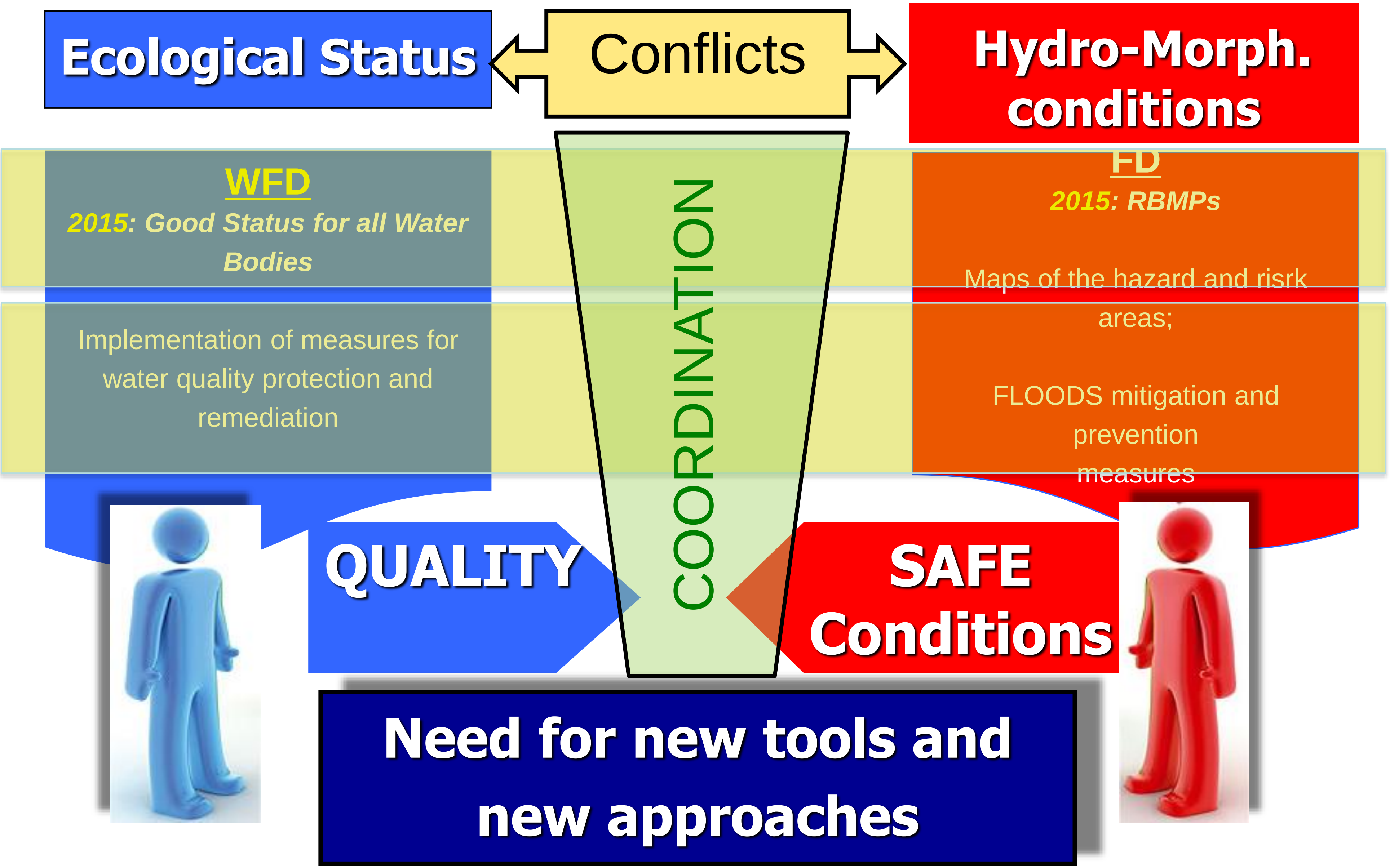
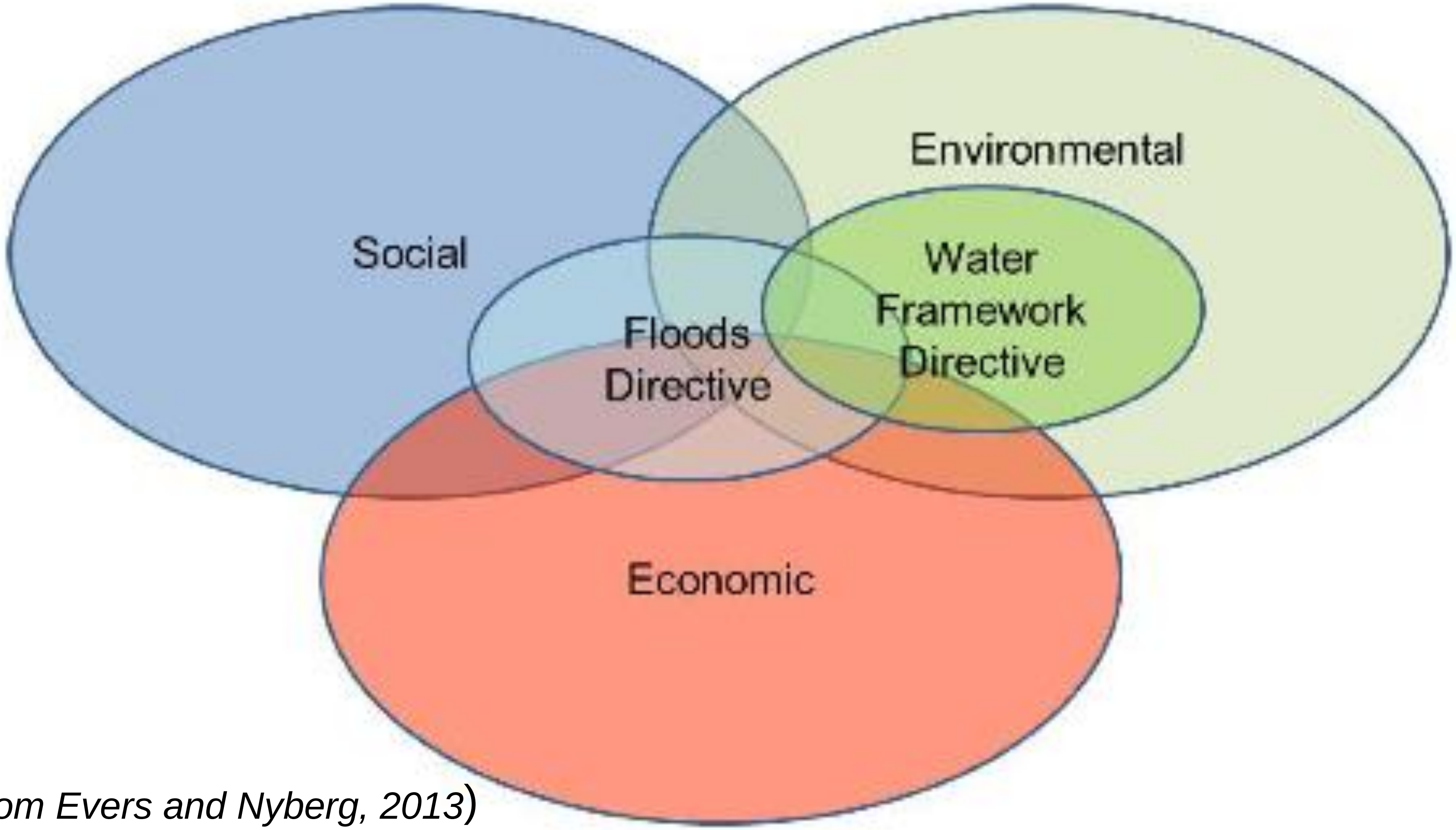
MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE



