WES-BCA
Water and Environment Support - Biodiversity and Climate Action
in the Neighbourhood South region

Funded by the European Union

WES-BCA Regional Training & Study Tour

"Adaptation measures for flood and storm water management"

21-24 April 2026, Nice, France

WES-BCA
Regional Training and Study Tour

Adaptation Measures for flood and storm water management

Activity Number: C1_REG/ST-6

WES-BCA
Water and Environment Support - Biodiversity and Climate Action in the Neighbourhood South region

21 April 2026 at 09:30

Sheraton Hotel Nice

Overview of flood and stormwater management practices and planning approaches

Presented by:
Dr Ioanna ZALACHORI, Senior Flood Expert, LDK Consultants S.A.

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Floods

Kerala (India), August 2019
Source: BBC news

Floods in numbers

According to Yang et al. (2023) based on observation of 761 communities worldwide:

- flood events make up the **43%** of all disasters,
- **23%** of people are directly exposed to over 0.15m every decade.

Between **1970 and 2019**, water-related hazards accounted for **50%** of all disasters and **45%** of all reported deaths.

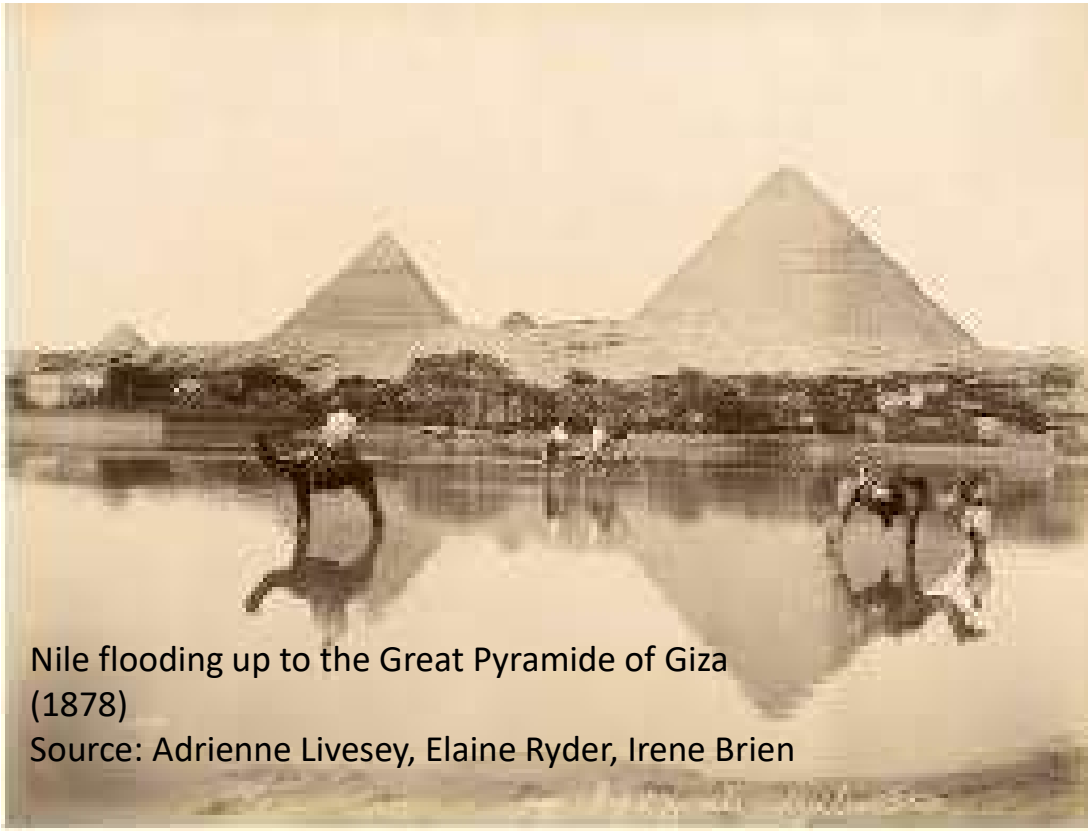
Since 2000, the number of recorded flood-related disasters has **risen by 134%** compared with the two previous decades.

Riverine floods are the costliest with an average annual losses of **USD 388.4 billion**. (source: UNDRR).

Floods in the Mediterranean Basin

Floods through history

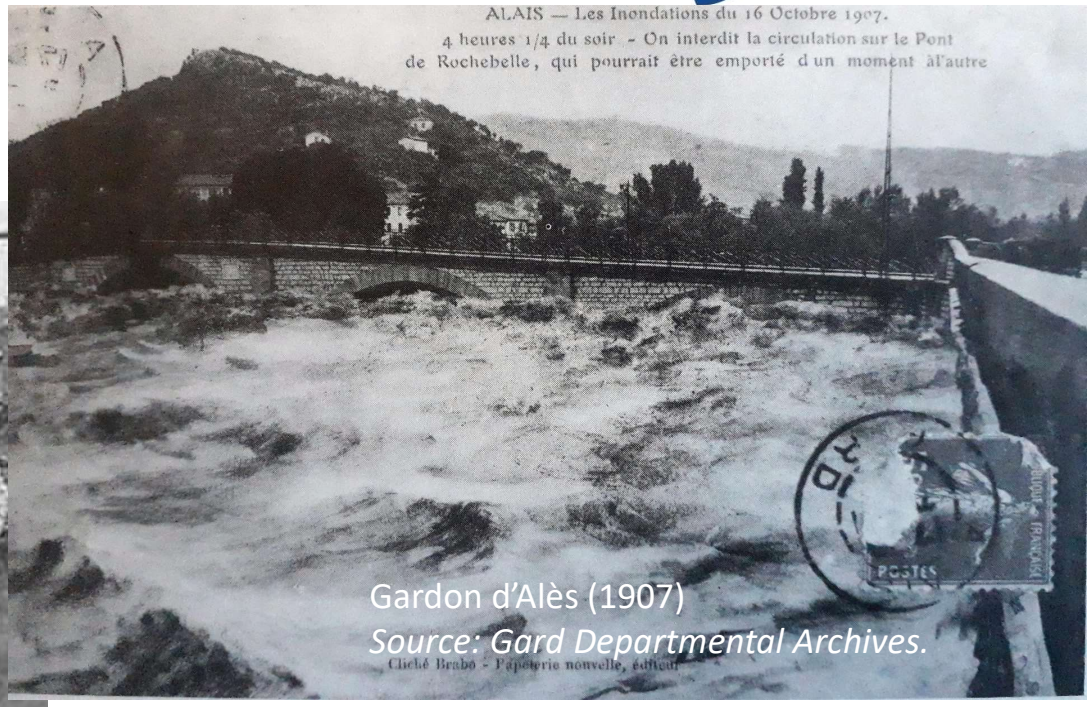
Flood in Valencia (1957)
Source: PereDrak's Valencia Slideshow



Nile flooding up to the Great Pyramide of Giza (1878)
Source: Adrienne Livesey, Elaine Ryder, Irene Brien

Floods through history

Pinios flooding, Larisa (Greece)
23 Οκτωβρίου 1883



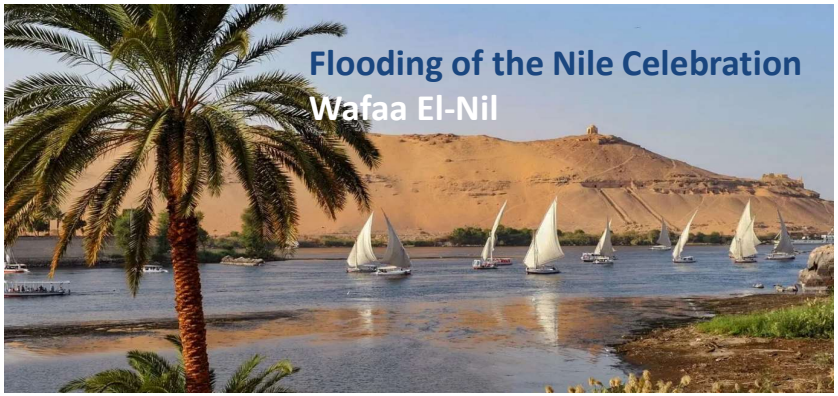
Gardon d'Alès (1907)
Source: Gard Departmental Archives.

The beneficial role of floods

The annual flooding of the Nile (or ***Akhet***), was the heartbeat of civilization in Egypt for thousands of years.

Around 2200 BC, **centralized government in Egypt collapsed** due to a prolonged reduction in Nile flood discharge.

During the Ptolemaic period (c. 300 BCE), **failure of the Nile to flood** on schedule **led to severe socioeconomic strain and revolts**.



The beneficial role of floods

Recharging water sources:
Inundation of the flood plains helps:

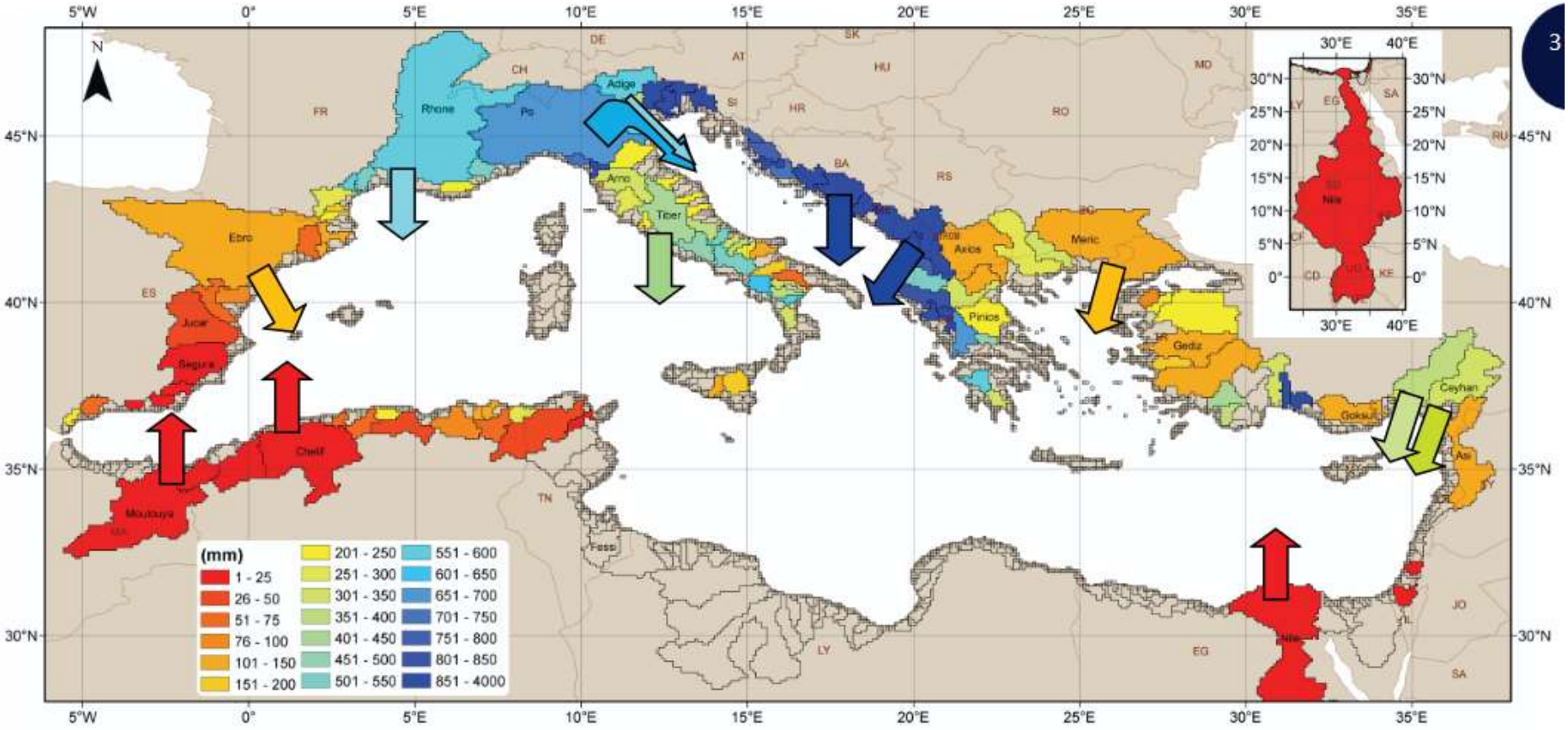
- ❑ recharge the groundwater
- ❑ restock reservoirs, ponds, etc.

Agriculture:
Floodwaters carry nutrients and sediments, enriching the soil.

