A photograph of a sunset over a body of water, with silhouettes of people and structures in the foreground. The sun is low on the horizon, creating a bright glow and reflecting on the water. The silhouettes include what appears to be a boat and some structures, possibly in a lagoon or coastal area.

## **Adaptation to Climate Change in Coastal Zones: an Analysis of the Intervention to Safeguard Venice and its Lagoon**

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# Outline

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- Venice as a complex system: characteristics and current problems
- Climate change challenges for the Venice system
- Venice safeguard programme as adaptation response: does it make the lagoon and its urban centres climate-proof? → Short and mid-term vs long term perspective
- Conclusions

# Venice lagoon: an “artificially maintained natural environment”

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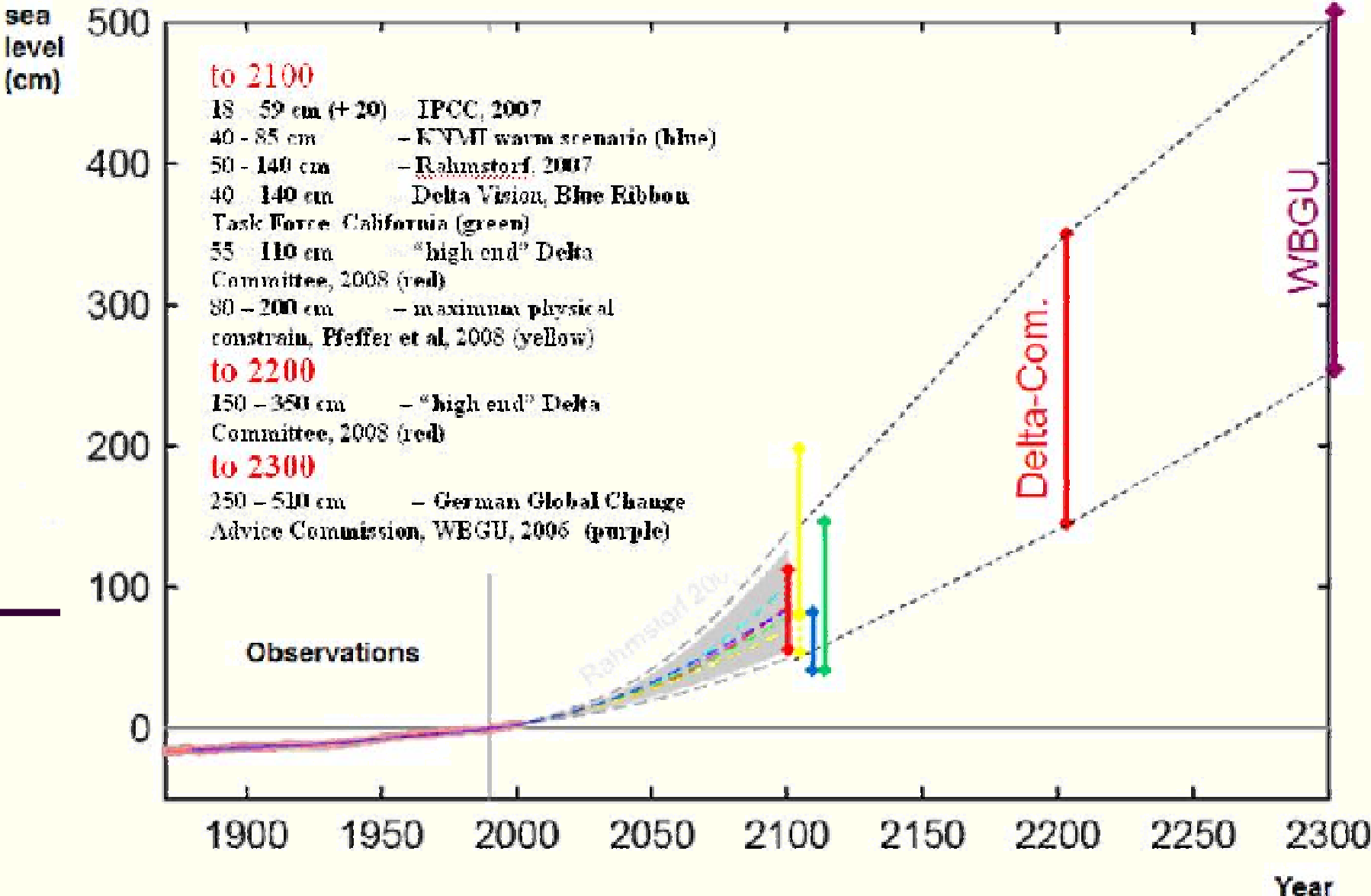
## Venice lagoon: major existing problems