Sustainability addressed by the FD and WFD and their overlapping areas

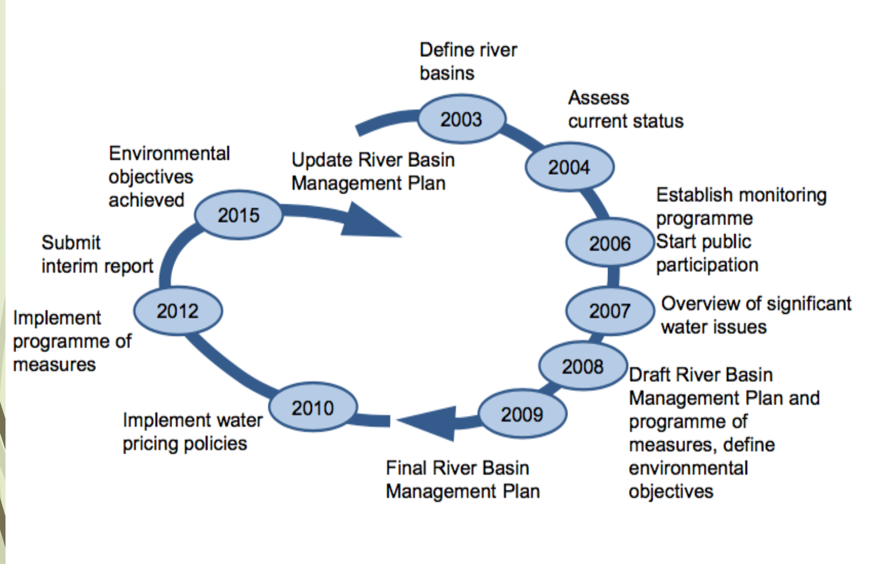


(Source: Adapted from Evers and Nyberg, 2013)

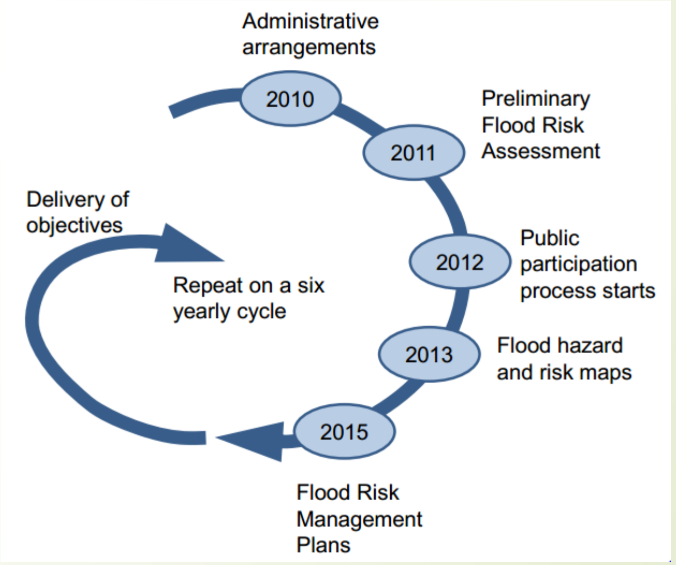
European Regulations – WFD and FD

Both Directives address for an integrated approach to river basin management, through a collaborative governance agenda able to conjugate multi-objectives, multi-levels and multi-stakeholders decision making processes and to achieve jointly the objectives of environmental enhancement and flood risk management.

