Υδραυλική και Υδρολογική Μηχανική: Διαχείριση του Ουσιωδέστερου Φυσικού Πόρου

Hydraulic and Hydrologic Engineering: Managing Life's Most Essential Element

Συνεδρίαση Υποεπιτροπής Πολιτισμού, Πολυμορφίας και Κληρονομιάς της Κοινοβουλευτικής Συνέλευσης του Συμβουλίου της Ευρώπης

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Overview

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3. Flood Risk
4. Water Preservation
5. Coastal Erosion
6. Conclusion

Introduction

- “Αρχήν των πάντων απεφήνατο το ύδωρ” - Θαλής ο Μιλήσιος
- “The primary principle of everything is water” - Thales of Miletus
- “Water is the driving force of all nature” - Leonardo da Vinci

- The **positive** effect of water:
  - Drinking water supply
  - Irrigation
  - Energy (hydroelectric and hydrokinetic power)
  - Navigation (sea and river transport routes)

- The **negative** consequences of water:
  - Flooding (fluvial and coastal including tsunamis)
  - Landslides
  - Coastal erosion

Water & Engineering (1)

The role of Engineers is the design of **works, systems and processes** to:

- Manage/facilitate the positive effects of water.
  - Water storage, treatment and distribution
  - Wastewater collection and treatment
  - Rainwater drainage networks
  - Irrigation systems
  - Hydroelectric and hydrokinetic power
  - Ports and river canals
    - Challenge: Achieve sustainable use of water resources.
- Protect life/infrastructure against the negative aspects of water.
  - Flood hazard/risk maps and prevention/mitigation management plans
  - River levees and dikes
  - Coastal groins and detached breakwaters
    - Challenge: Resilient solutions to climate variability/change.

Water & Engineering (2)

Cornalvo Dam, Spain,

Roman Gravity Dam,

1st or 2nd century AD

Peiros-Parapeiros Dam,

Greece, Gravity Dam,

2019, 2021

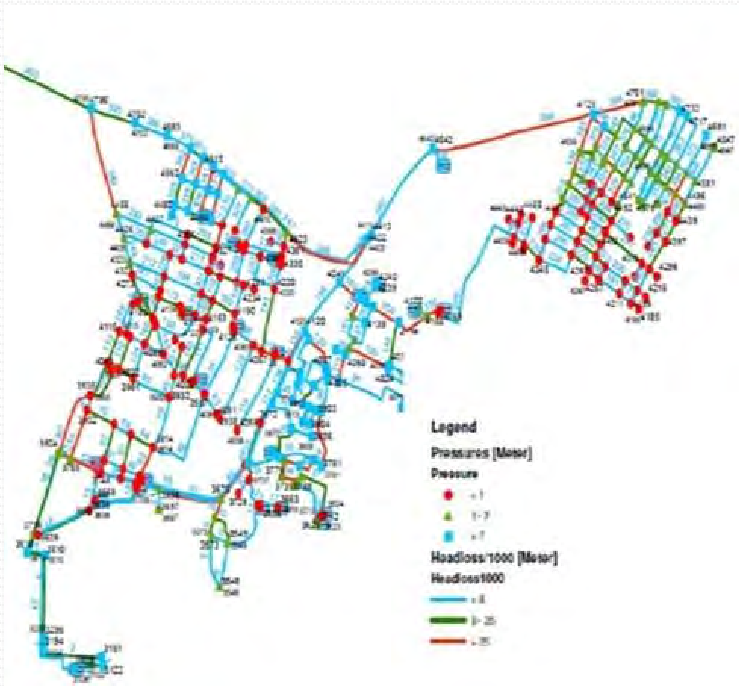
Water & Engineering (3)

Water treatment facilities

Wastewater treatment facilities

Water & Engineering (4)