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- Occasional floods (“high water”)
  - Urban degradation
  - Coastal and lagoon erosion
  - Habitat and biodiversity loss
  - Water, sediment and land contamination
- Pollution in the lagoon:
    - heavy metals, synthetic organic compounds, nutrients and organic matter
    - from drainage basin, industrial area and urban lagoon centres
    - 53% from agriculture and livestock; 43% from industrial, civil and urban sources

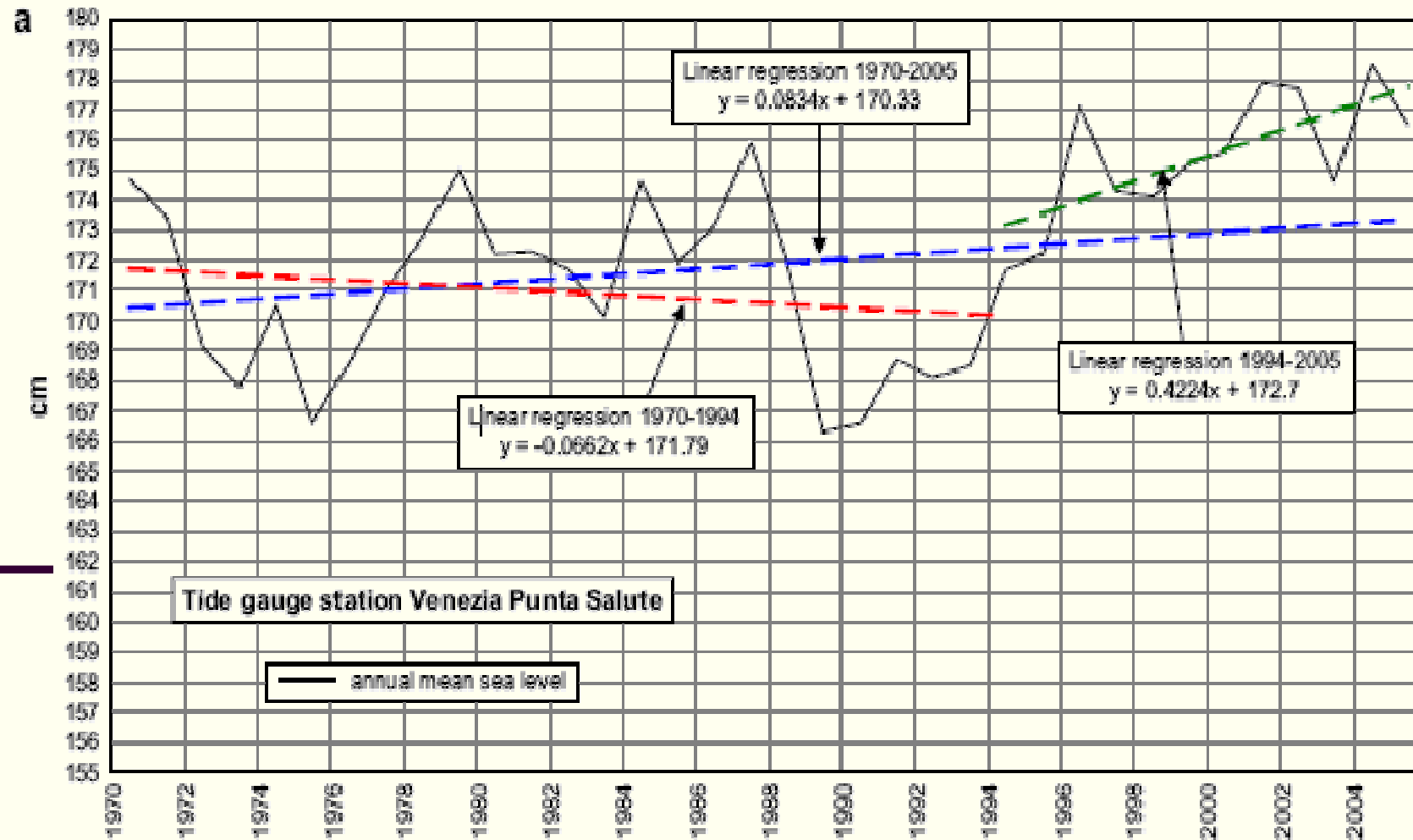


# Climate change: projections for global mean sea level rise in 2100



# Sea level rise in Venice

Sea level at Venice for the period 1970-2005



Source: Ferla et al., 2006

# Major impacts of climate change on the Venice system

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- **Sea level rise:**
  - Increase in frequency of high water events

Tidal peaks (cm)	Mean annual frequency for current m.s.l	Mean annual frequency for m.s.l. +10 cm	Mean annual frequency for m.s.l. +20 cm	Mean annual frequency for m.s.l. +30 cm
+80	39	94	204	356
+100	7	16	39	94
+120	1	3	7	16
+140	1/6 y	1/2 y	1	3

*Annual frequency of different tidal peaks according to four different sea level rise scenarios. Tidal peaks are measured with reference to m.s.l. 1897*

*Source, Tethis, 1997*

## **Venice safeguard intervention: *legislative and institutional system***

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- **Special legislation** (since 1973):
  - defines safeguard goals, institutions' responsibility, management tools, water quality objectives for the lagoon
- **Goals:**
  - protection from high waters and sea storms
  - arresting environmental and habitat degradation
  - urban restoration and socio-economic revitalization
- **Responsibility** split between *national* and *local* authorities in the lagoon, drainage basin and facing sea
- Allocation of national **funds** for studies, plans, projects and structures (more than €15 billion investment, 64% funded)

# Venice safeguard: *protection from sea storms*

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## Tot. investment €540 million:

- beaches (40 km) and dune belt (8 km) reconstruction
- reinforcement of ancient sea wall and breakwaters (11 km)