WFD planning cycle



FD planning cycle

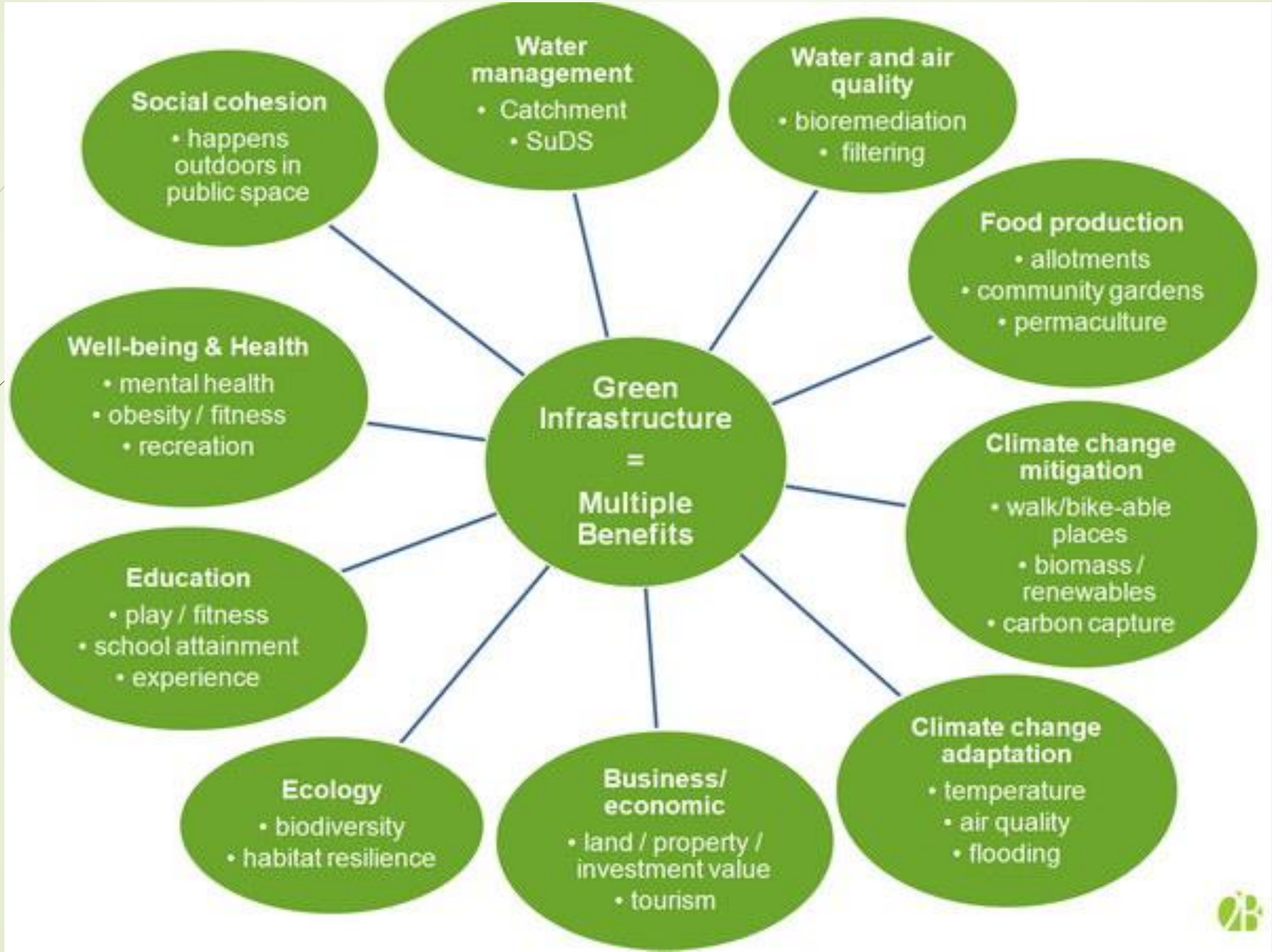


4. Green Infrastructures

Green Infrastructures = Nature Based Solutions

- To understand from nature and to mimic **natural functions** to react to extreme events driven by CC;
- **Resilience** of global energy and food systems;
- **Groundwater** represents a resilient system, providing fundamental contribution for aquatic ecosystems functionality;
- "**Green" and "Blue" solutions**, complementary to "Grey" ones;
- **Multifunctionality**: the added value of nature based solutions;
- To work at the **appropriate scale** (global/local, RBD, Water Body), **international cooperation**;
- Need for a shift in **planners mentality**;
- Exploring trade-offs with **economic and social goals** and **PES** understanding;
- Need to **monitor**, evaluate and disseminate the benefits in terms of ES and to provide operational tools to all stakeholders;
- Public participation, education and **awareness** on the effects of CC on the water cycle;
- Technical (monitoring) and legal tools (national and international rules) to support **conflicts management**;
- **River Restoration**: to give back space for the river to perform its natural functions (wise use of floodplains, sediment management, etc..)

Multifunctionality



RETENTION
DETENTION
BASF SITE
CONSTRUCTED WETLANDS
PINO SITE
SUBSURFACE STORAGE
BLOCK 12 SITE
GREEN ROOFS
RAINWATER HARVESTING
INFILTRATION
BIOSWALES
STORMWATER PLANTERS
Google earth

Sustainable Drainage Systems
(SuDS).

The idea behind SuDS is to try to replicate natural systems that use cost effective solutions with low environmental impact to drain away dirty and surface water run-off through collection, storage, and cleaning before allowing it to be released slowly back into the environment, such as into water courses.