Water distribution networks



Eupalinos Tunnel, Samos, Greece
6^{th} century BC

Mornos, Greece

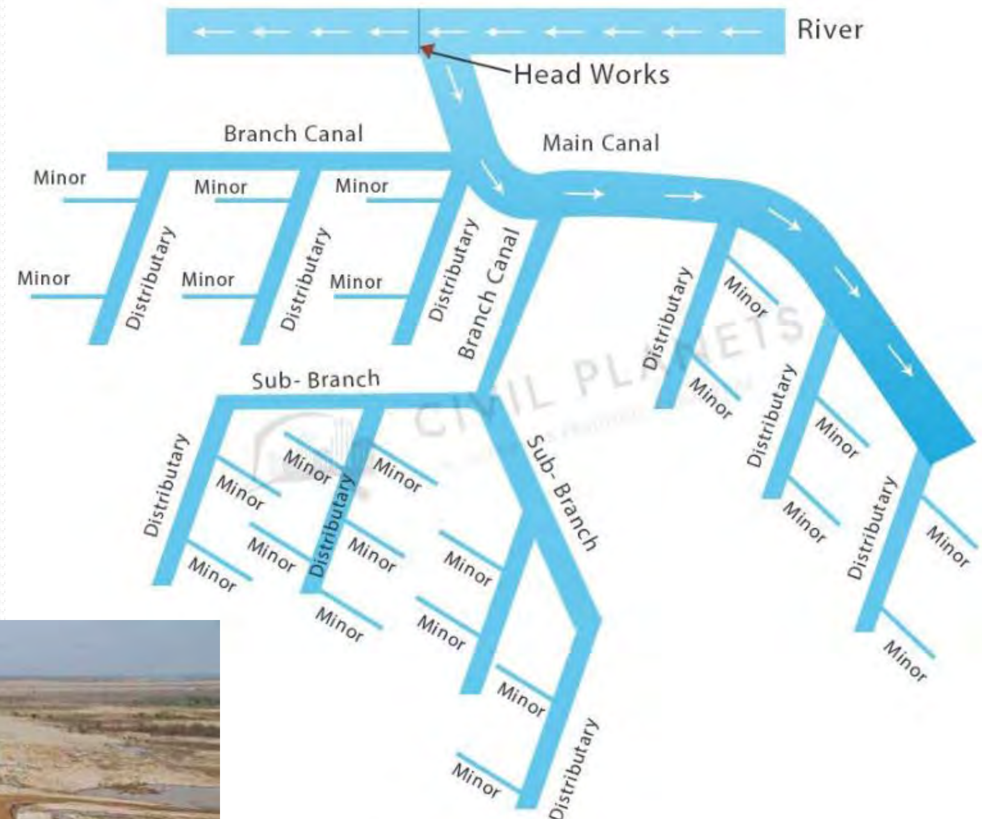
Aqueduct, Pont du Gard, France

Clay Water Pipeline

Naxos, Greece, 6^{th} BC

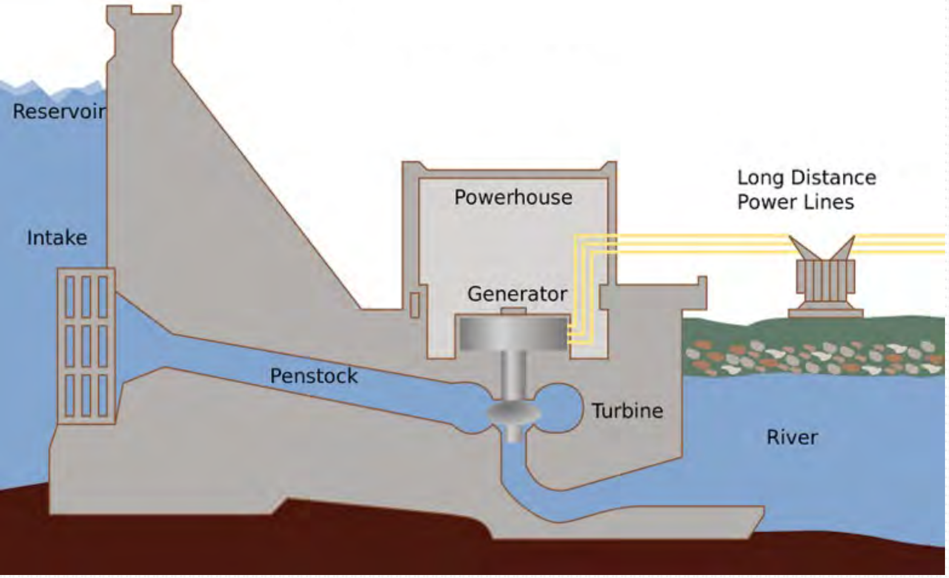
Water & Engineering (5)