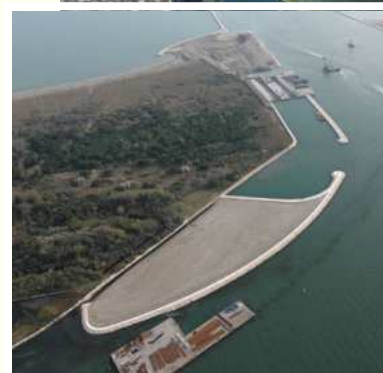
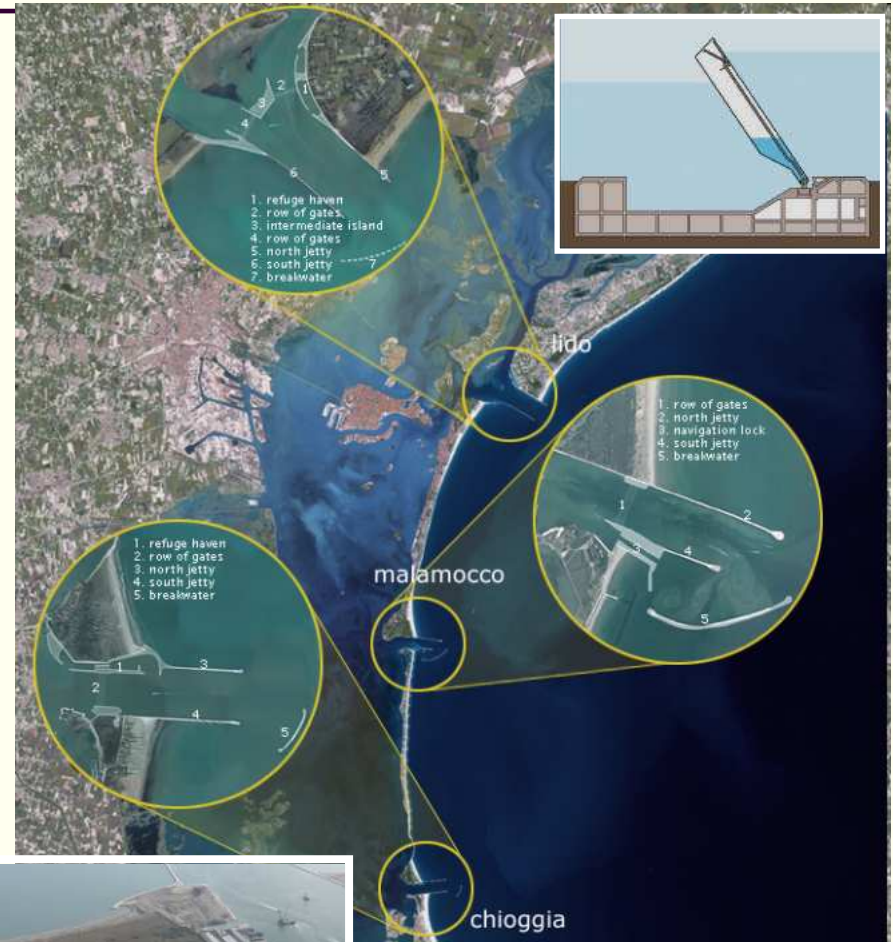


*Source: Venice Water Authority, 2008*

# Venice safeguard: *protection from high waters*

**Tot. investment €5.5 billion:**

- mobile barriers at the inlets (48% done; operating by 2014)
- public walkway raising (43% done)
- lagoon embankments restoration (77% done)



*Source: Venice Water Authority and Venice Municipality, 2008*

# Venice safeguard: *morphological restoration and habitat reconstruction*

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## Tot. investment €700 million:

- salt marshes, mudflats and shallows reconstruction (2.5% lagoon surface) and protection (33 km)
- protection of islands from erosion (n. 12)
- canal re-calibration (176 km)
- planting eelgrass (n. 38 sites)



Source: Venice Water Authority, 2008

# Venice safeguard: *pollution abatement*

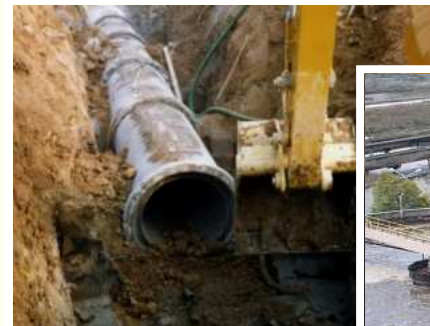
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## Tot. investment €2.9 billion:

- securing industrial canal shores (35 km) and dams (182 ha), polluted sediment removal (322,000 m<sup>3</sup>)
- sewerage system (74% population connected), sewage treatment plant adjustment (n. 51), phytopurification areas (65 ha), drainage network adjustment (160 km), river naturalization (76 km)



*Source: Veneto Region and Venice Water Authority, 2008*

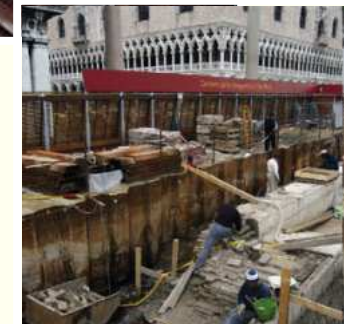


# Venice safeguard: *urban restoration*

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## Tot. investment €5 billion:

- historical buildings (n. 205), bridges (n. 242), city canal shores (70 km) and dredging (55 km, sediment removed 800,000 m<sup>3</sup>), drainage shafts and utilities renovation (17 ha)
- grants for buying and maintenance of private housing, economic revitalization