Natural Water Retention Measures (NWRM)

Natural Water Retention Measures are multi-functional measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes. […]

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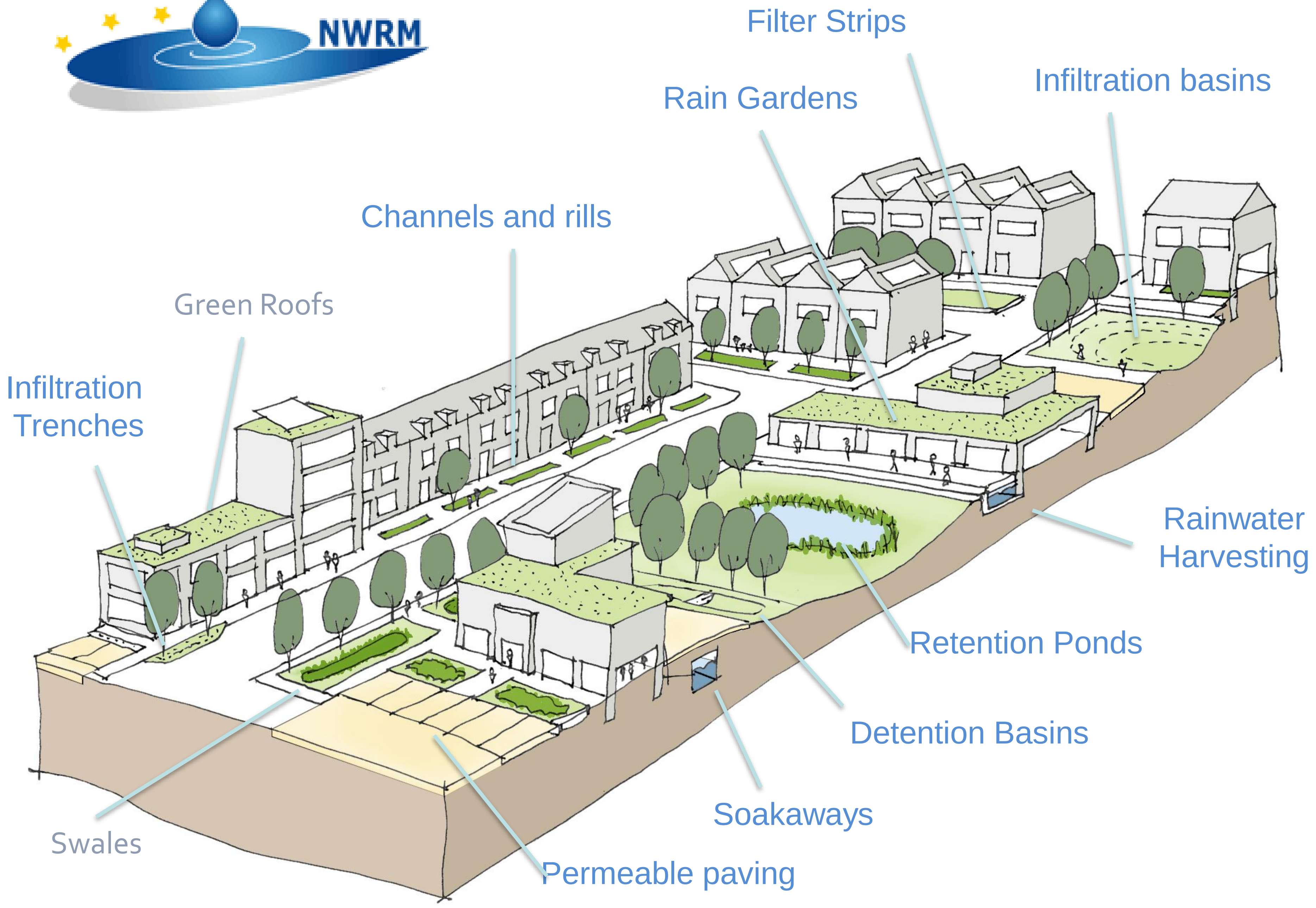
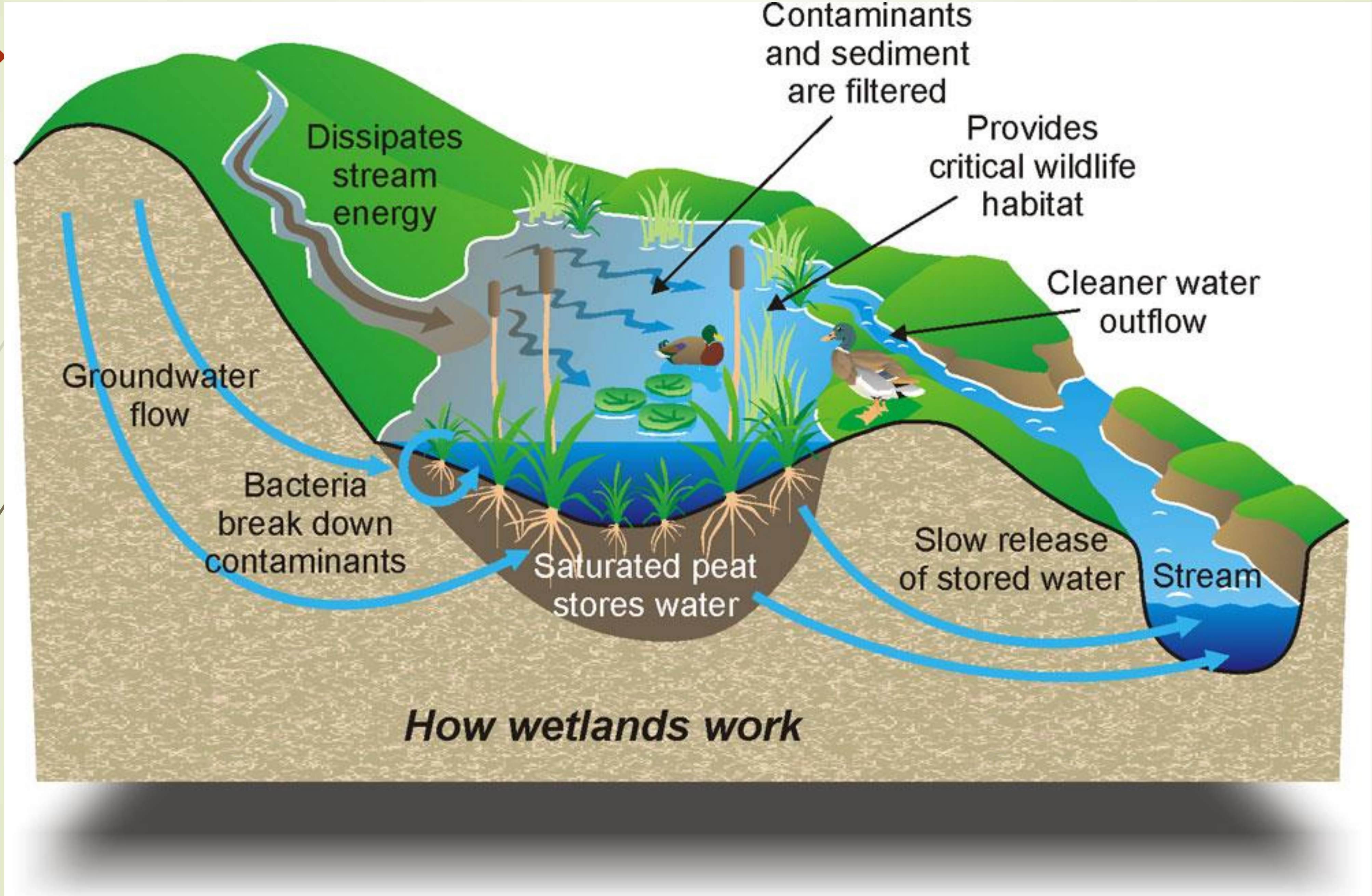
NWRM