Irrigation canal systems

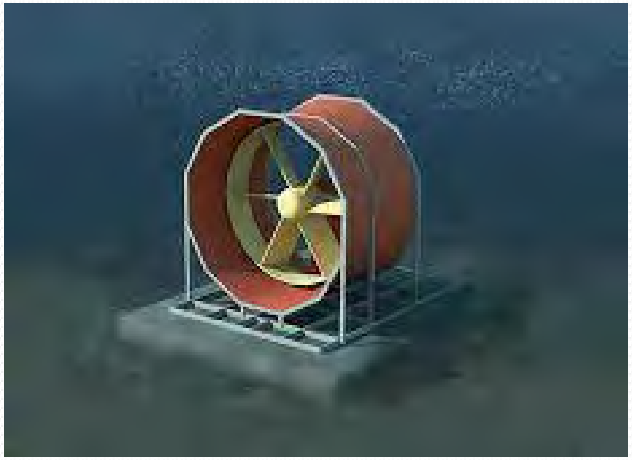


Water & Engineering (6)

Hydroelectric dams



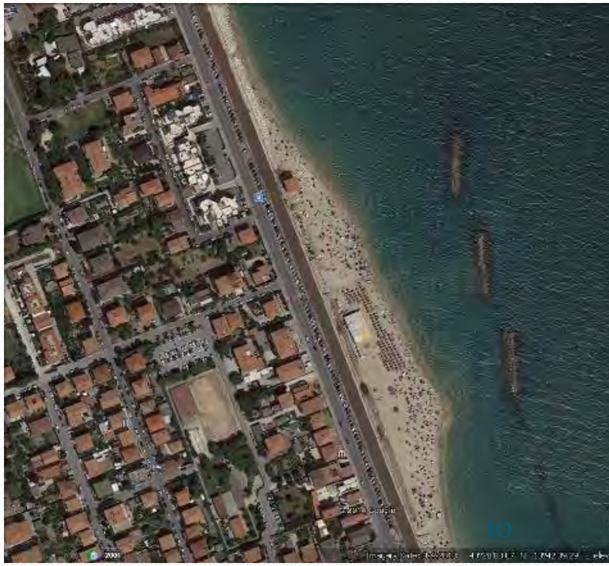
Hydrokinetic systems



Water & Engineering (7)

River levees and dikes

Detached breakwaters and coastal groins



Flood Risk (1)

➢ The blame game of flood occurrence:

- Climate variability/change (i.e. long-term variations of regional hydroclimatic extremes)
- Change and/or intensification of land uses
- Increase of the density and extent of urban areas
- Project development in regions lacking the required (flood prevention) infrastructure
- Interventions in streams and watercourses (culverts, closed channels, etc.)
- Inadequate maintenance (e.g. dredging or cleaning) of existing storm water drainage systems, rivers and channels
- Wildfires ⇨ Increase of surface runoff
- Population growth and underestimation of flood risk by individuals

➢ *The frequency of flood events and their impacts may change even if the frequency of extreme rainfall events remains approximately the same …*

Flood Risk (2)

- Solutions based on **Preparation - Prevention - Mitigation - Adaptation →**

Life and infrastructure protection:

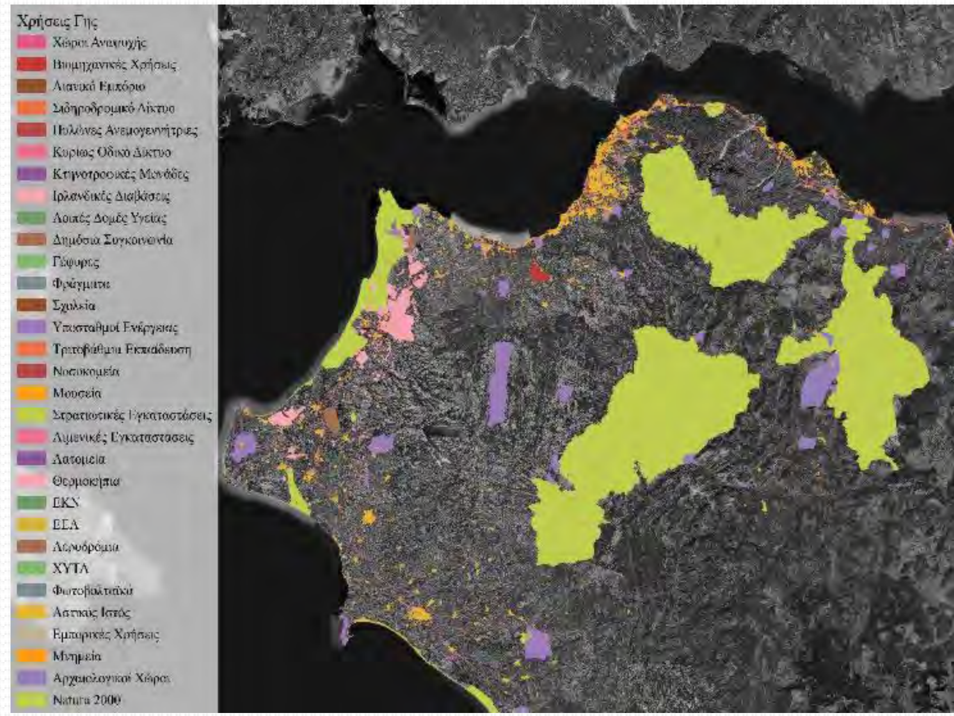
  - Maintaining an updated hydrometeorological database
  - Recording/tracking of historical flood events for disaster assessment (official records from competent authorities)
  - Land use mapping with emphasis on critical infrastructure (based on technical, economical, societal, and environmental criteria)
  - Estimation of Flood Risk in areas of increased interest (based on flood susceptibility maps)
  - Identification and registration of critical infrastructure within flood prone areas
  - Mapping and evaluation of existing flood protection infrastructure
  - Prioritization of actions (i.e. design of new and interventions to existing infrastructure)

- **Improve citizens' perception of security to water related hazards**
- **Significant reduction of flood claims**

Flood Risk (3)

Region of Western Greece: Water District of Northern Peloponnese (EL02)

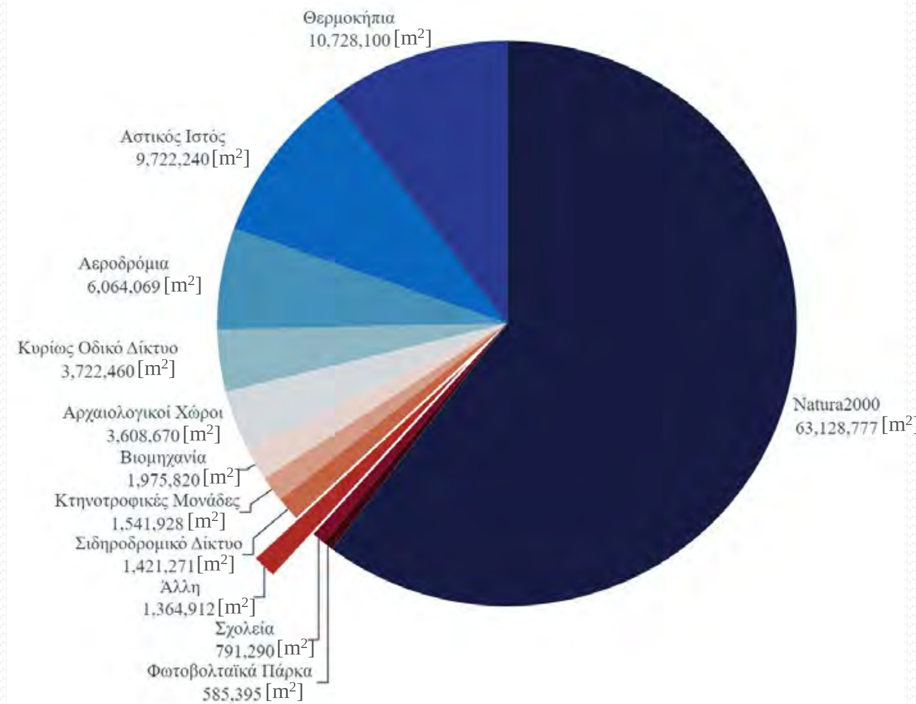
Flood plain corresponding to the 1000 yr flood event, for areas of the Water District of Northern Peloponnese (EL02) under the jurisdiction of the Region of Western Greece.



Map of land uses and critical infrastructure for areas of the Water District of Northern Peloponnese (EL02) under the jurisdiction of the Region of Western Greece.