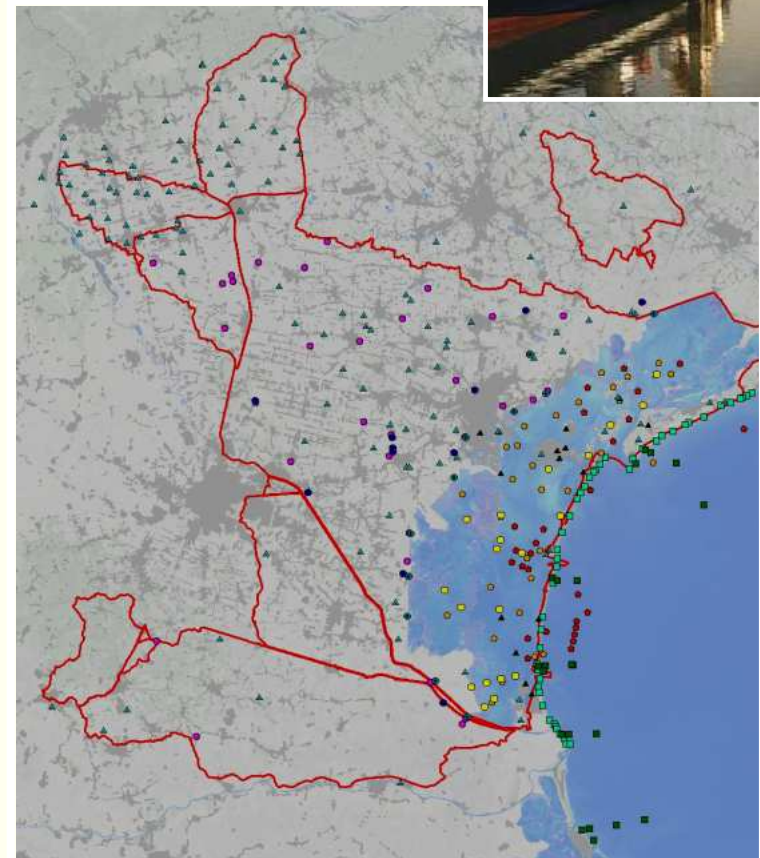


*Source: Venice municipality, Venice Water Authority, 2008*

# Venice safeguard: *systems of knowledge*

## Tot. investment €385 million:

- studies, investigations, experiments, environmental monitoring, tidal forecast
- Wide network of monitoring stations and availability of data
- Good knowledge of state of the environment, processes and trends in the lagoon ecosystem



## *Water bodies monitoring stations*

Source: Veneto Region and Venice Water Authority, 2005

## The safeguard programme as an adaptation solution in the *short and mid-term*

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- So far, safeguard measures have improved environmental quality and protection of coastal and lagoon settlements, thus enhancing Venice adaptive capacity
- In a few years most of the safeguard works will be finished, further improving adaptive capacity. They will ensure:
  - **protection from extreme high waters** → mobile barriers
  - **protection from most frequent high waters** → walkway raising and embankment restoration
  - **protection from sea storms** → coastal defences
  - help to **restore** environmental balance and **natural resilience and adaptability** → habitat reconstruction and pollution abatement

## The safeguard programme as an adaptation solution in the *long run*

	ADVANTAGES	DISADVANTAGES
Mobile barriers	Protection of up to 60cm sea level rise Positive environmental effects by flexible management	Increasing number of inlet closures
Walkway raising	Possible further raising helps reducing number of inlet closures	Architectonical structure of urban centres
Environmental defence	Improvement of natural resilience and adaptability	Possible unknown effects on ecosystems due to climate change
Coastal defence	Possibility to maintain protection of coastal strips	Need to enhance sea walls and reinforce structures
Urban restoration	Possibility to further increase resistance	Continuous maintenance