Rejuvenation of the river ecosystem:
Help maintain ecological biodiversity in rivers and flood plains.


Rice Paddies
Source: Sue/Flickr

Major rivers in the Mediterranean basin



Source: NEP/MAP Report, (2015)

Population concentration in the Mediterranean basin

Population density and urban centres in the Mediterranean basin

Population density, 2008
Inhabitants per square kilometre

- Less than 5
- 5 to 25
- 25 to 50
- 50 to 100
- 100 to 250
- More than 250

Population in urban centres, 2010
Millions

10
3
1

Mediterranean catchment area

Sources: personal communication with Blue Plan, data collected from national sources, 2011; UNDESA, Population Division, online database, accessed in August 2011.

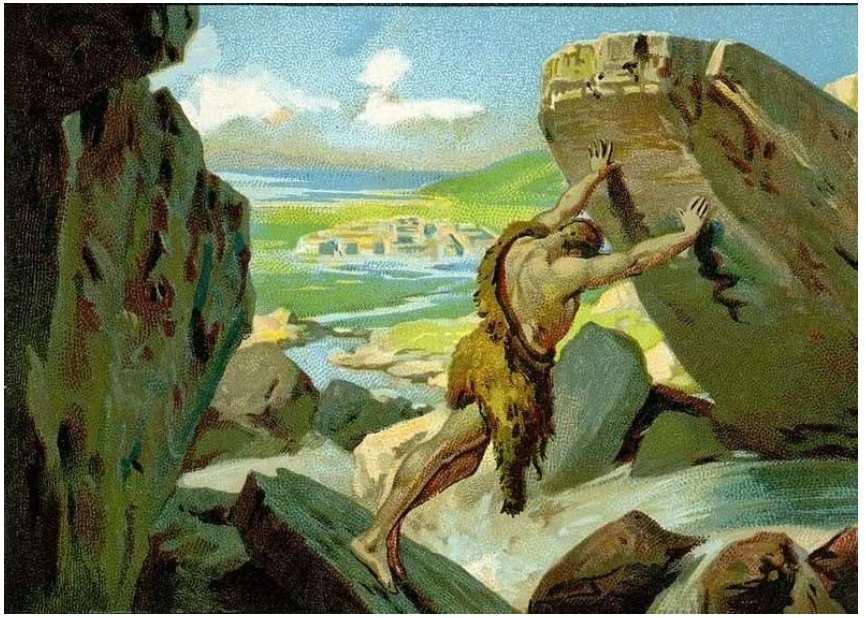
How to deal with floods

From antiquity people realized:

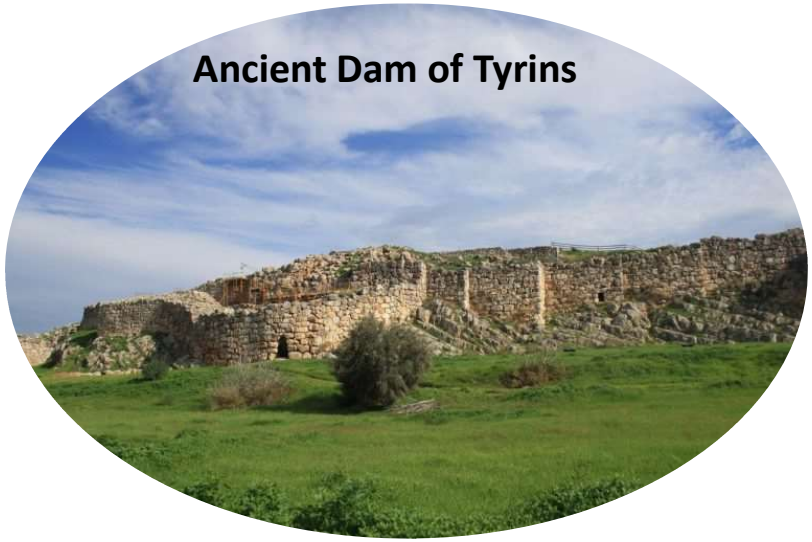
- ❑ the **necessity to be installed near water bodies**,
- ❑ that human ingenuity can (try to) **control water**.

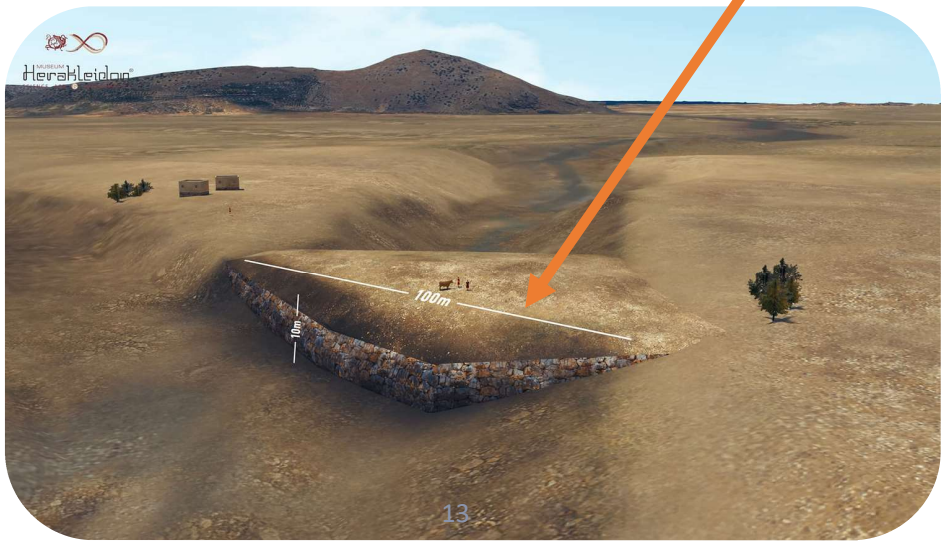
This was summarized in a myth:
5th Herculean task was **to clean the Augean Stables in a single day**!