Flood Risk (4)

Region of Western Greece: Water District of Northern Peloponnese (EL02)



Total risk estimates in areas of the Water District of Northern Peloponnese (EL02) under the jurisdiction of the Region of Western Greece.

Categorization of the total area in the Water District of Northern Peloponnese (EL02) under the jurisdiction of the Region of Western Greece, with respect to the different types of critical infrastructure.

Water Preservation (1)

- Although disastrous, floods are short (in time) and sparse (in space) natural phenomena that affect limited areas. **Are we ready for a long-term drought;**

Kallio, Mornos (2007)

In the next decades, across the southern parts of Europe and the Balkans, the minimum flow in rivers is expected to decrease significantly, with simultaneous increase of the duration of dry periods (JRC EC & UKassel: Forzieri *et al.*, 2014, HESS).

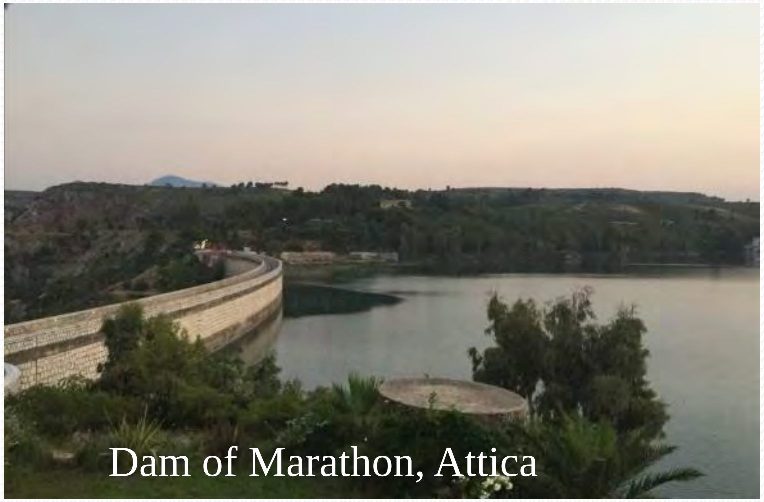
- **Increased water demand during summer**, due to intensification of tourism.
- **Excessive exploitation of groundwater reserves** (i.e. over-pumping) could lead to encroachment of seawater into fresh groundwater supplies (**saltwater intrusion**).

Water Preservation (2)

- Solutions based on **Preparation - Prevention - Mitigation - Adaptation** →

Increase water reserves:

- Water import
- Desalination of seawater (unlimited use)
- Construction of reservoirs
- Reuse of treated wastewater (irrigation)
- Artificial recharge of groundwater reserves



Dam of Marathon, Attica

Artificial reservoir in Livada, Tinos

Water Preservation (3)

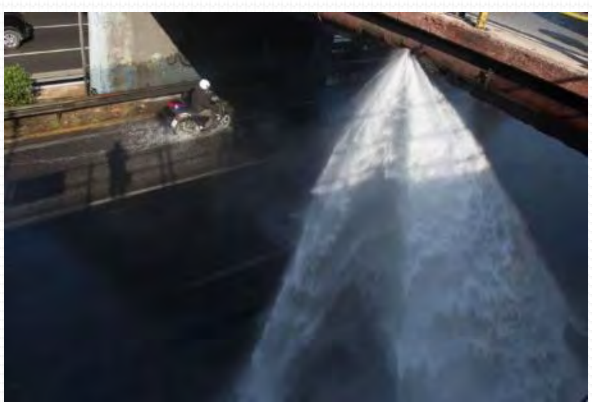
- Solutions based on **Preparation - Prevention - Mitigation - Adaptation** →

Water conservation:

  - Minimize residential consumption (e.g. installation of water saving systems)
  - Water losses estimation in Water Distribution Networks (WDNs)
  - Water losses reduction in Water Distribution Networks (WDNs)

- **Pressure regulation:**
  - Partition of Water Distribution Networks (WDNs) into Pressure Management Areas (PMAs; Serafeim et al., 2021, 2022a, 2022c).
  - Pressure management using Pressure Regulation Valves (PRVs; Serafeim et al., 2022b).