## Limits to adaptation: legislative, institutional and managerial complexity

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- **Over-legislation:** special, ordinary, *ad hoc* temporary legislative tools to manage emergency
- **Split** and some **overlap** of institutions' **responsibility**
- **Lack of coordination** of knowledge, institutions, management tools
- **Separated monitoring systems** for lagoon, drainage basin, sea → duplication of data and stations, incomparability of data, short-term data series



**undermine the management** of the defence facilities **and** therefore the **ability to cope with climate risks in the long run**

## **Taking advantage of opportunities and overcoming disadvantages**

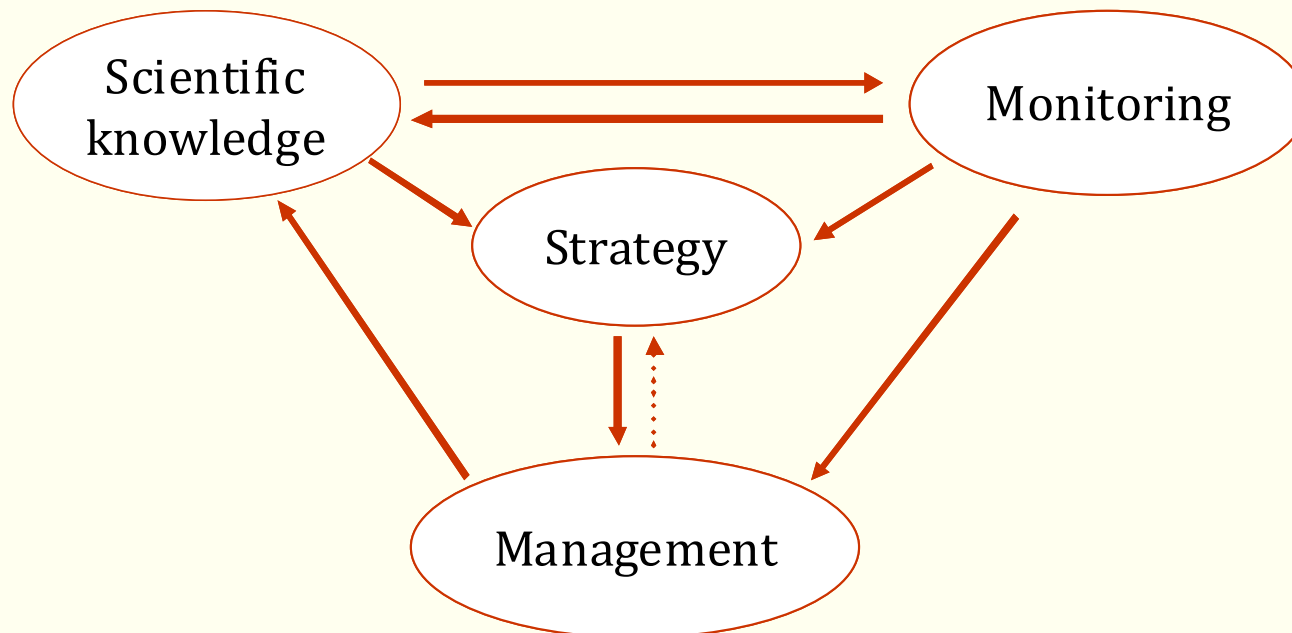
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- Development of a **sustainable management strategy** for the whole safeguard programme
- Establishment of **an authority** to implement the strategy, which:
  - integrates safeguard objectives and management of defence infrastructures
  - coordinates all important sectors and levels of government over the Venice lagoon, its drainage basin and the sea
  - coordinates the different monitoring systems and creates a unified system of information to support decision-making
- **Reinforcement of scientific research** of local climate change and impacts on the Venice lagoon

## Conclusions: adapting adaptation

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- Venice has **potential to improve** as an adaptive system
- Adaptation is a dynamic process that requires:
  - **coordination** of sound knowledge, institutions and management tools
  - **a balanced mix** of institutional arrangements and structural measures
  - management over a **wide territory**



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*Surfing on a  
wakeboard in St.  
Mark's square -  
December, 1st  
2008*

**Adaptation?**



*Photo by Joerg Mitter*

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