A mythical reference to the actual dam of Tiryns



How to deal with floods





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How to deal with floods

Recent years: facts

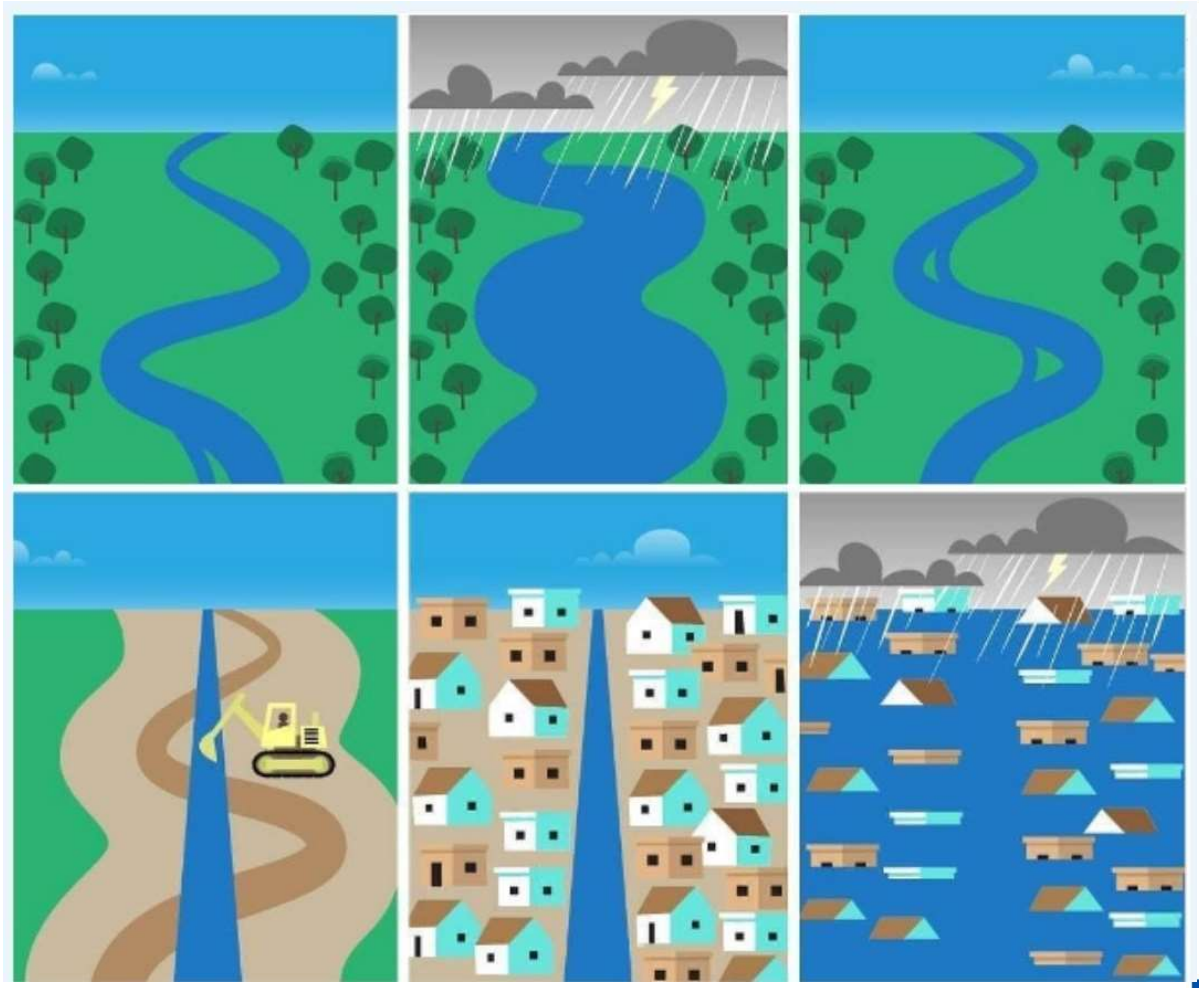
Rising urbanisation

↓

Flood plains invasion

↓

Increased flooding risk



Recent years: facts

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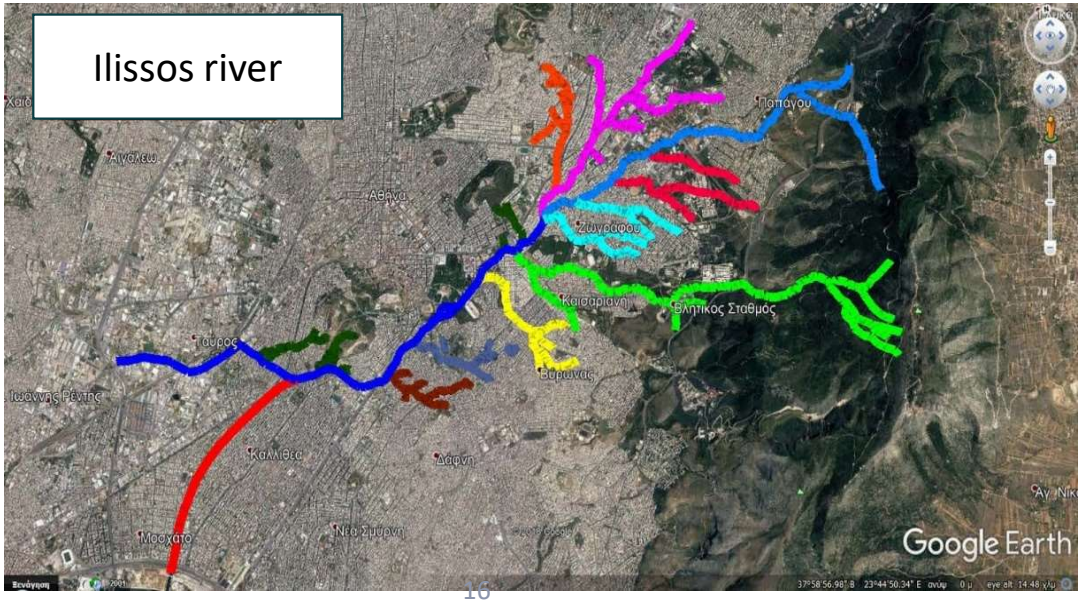
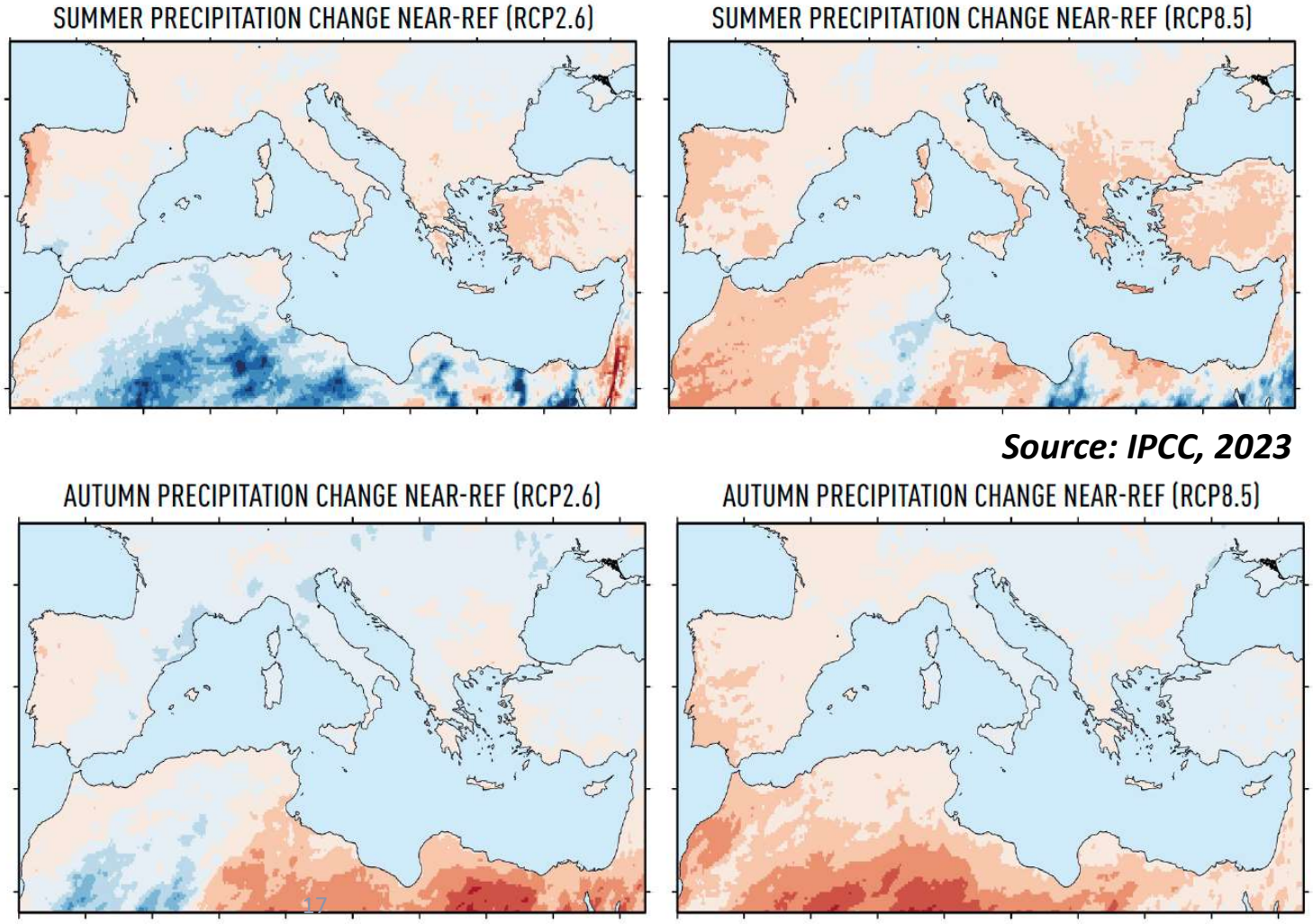


Recent years: facts

Climate change

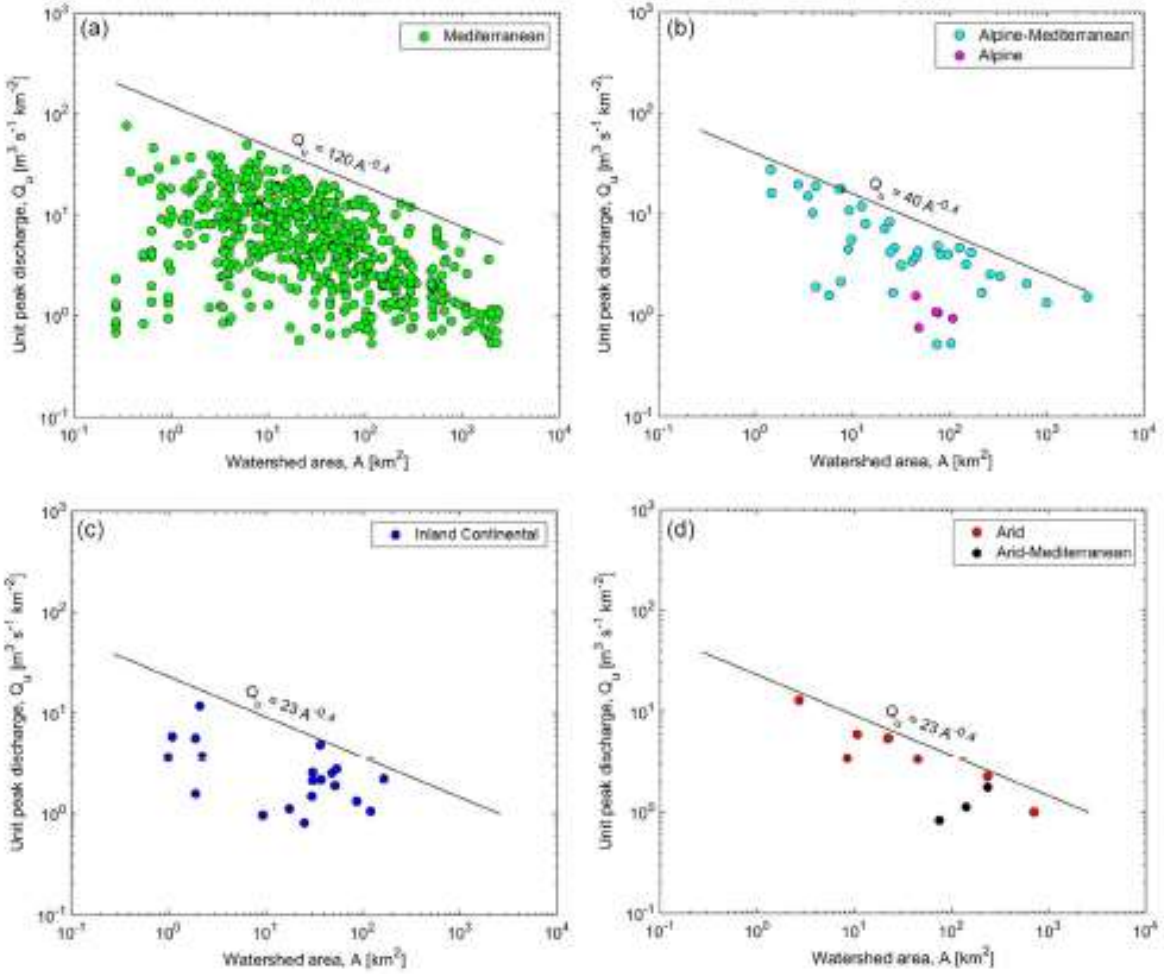
Reduction in rainfall (annually)

Increase in storm intensity (flash floods)



Source: IPCC, 2023

Climate change through flash floods



(Source: Amponsah et al., 2018)

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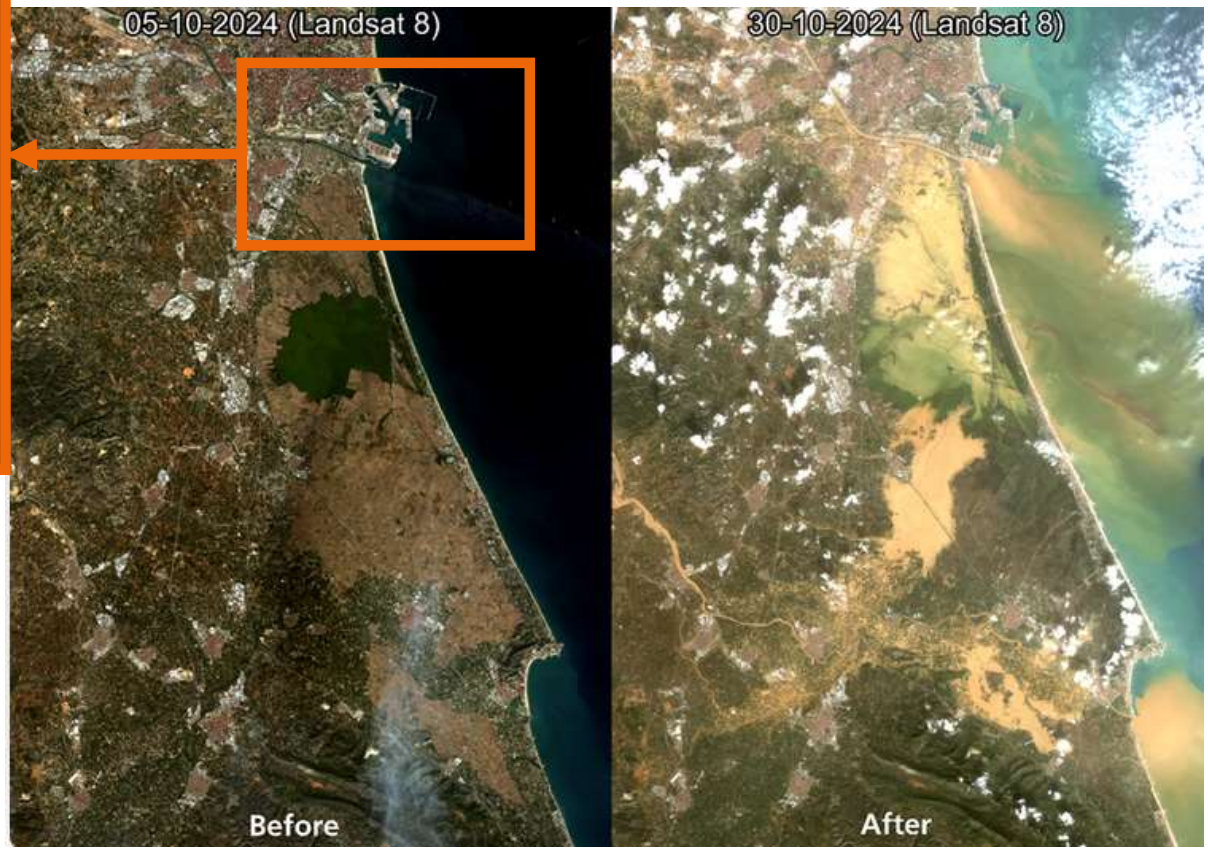
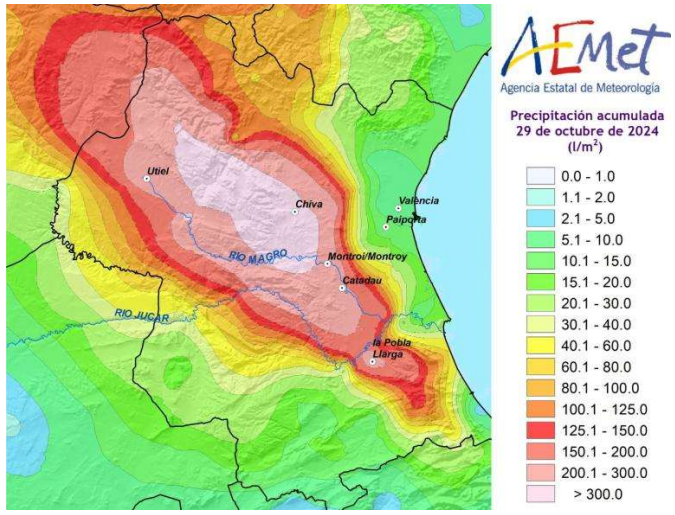
Climate change through flash floods: The Valencia case





AEMet
Agencia Estatal de Meteorología

Precipitación acumulada
29 de octubre de 2024
(l/m²)

- 0.0 - 1.0
- 1.1 - 2.0
- 2.1 - 5.0
- 5.1 - 10.0
- 10.1 - 15.0
- 15.1 - 20.0
- 20.1 - 30.0
- 30.1 - 40.0
- 40.1 - 60.0
- 60.1 - 80.0
- 80.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 200.0
- 200.1 - 300.0
- > 300.0

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Climate change through flash floods: The Valencia case

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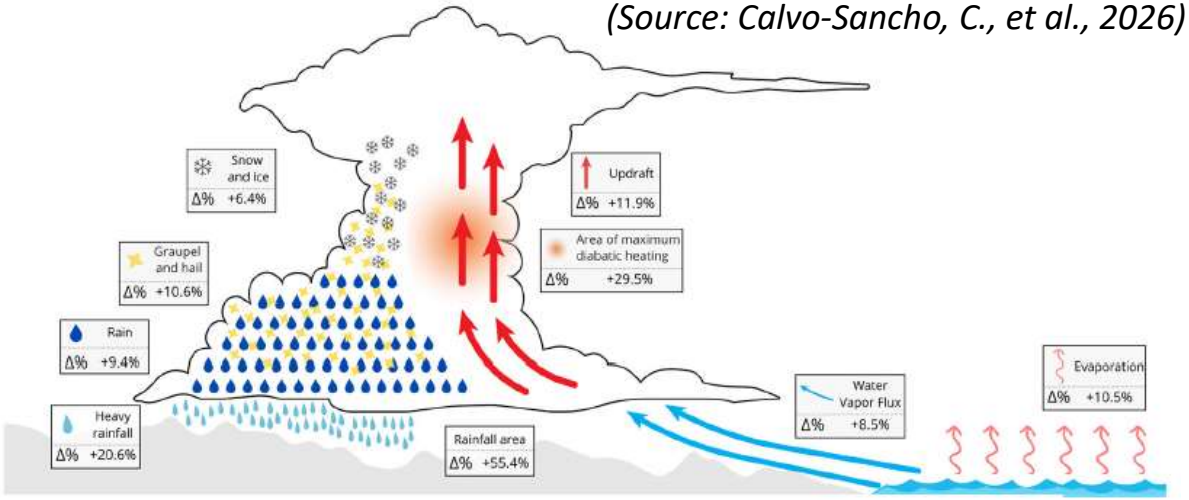
Water and Environment Support - Biodiversity and Climate Action in the Neighbourhood South region

Calco-Sancho et al. (2026), showed that anthropogenic climate change in Valencia could:

- **intensify** the 6-h rainfall in rate by **21%**,
- **amplify** by **55%** the area with total rainfall above 180 mm and
- **increase** by **19**% the volume of total rain within the Jucar River catchment compared to the pre-industrial area.