DELL'AMBIENTE
DEL TERRITORIO E DEL MARE

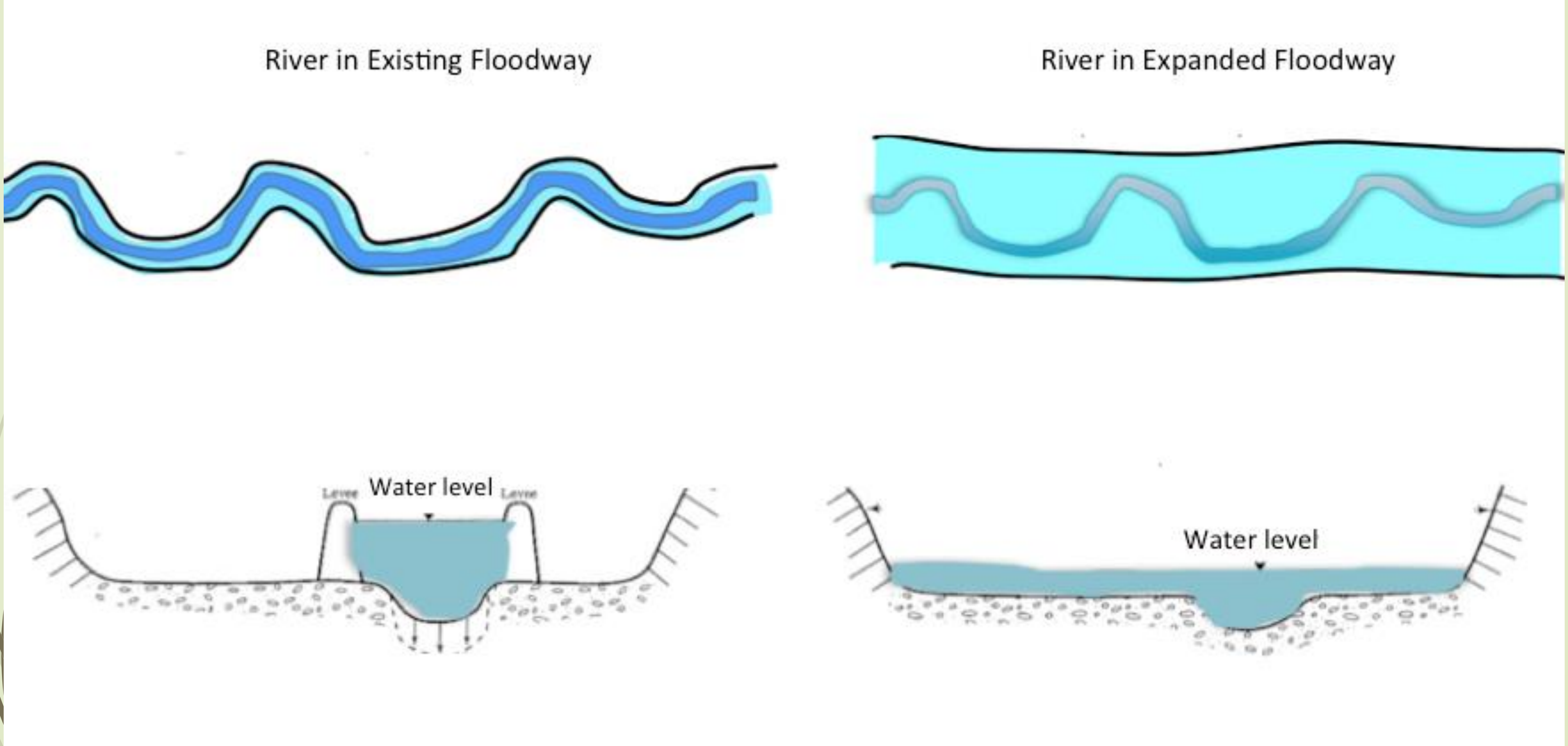



Contaminants
and sediment
are filtered
Dissipates
stream
energy
Provides
critical wildlife
habitat
Cleaner water
outflow
Groundwater
flow
Bacteria
break down
contaminants
Saturated peat
stores water
Slow release
of stored water
Stream
How wetlands work

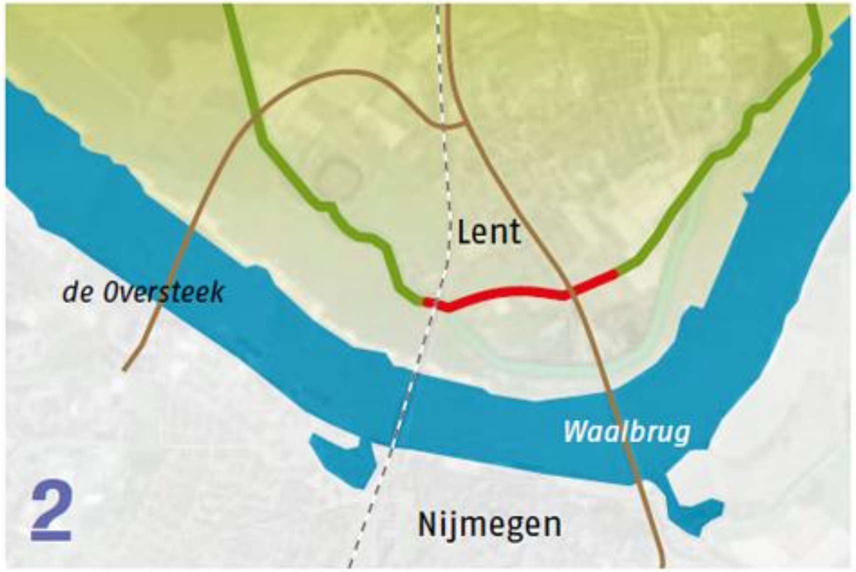
Usain Bolt
100 mt (9'' 58)