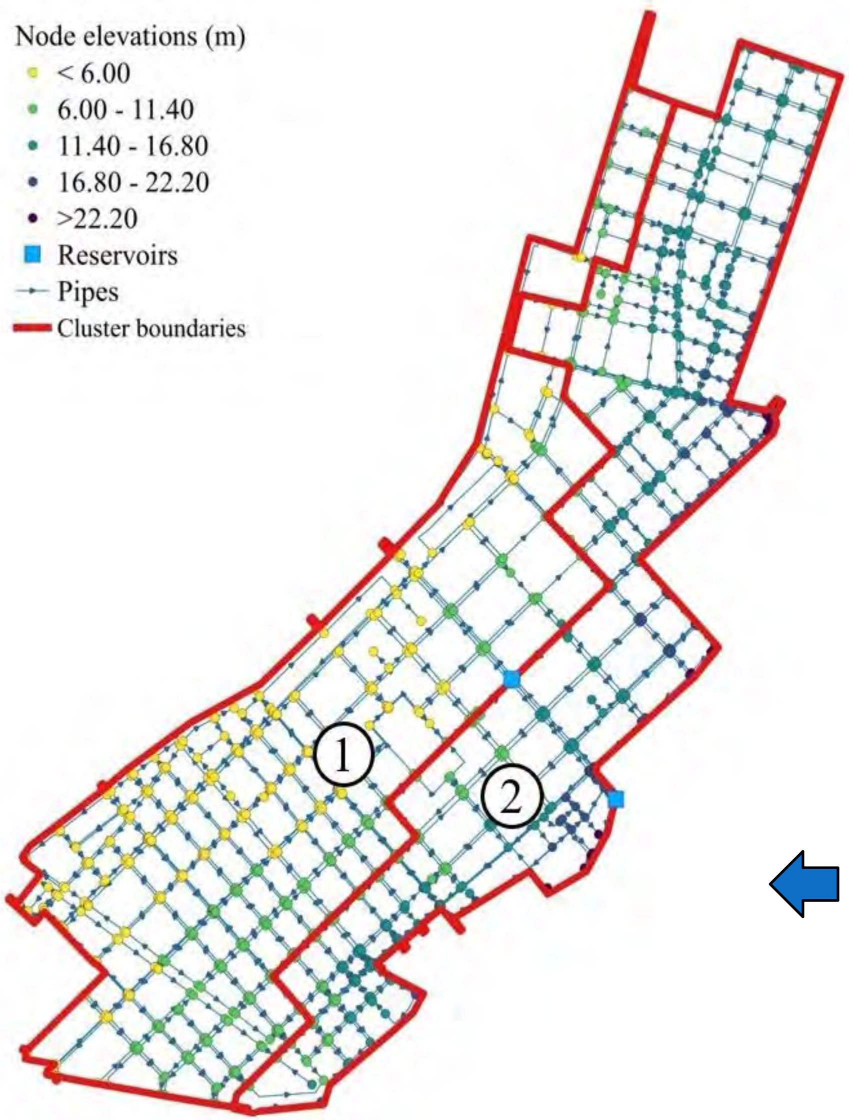
- **Detection and localization of leakages:**



Athens, November 2022

Patras, September 2021

Water Preservation (4)



Development of algorithmic methodology for partitioning of water distribution networks into smaller **Pressure Management Areas** (Serafeim et al., 2022c):

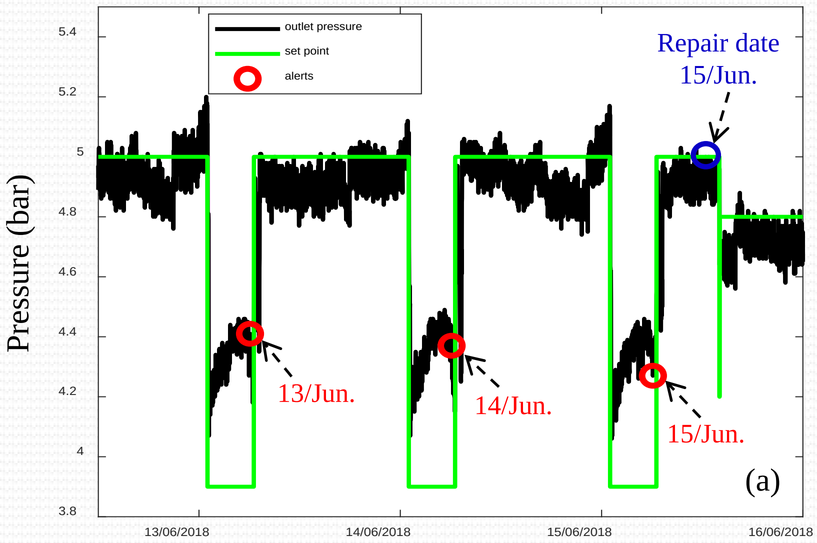
- Statistically reliable methodology
- Easily applicable
- Minimal time complexity
- Maintaining a sufficient level of hydraulic resilience
- Allows for optimal pressure regulation