(Source: Calvo-Sancho, C., et al., 2026)

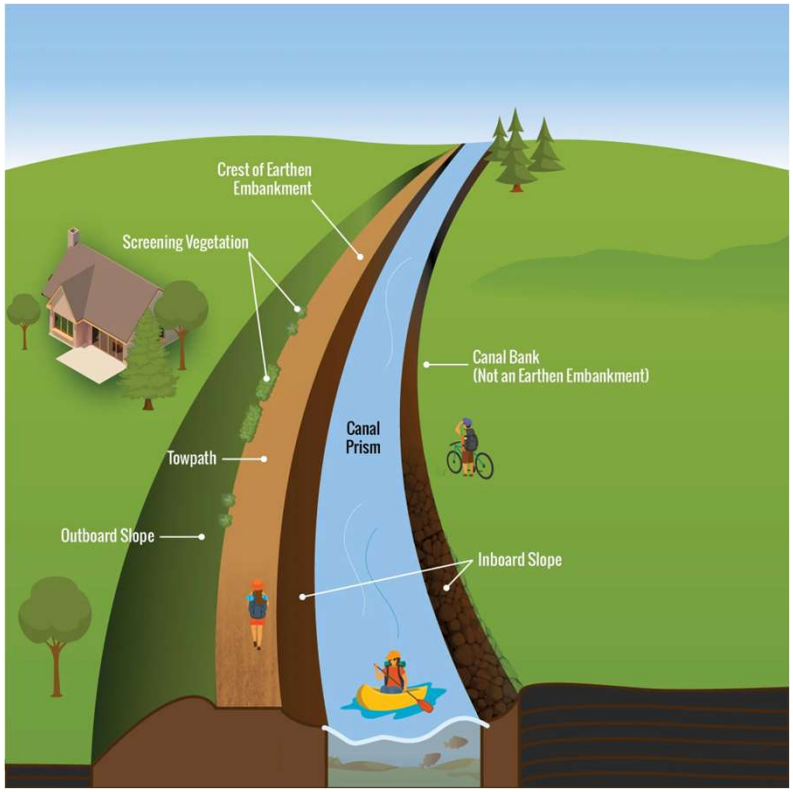


Explication: This intensification driven by enhanced atmospheric moisture from warmer sea surface temperatures, leading to increased convective potential energy, stronger updrafts and microphysical changes.

Flood Protection: is it possible?

Conventional measures:

❑ Levees and Embankements



Source: https://www.nyscanalintegrity.org/

Lez river, France (source: france bleu)

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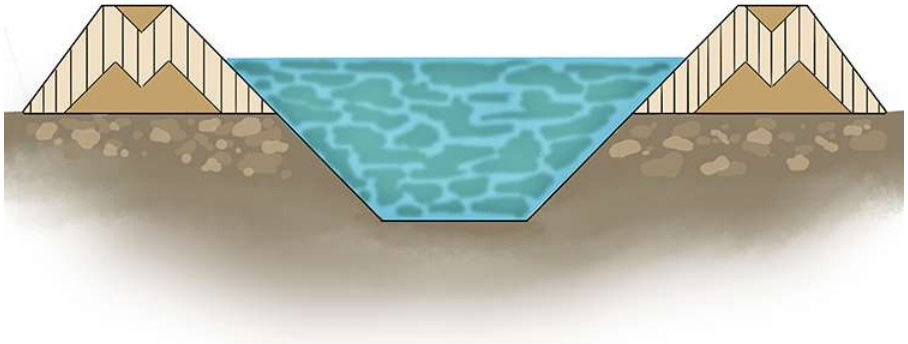
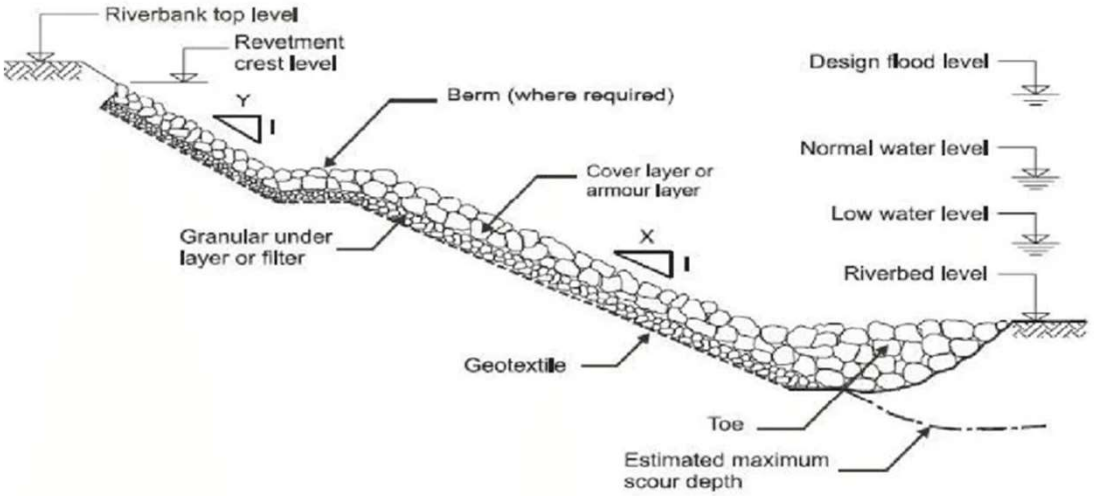
Flood Protection: is it possible?

Conventional measures:

- **Levees and Embankements**



Source: https://mammothmemory.net



Fatema, N. & Ansary, M. (2014)

Flood Protection: is it possible?

WES-BCA
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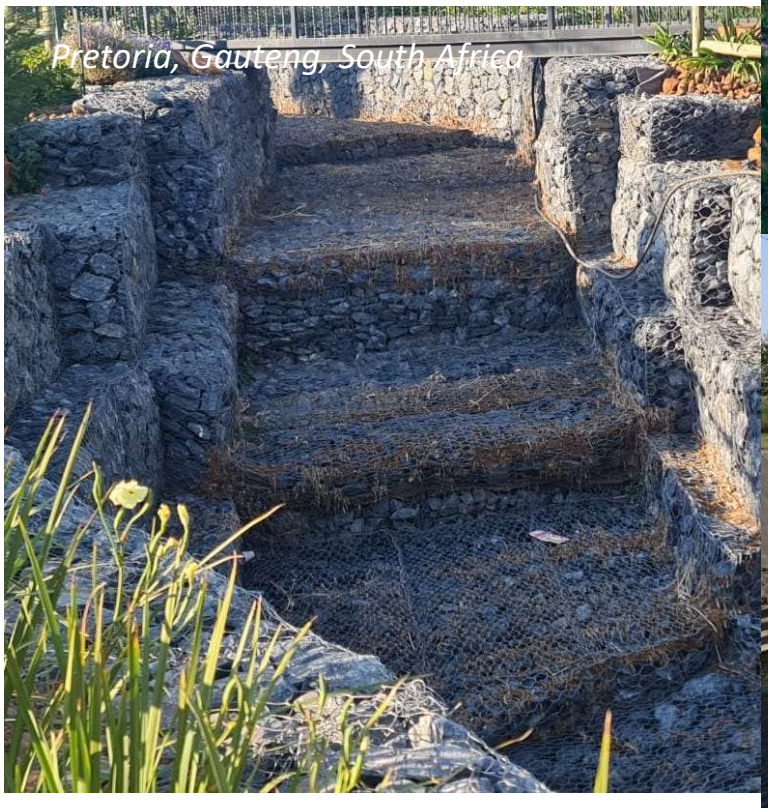
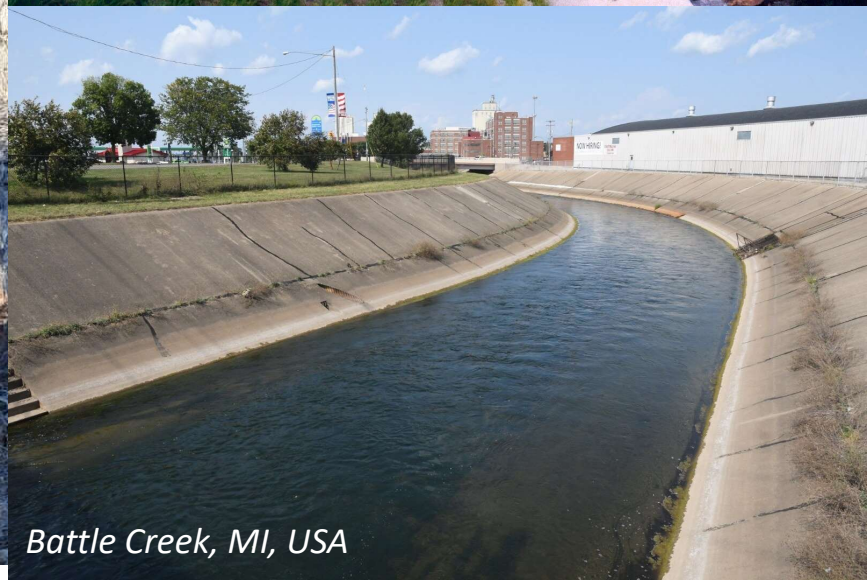
in the Neighbourhood South region

Conventional measures:

- **Levees and Embankements**


Ubaye affluent, Barcelonette (FR)


Pretoria, Gauteng, South Africa


Battle Creek, MI, USA

Flood Protection: is it possible?