Ashton Eaton
Decathlon World Champion
(10'' 21)

Room for the River



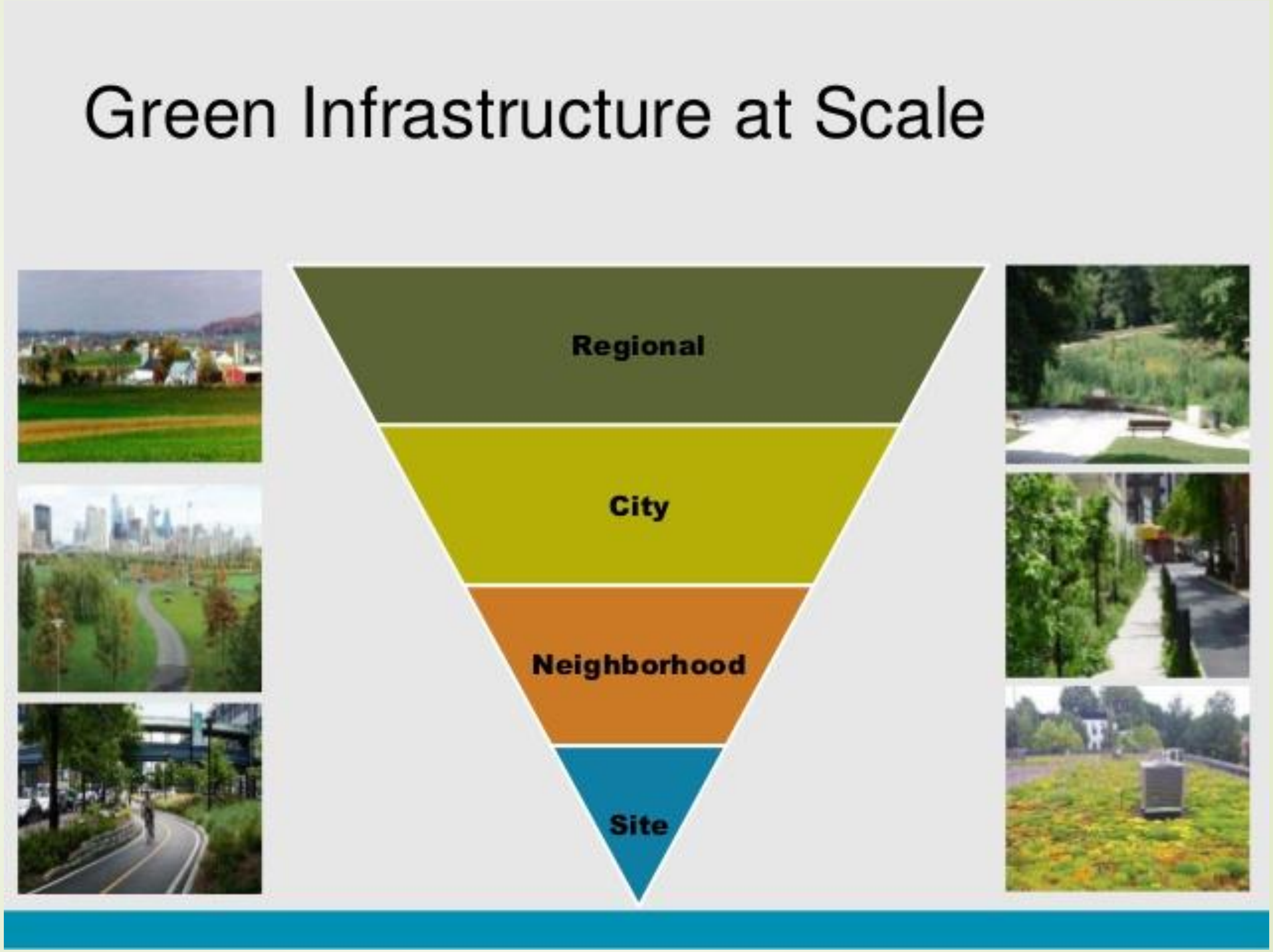
The initial situation with the existing dike.



The dike was moved 350 metres inland.

An ancillary channel is to be dug in order to give the river more room. This will create an elongated island.

Bridges across the ancillary channel.


Green Infrastructure at Scale
Regional
City
Neighborhood
Site