Applying the proposed methodology to the city center of Patras leads to 13.5% reduction in the leakage rate (**900 m^3/day**; Serafeim et al., 2022c)

Water Preservation (5)

Development of statistical methodology for **early detection/alerting of malfunctions** in Pressure Regulation Valves (Perdios et al., 2022):

- Timely and reliable detection
- Reduction of response time
- Financial benefits
- Operational benefits.



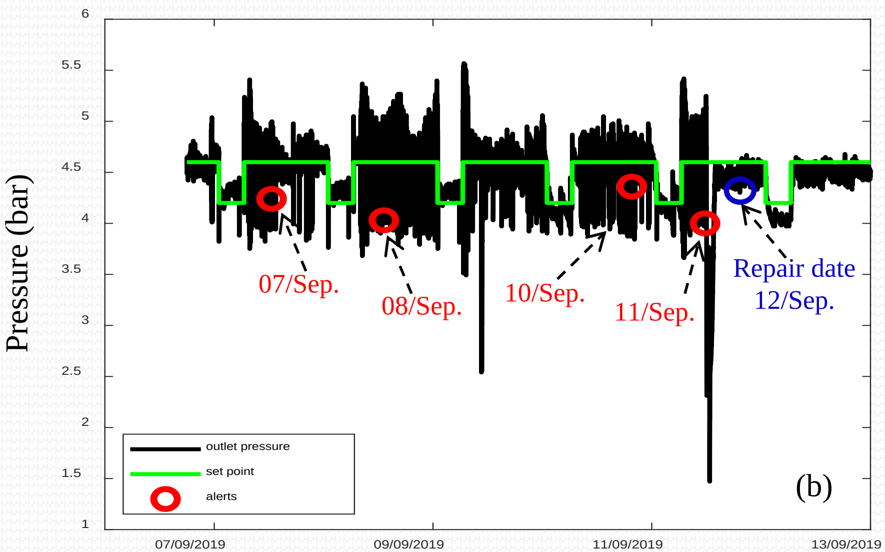


Illustration of PRV outlet pressure (black line) and set point (green line): (a) in June 2018, and (b) September 2019. Red circles denote the date of alerts issued by the developed framework, whereas blue circles denote the repair dates reported by the competent authority.

Coastal Erosion (1)

- **Wave-generated** nearshore processes (Dimas and Koutrouveli, 2019; Leftheriotis and Dimas, 2022) induce sediment transport/removal (longshore and/or cross-shore) and cause coastline retreat. Their dynamic equilibrium depends on:
  - Variability of environmental loads (waves)
  - Effect of coastal infrastructure
  - Sediment supply by external sources (i.e. rivers)
- **Coastal vulnerability** is assessed based on the following relative risk variables:
  - Mean land elevation
  - Local subsidence trend
  - Geology and Geomorphology
  - Mean shoreline displacement
  - Maximum wave height
  - Mean tidal range

Coastal Erosion (2)