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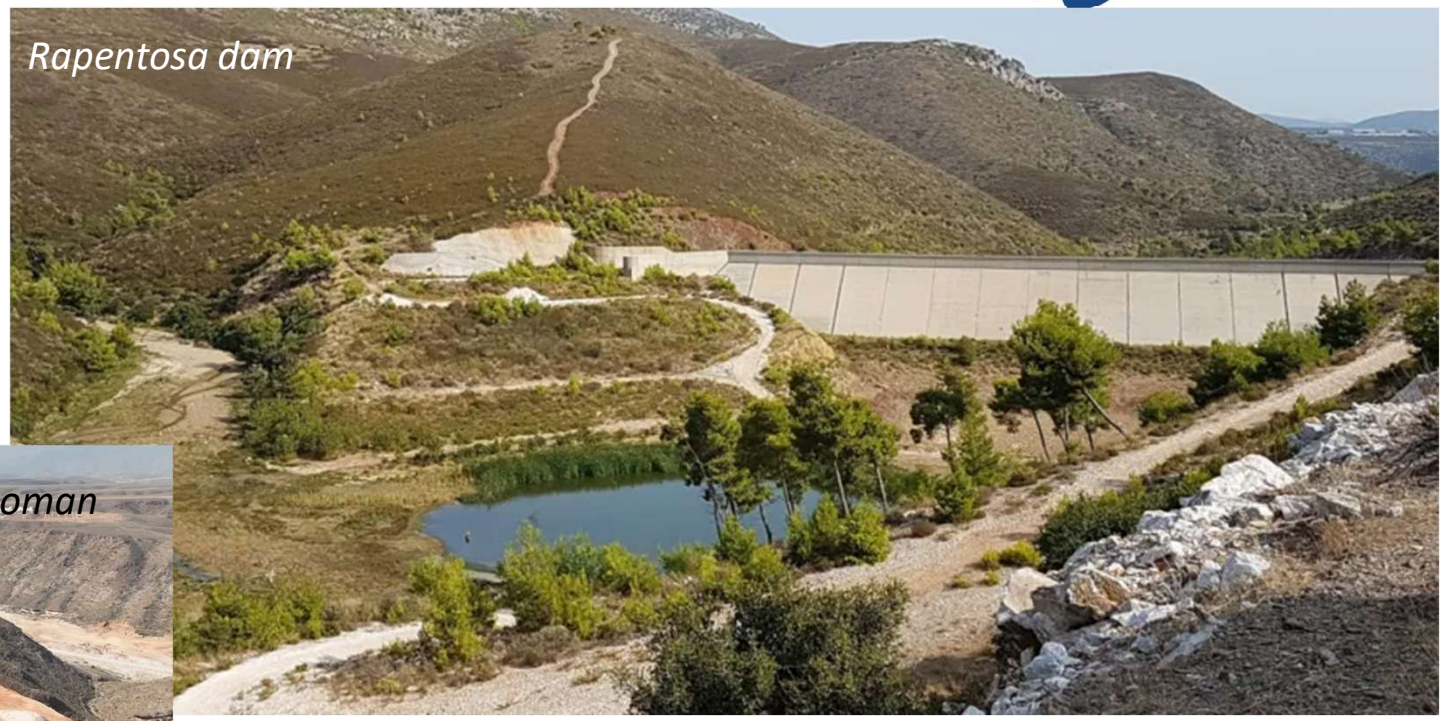
Conventional measures:

- **Dams and Reservoirs**


Rapentosa dam


Adawnib Flood Protection Dam-salalah oman (source: ntf)

Flood Protection: is it possible?

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Dams and Reservoirs

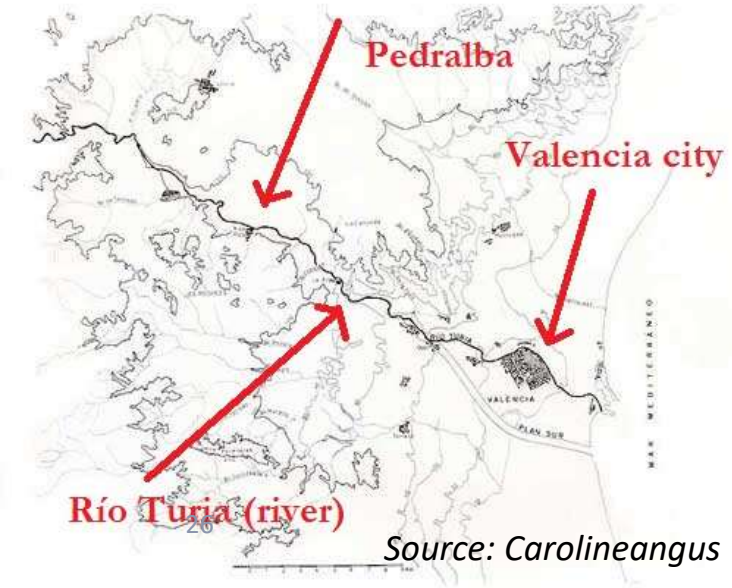
- **Reduction of Impact:** By reducing peak discharges, dams can substantially reduce the risk of downstream flooding.
- **Controlled Discharge:** Instead of a rapid surge of water flooding, dams use gated spillways to release water at a controlled, safe rate.
- **Operational Procedures:** Before rainy seasons, operators lower reservoir levels, creating space for anticipated incoming floodwaters.
- **Multipurpose Functionality:** Many dams also serve other purposes, including hydropower generation, water supply, irrigation and recreation.
- **Regional Effectiveness:** integrated management of multiple dams within a river basin is considered the most effective way to manage large-scale floods for multiple communities.

Flood Protection: is it possible?

Diversion & bypass channels

- **redirect flood** away from populated areas.
- **mitigate the impacts** of a flood by offering an alternative route for excess water.
- **diversion channels** are built around major cities (e.g. the Plan Sur in Valencia, the New Danube in Vienna, or the Red River Diversion Channel in Manitoba).

The Plan Sur Project in Valencia (source: metropolismag)



Source: Carolineangus

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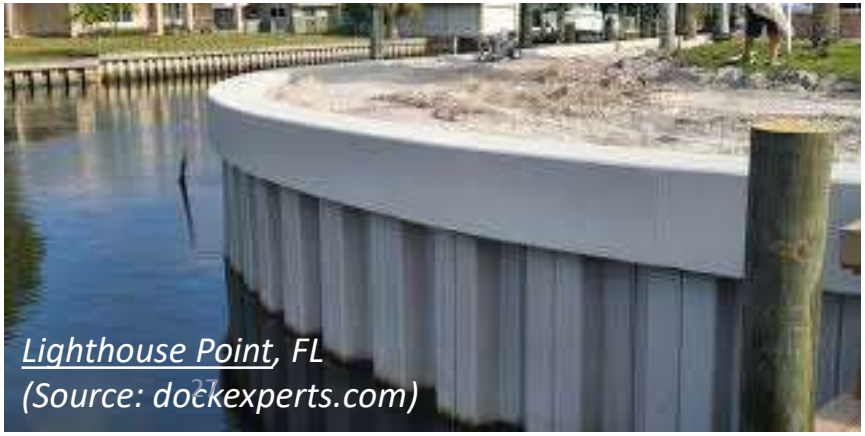
Flood Protection: is it possible?

Flood walls and seawalls

- **Vertical (or almost) barriers** constructed from like reinforced concrete, steel sheet piling, or rubble.
- **Prevent flooding** in areas with limited space.
- **Permanent** or temporary/ movable barriers.


Williamson, Mingo County, WV
(source: Hatfield Construction, LLC)


Zruč nad Sázavou, Czech Republic


Lighthouse Point, FL
(Source: dockexperts.com)

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Flood Protection: is it possible?

Flood walls and seawalls

- *Flood doors and windows*
- *Flood barriers*
- *Concrete floors*
- *Water resistant mortar*

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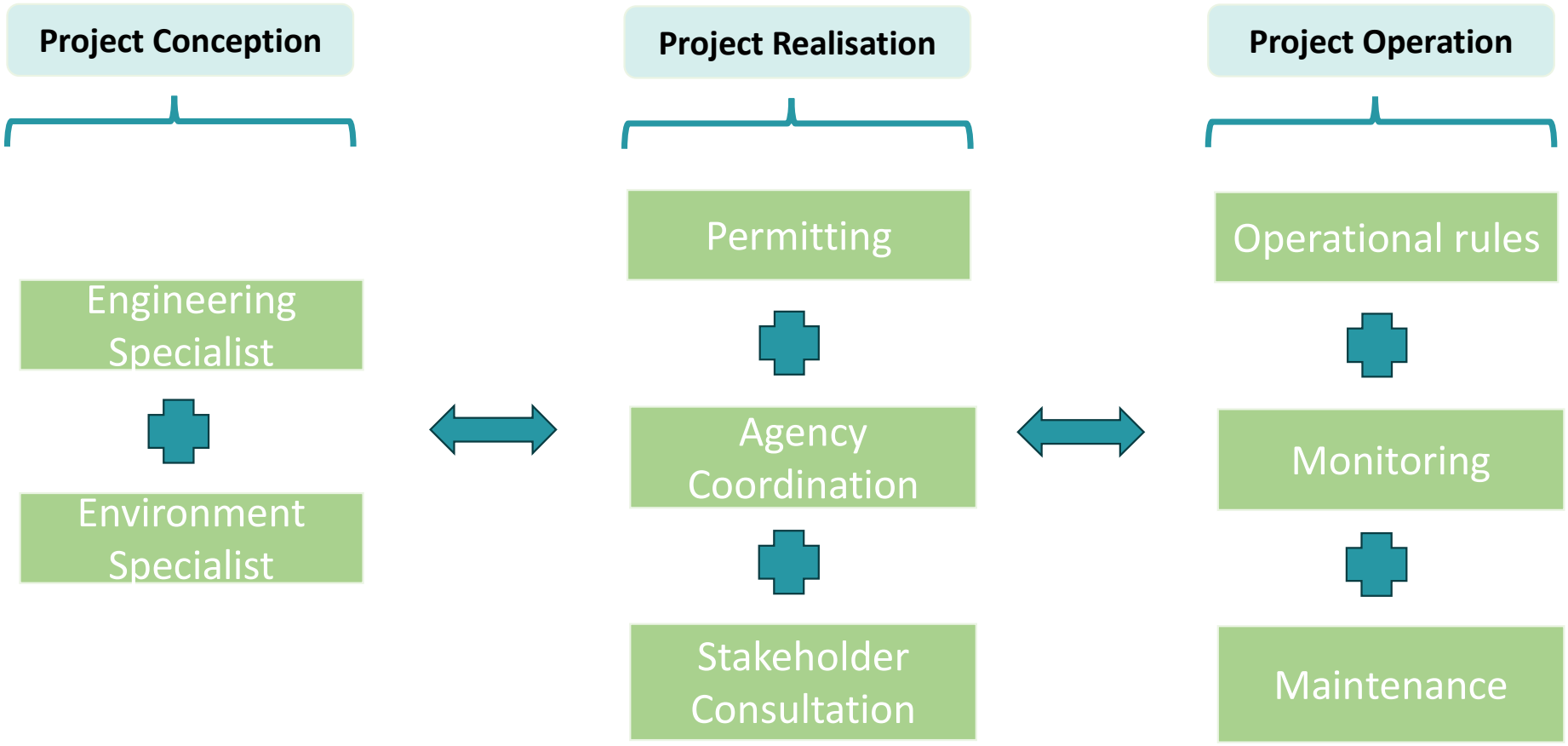
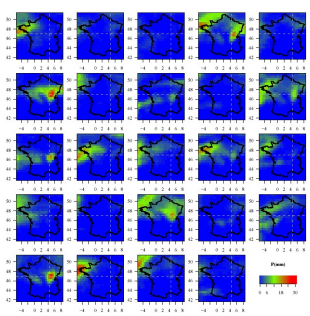
Implementation Process



Project Conception

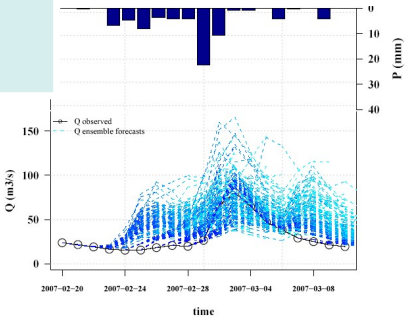


Climate/ Design Scenarios

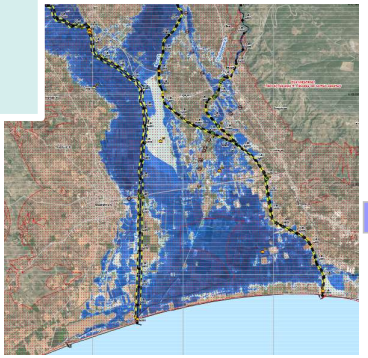
Hydrological model

(rainfall to runoff)

Hydrological Design Scenarios



Hydraulic Modelling & Flood Hazard & Risk Mapping



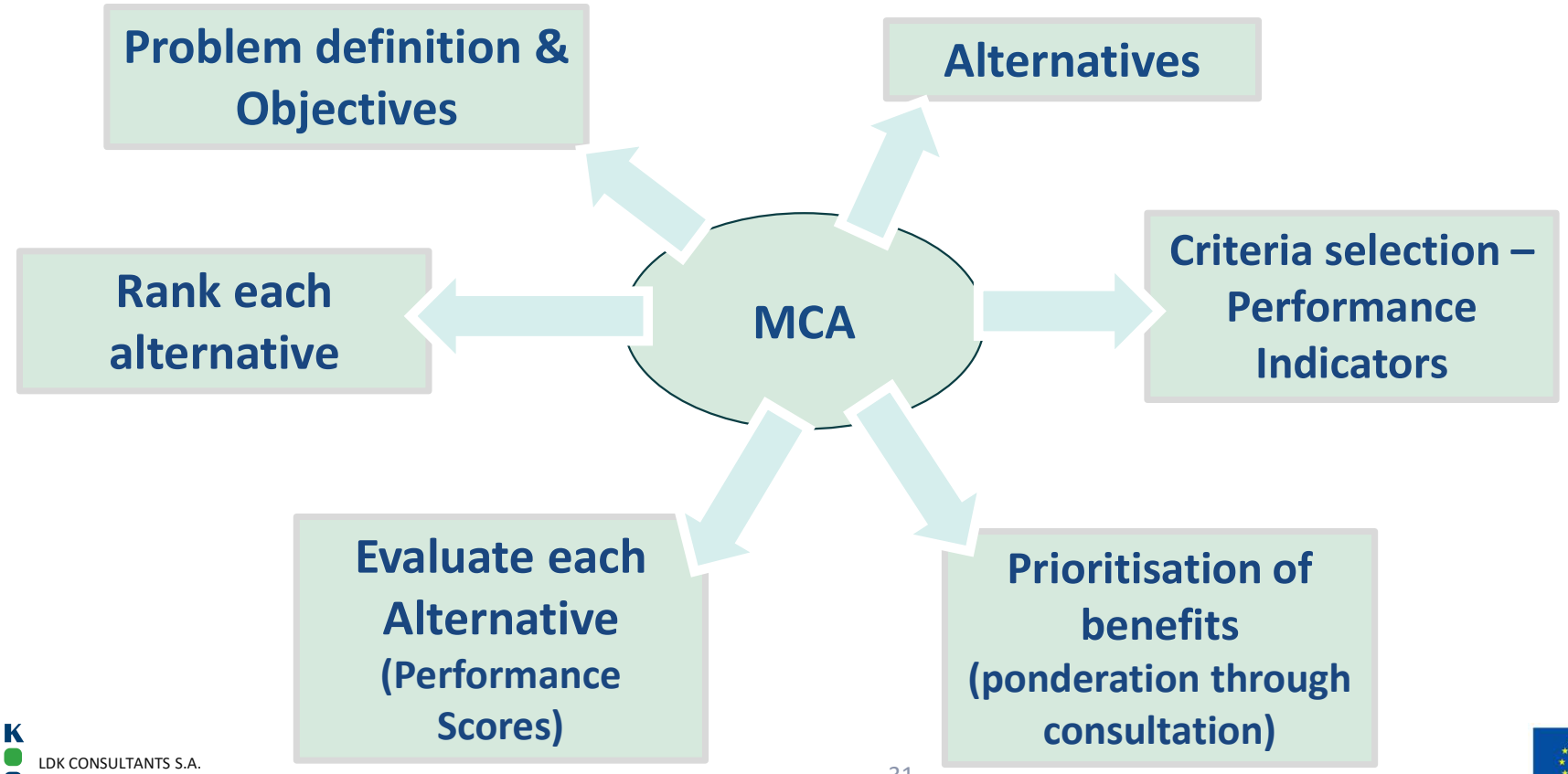
Multi-Criteria Assessment &

Sensitivity Analysis

Optimal decision based on set criteria

Multi-Criteria Assessment

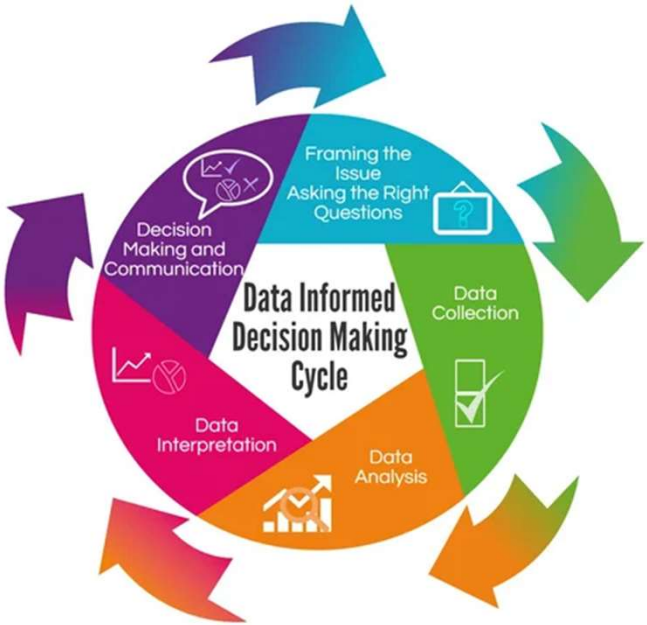
A key in a project's conception is **Multi-Criteria Assessment (MCA)**



Informed Decision

Based on:

- ✓ ***comprehensive site investigation***
- ✓ ***topographical survey***
- ✓ ***geotechnical/ geological investigation***
- ✓ ***hydrological conditions***
- ✓ ***hydraulic conditions* & existing infrastructure**
- ✓ ***material availability and suitability***
- ✓ ***constructability and access requirements***
- ✓ ***regulatory, environmental and land preconditions***
- ✓ **risk assessment and safety considerations**
- ✓ **financial and operational considerations**



Sensitivity Analysis

A useful tool in Multi-Criteria Assessment is **Cost-Benefit Ratio**

(~*ratio of construction and operational costs over the benefits from water retained*)

Costs

Construction cost
(material, personnel, machinery)

Design & Permitting costs
(engineering fees, etc)

Land Acquisition Cost

Maintenance Costs
(instruments, personnel, repairs)

Ecological Degradation Valuation

vs

Benefits

Flood risk reduction
(Insurance reduction costs, damages avoided, critical infrastructure protection, etc)

Riverbanks Stabilization valuation
(agricultural land increase, projects increased lifespan though regular maintenance is required)

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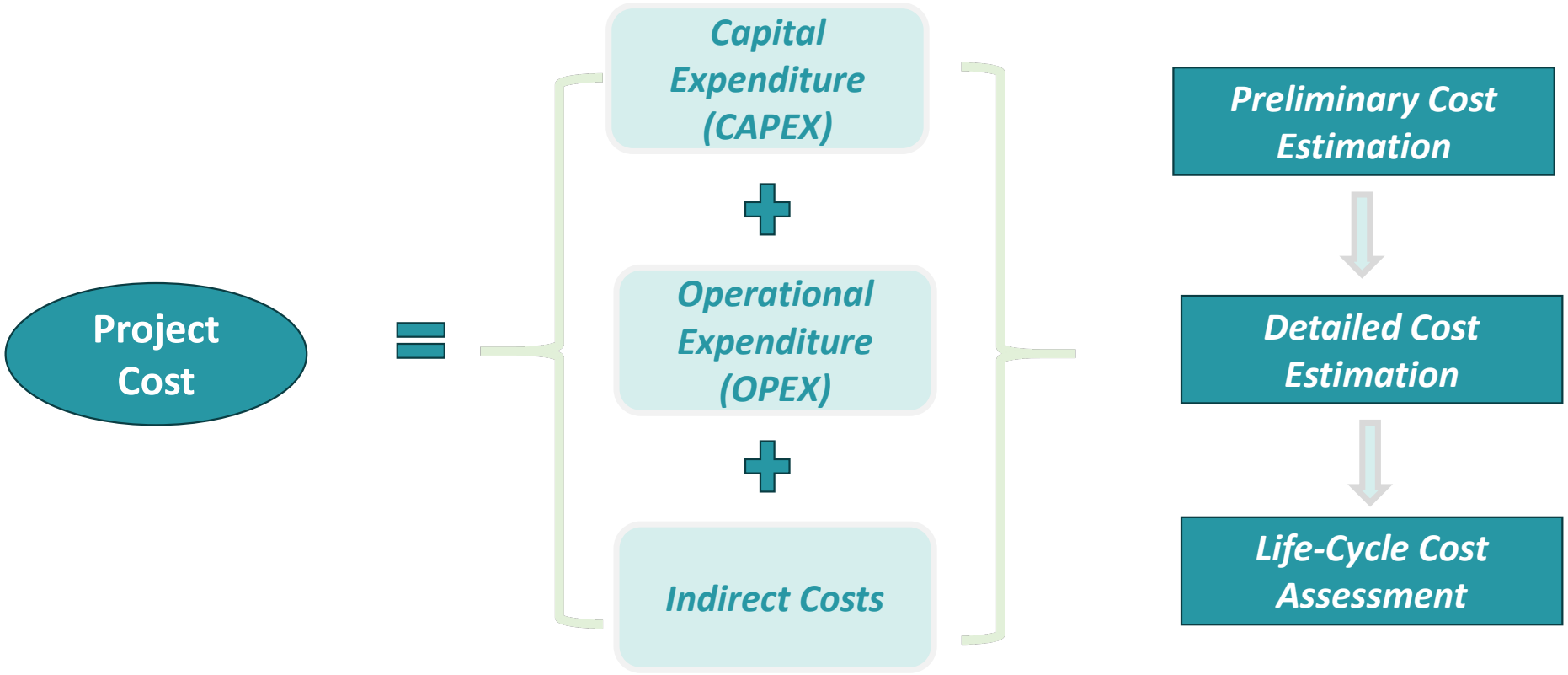
Cost estimation



Cost estimation is inherently site-specific. Thus, comparison btw alternatives is done in terms of unit cost per m^3 of runoff reduction or unit cost per area (hectare) of restored area is often used.

Conventional measures benefit vs limitations

Benefits	Limitations
- Provide immediate flood protection. - Protect critical infrastructure & communities - Reduce flood peaks - Effective for moderate to low frequency events - Stabilize riverbanks and prevent erosion - Suitable for dense urban areas - Provide clear, visible risk-reduction benefits - Mature engineering methods - Often politically popular due to immediate results - Standardized design guidelines and regulatory frameworks	- Flood risk may shift downstream - Lack of flexibility in changing climate conditions - Disrupt natural sediment transport - Degrade river and floodplain ecosystems - Reduce natural filtration and self-purification - Increase pollutant concentrations - High construction and maintenance costs - Necessary inspection protocols - Complex permitting and environmental compliance - Encourage development in high-risk zones

Paradigm Shift

Shift from **“flood control”** towards **“flood management”** in the last decades.

“*Flood management consists in accepting that floods as part of river’s natural life*”:

- ❑ shifting from a *re-active* to a ***pro-active*** flood management strategy,
- ❑ balancing *flood risk* to ***sustainable development*** and
- ❑ from *ad-hoc flood control* to ***integrated flood management***.

Integrated Flood Management (IFM)

Associated Program on Flood Management

The Associated Program on Flood Management (APFM):

- **promotes** the concept of Integrated Flood Management globally,
- **supports** countries in implementing IFM within the framework of *Integrated Water Resources Management (IWRM)*.
- **aims to maximize benefits** from the use of floodplains while minimizing loss of life and environmental impact.
- **offers tools, publications and a HelpDesk** for a common strategic vision on IFM issues,
- **promotes** the implementation of effective policies and strategies worldwide.

Most importantly aims to streamline the multi-facets of flood management issues into the decision-making of policy makers, flood managers and other stakeholders.

Integrated Flood Management

- ✓ **IFM** aims at ***maximizing the net benefits*** ***linked to social development close to river plains, while*** ***minimizing life and property loss*** ***from flooding.***
- ✓ **IFM** recognizes that *hydrological systems are* ***dynamic*** *and subject to* ***variability***.
- ✓ **IFM** promotes ***adaptive management strategies*** that are ***flexible*** *and* capable of ***adjusting to evolving conditions***.
- ✓ **IFM** promotes **planning and decision-making** ***at the river basin scale***.
- ✓ **IFM** ensures **coherence between** ***local actions*** and ***basin-wide objectives,*** aligning flood management with broader water resources planning.