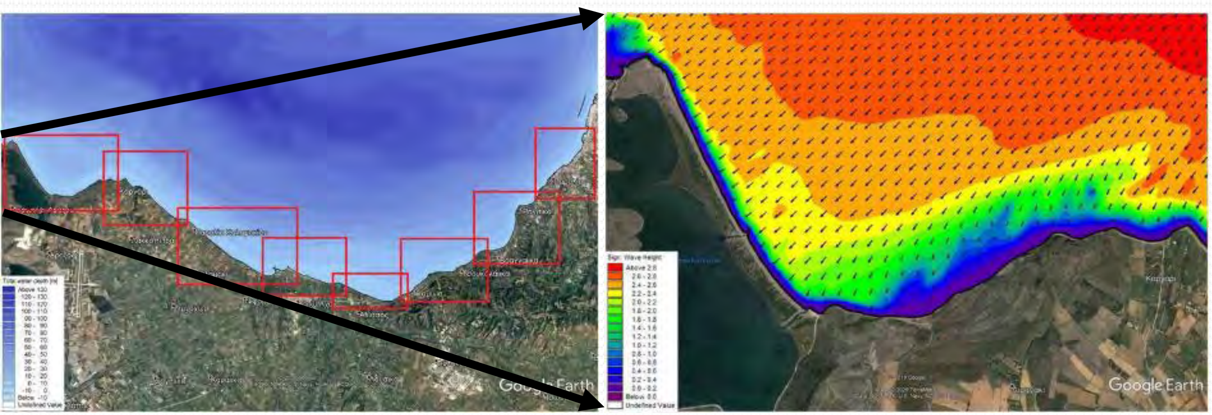
- The European Commission (1999) recommends that coastal problems, including erosion, should be addressed using an Integrated Coastal Zone Management (ICZM) strategy.
- ICZM is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones.
- It includes information/data collection, planning/design, decision making, management and monitoring of implementation.
- "Integrated" in ICZM refers to:
  - Integration of objectives and also integration of the many instruments needed to meet these objectives.
  - Integration of all relevant policy areas, sectors, and levels of administration.
  - Integration of the terrestrial and marine components of the target territory, in both time and space.

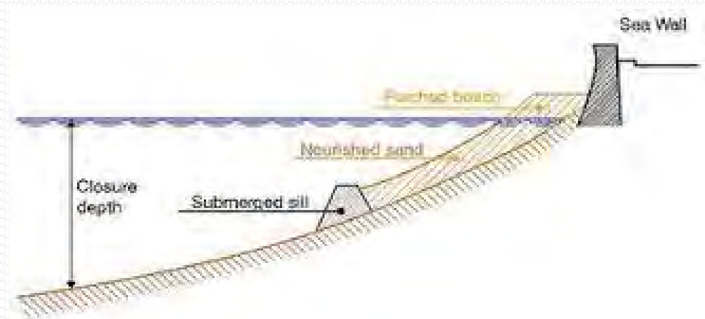
Coastal Erosion (3)

- The EU (2002) recommendation on the principles to be followed under ICZM:
  1. Broad thematic and geographic perspective.
  2. Long-term perspective.
  3. Adaptive management and sound knowledge basis.
  4. Local specificity.
  5. Working with natural processes, carrying capacity.
  6. Involvement of all the parties concerned.
  7. Support and involvement of relevant administrative bodies at national, regional and local level.
  8. Use of a mix of instruments, to facilitate coherence between sectoral policy objectives and coherence between planning and management.

Coastal Erosion (4)

- Elements of an ICZM strategy for the Gulf of Patras were set by the Interreg (Greece-Italy) funded project TRITON (www.interregtriton.eu).
  - Monitoring and measurements. Installation of a wave buoy system south of the Port of Patras.
  - Scientific knowledge basis. Assessment of nearshore processes by numerical modeling (Dimas and Leftheriotis, 2019).
  - Proposal for nature-based solutions for coastal protection against erosion. Perched beach nourishment.





Perched beach nourishment

Left: Satellite image (Google Earth) of the pilot area of the Gulf of Patras showing the 8 coastal independent subregions.
Right: Significant wave height and velocity (vectors) distribution due to NE waves in the coastal zone of subregion 1.

Conclusions

Monitoring /Measurements - Planning/Design - Implementation - Monitoring/Measurements

The pronounced spatial and temporal variability of water resources and environmental loads mandates extensive and up-to-date records of hydrometeorological data (**monitoring and measurements**) that are particularly important for the design of new and/or improvement of existing infrastructure to **effectively manage water resources** and achieve:

- **Sustainable water supply**: Balance the needs of different users and minimize losses.
- **Improved water quality**: Protect and improve the quality of water resources, reduce the risk of water-borne diseases and protect aquatic life.
- **Effective flood control**: Reduce the impact of floods by improving drainage systems, construct flood barriers, and develop early warning systems.
- **Ecosystem protection**: protect and restore aquatic ecosystems, preserve biodiversity and the services they provide.
- **Economic benefits**: increase agricultural production, reduce water treatment costs, and increase recreational opportunities.
- **Social benefits**: improve access to clean water for communities, reduce water-related health problems and improve life quality.
- **Adaptation to climate change**: adapt to the impacts of climate change, such as more frequent droughts, floods and increased erosion.

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