Integrated Flood Management

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IFM maximizes net benefits of social development next to river, while minimizing life and property loss from flooding

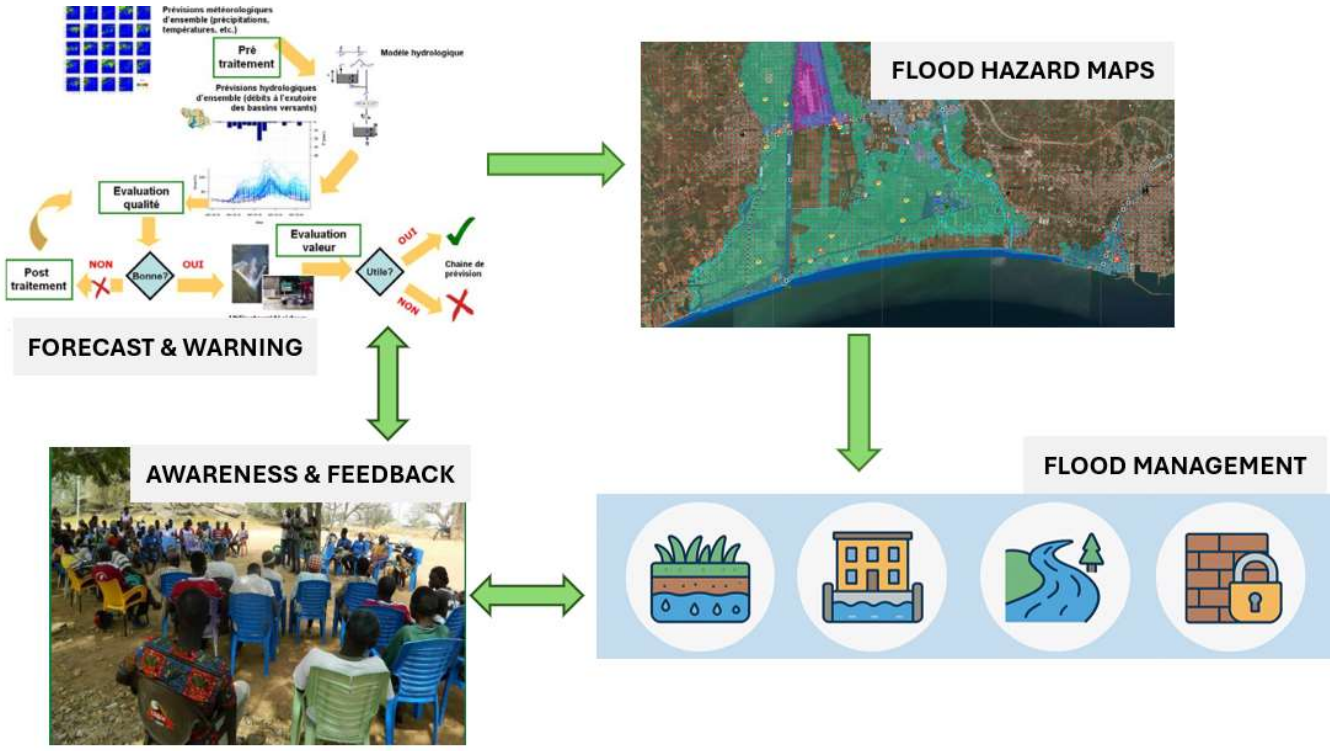
Integrated Flood Management consists in a few phrases:

- ❑ **adopting** a basin approach to flood management,
- ❑ **bringing** a multidisciplinary approach in flood management,
- ❑ **reducing** vulnerability and risks due to flooding,
- ❑ **enabling** community involvement,
- ❑ **preserving** ecosystems.

Integrated Flood Management

Integrated Flood Management key components:

- ✓ **Risk** Assessment and Mapping,
- ✓ **Land Use** Planning,
- ✓ **Infrastructure** Development,
- ✓ **Nature-based** Solutions,
- ✓ **Early Warning** Systems,
- ✓ **Community-based** management,
- ✓ **Managing Residual** Risks.



Integrated Flood Management

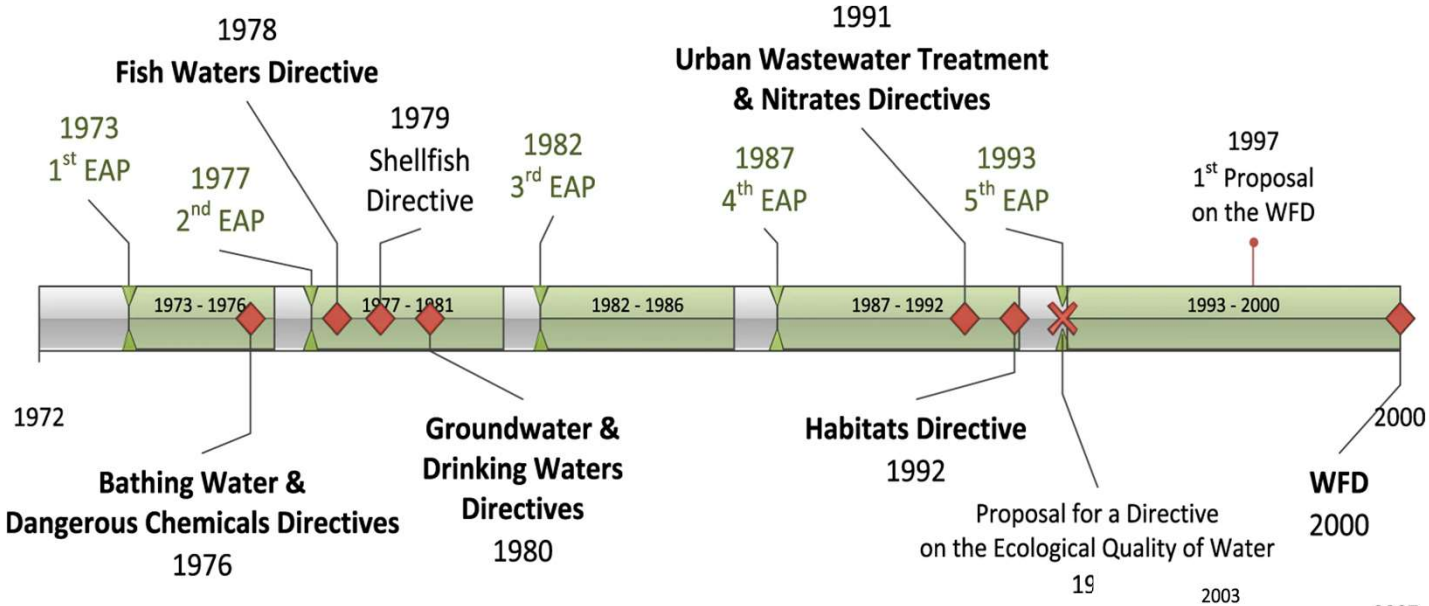
According to US National Institute of Building Sciences,

for every **$1** invested in flood mitigation, communities save **$7** in avoided damages

for every **$1 million** invested in integrated floodplain management **=>**

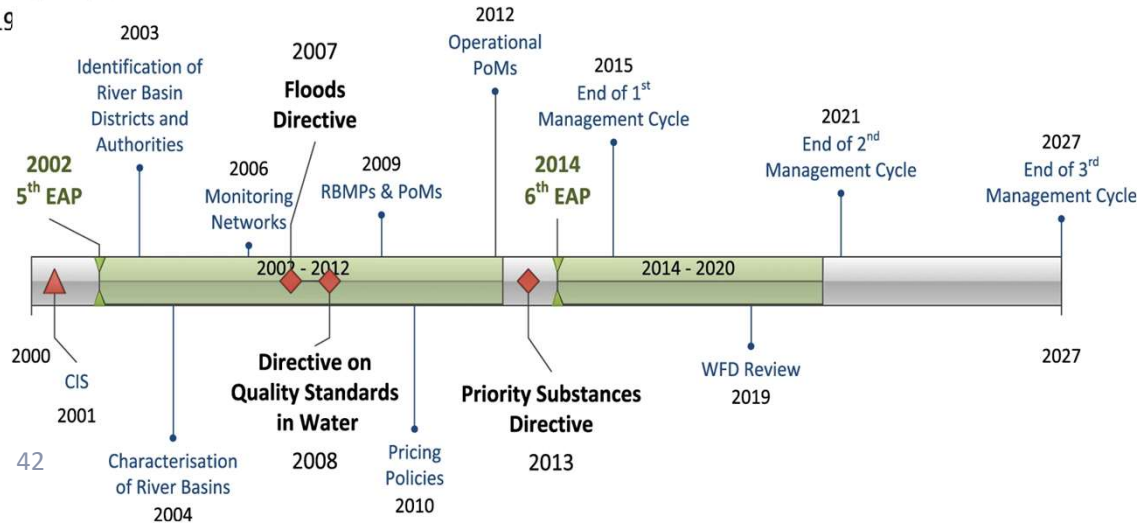
$2.2 – $2.5 million in total economic activity is generated
(**80%** of which stays within the local county)

EU FRAMEWORK



Source: Giakoumis & Voulvoulis, 2018

EU water policy evolution towards the WFD (1972–2027)



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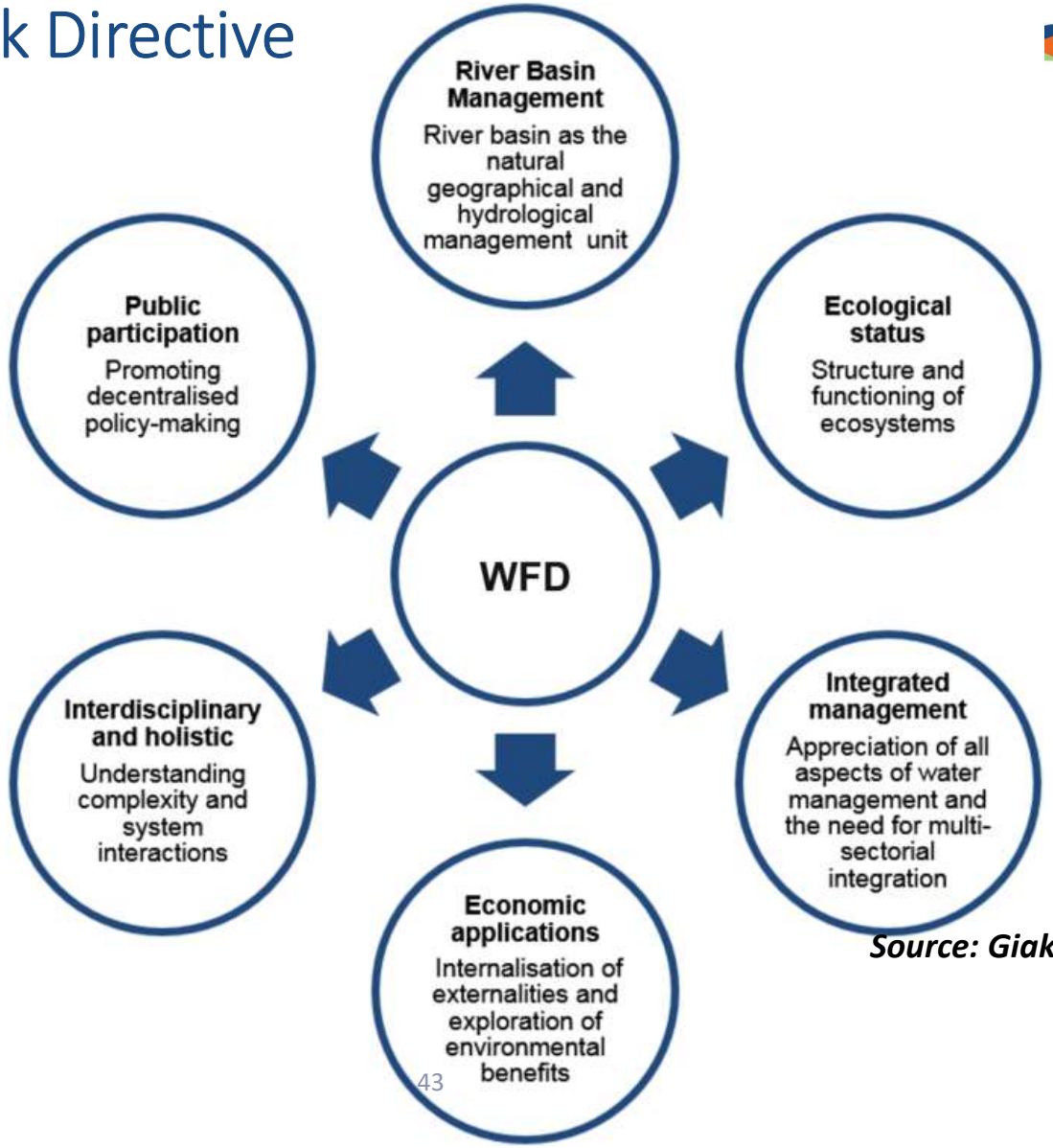
Water Framework Directive



Source: Giakoumis & Voulvoulis, 2018

EU Floods Directive

EU Floods Directive (2007/60/EC) *acknowledges that **floods are a natural phenomenon** that cannot be completely prevented; **while human activities and climate change may increase** both the probability of flood occurrence and the **magnitude of their adverse consequences**.*

, while it aims to establish «***a comprehensive framework for reducing the adverse consequences of flooding** for human health, the environment, cultural heritage and economic activity*».

*It requires each EU member states to **assess, map** and **manage flood risks** flood risks on a basin-scale. The objective is to identify areas exposed to significant flood risks and shape national flood-risk governance.

EU Floods Directive

For Mediterranean countries, where flash floods, steep catchments and rapid hydrological responses dominate, the Directive provides a **structured framework** that supports:

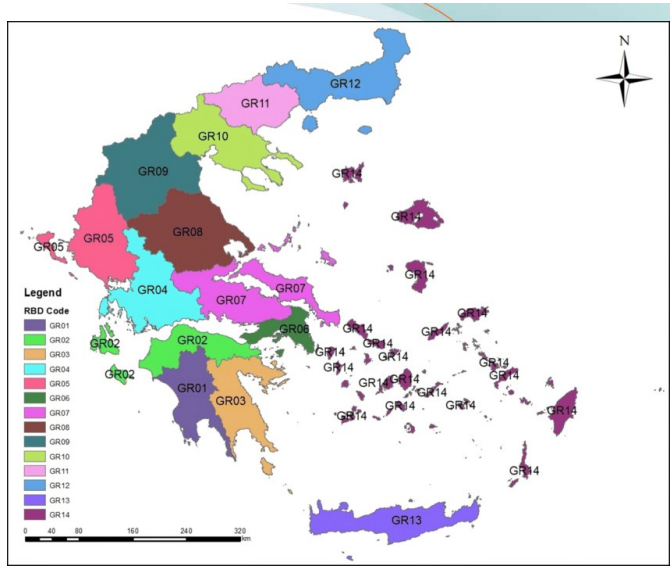
- **Basin-level coordination** across administrative boundaries
- **Integration of climate-change projections**
- **Transparent mapping for public awareness**
- **Alignment with EU funding mechanisms** (e.g., Cohesion Fund, LIFE, Civil Protection)

The Directive is often the **legal backbone** for designing flood management measures and Produce cross-agency operational protocols

River Basin Management Plans (RBMPs)

RBMPs are **6 year strategic plans** prepared for **each River Basin District (RBD)**.

Protection **Sustainability** **Restoration**



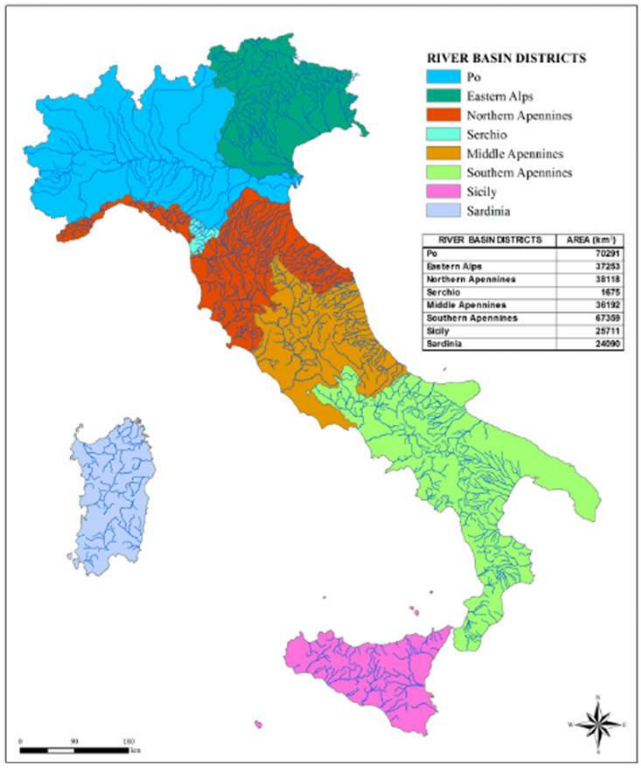
- ✓**good ecological and chemical status** for surface waters
- ✓**good quantitative and chemical status** for groundwater
- ✓**prevent deterioration** of water bodies
- ✓**integrate water management with spatial planning, agriculture, hydropower, industry, and ecosystems**
- ✓**provide a basin-scale, evidence-based framework** for investment and regulation

Flood Risk Management Plans (FRMPs)

Flood Risk Management Plans are coordinated **at the level of river basin districts**.

Their objectives focus on three core pillars:

- ***Prevention***: avoiding construction and inappropriate land use in flood-prone areas and promoting sustainable land-use practices,
- ***Protection***: incorporating structural and non-structural measures aimed at reducing the likelihood and impact of floods,
- ***Preparedness:*** improving public awareness, emergency planning, flood forecasting and early warning systems.



FRMPs are updated **every 6 years**.

Flood Risk Management Plans (FRMPs)

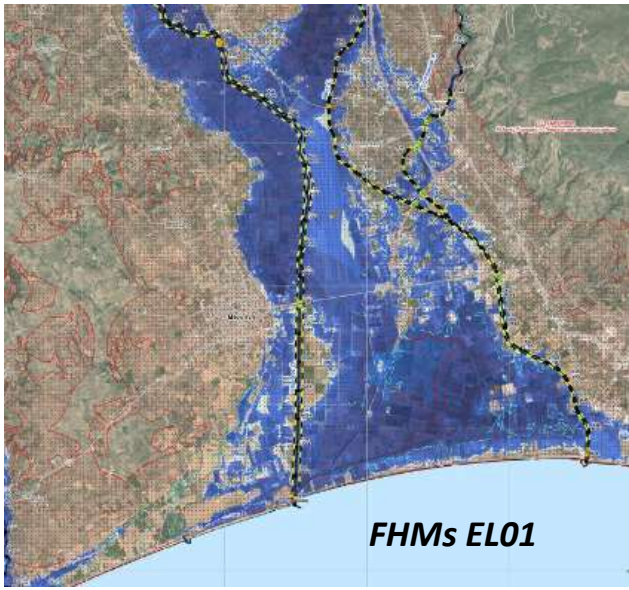
As part of FRMPS, ***areas at potentially significant flood risk*** are identified through **flood hazard maps** and **flood risk maps**.

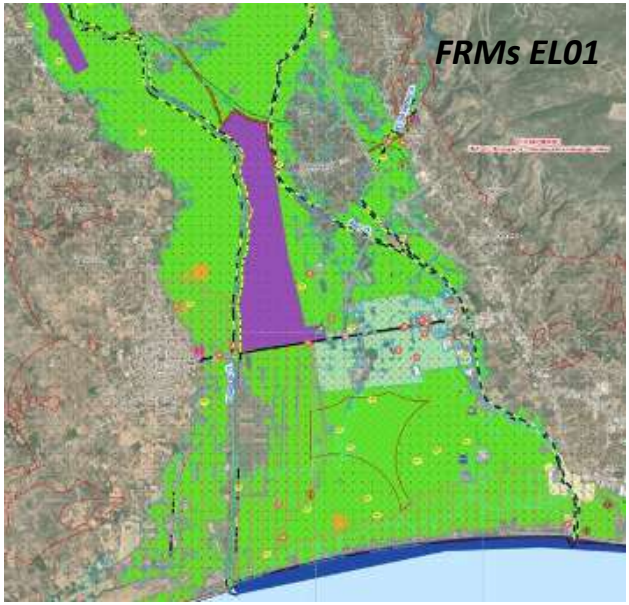
Flood Hazard Maps indicate the extent of flooding (water depth & flow velocity) and cover three scenarios:

- ***low*** probability floods (extreme events),
- ***medium*** probability floods (typically of 100 years return period),
- ***high*** probability floods, where appropriate.

Flood Risk Maps depict the potential adverse consequences associated with these flood scenarios, such as:

- the ***number of inhabitants*** potentially affected,
- the ***economic activity*** in the affected area, etc.





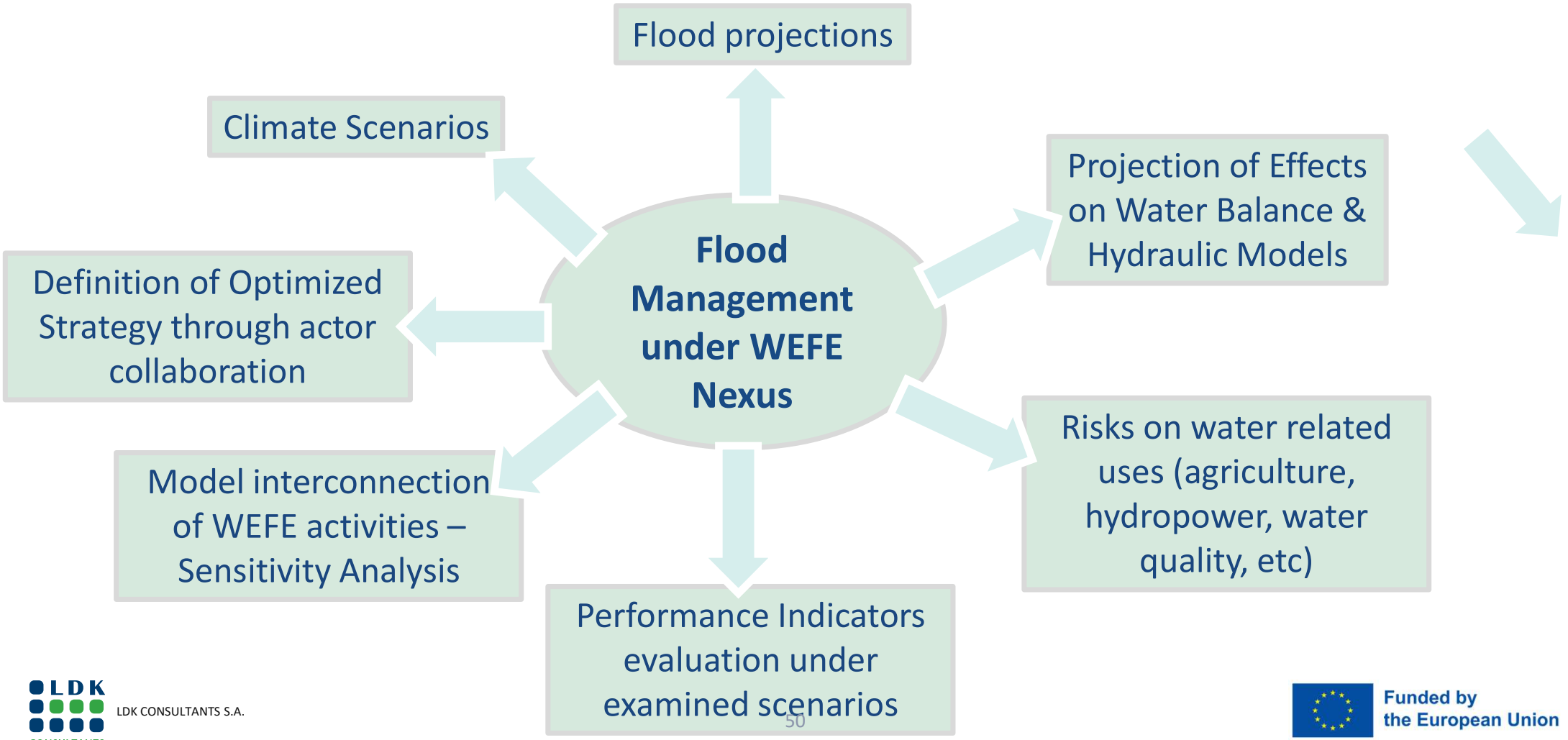
Integrative assessment

WEFE Nexus facilitates resource and intersectoral coherence in management natural resources. This is achieved through **risk assessment** in resources management.

Setting a **risk assessment** requires the following steps:

- ✓Gathering and analyzing **data**
- ✓Identifying food, energy, and water **risks & interrelationships** (quantitatively and qualitatively)
- ✓Calculating the **performance indicators**
- ✓Calculating the **amount** of water & energy consumed, the food produced per surface water consumed, the amount of profit through these performance indicators (ponderated according to the objective)
- ✓Creating **discrete models** (training and testing them with existing data)
- ✓Selecting the **optimal framework** based on existing training data.

Integrative assessment in flood management



Integrative assessment

The WEFE Nexus approach in **policy-making** offers several advantages:

- **Enhanced resilience**: integrated policies can build resilience against the impacts of climate change
- **Economic efficiency**: coordinated strategies can optimise resource allocation, reduce costs and stimulate a sustainable economy.
- **Social equity**: inclusive policies ensure equitable access to water, energy and food resources

Governance incorporating the WEFE nexus requires **coordination, coherence** and **collaboration** between all actors, **rather than the creation of new institutions**.

WES-BCA

Water and Environment Support - Biodiversity and Climate Action

in the Neighbourhood South region

Thank you for your attention!

LDK CONSULTANTS S.A.

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