4th International Conference of the Global Network of Water Museums

Learning from the past
An overview of Mediterranean Ancestral Hydrotechnologies

Dr. Jordi Morató
Microbial Ecologist / Sustainability Science
jordi.morato@upc.edu
http://www.unescosost.org

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
UNESCO Chair on Sustainability

unesco Chair

A WORLD IN CLIMATE HEALTH EMERGENCY

Future of the human climate niche

Chi Xu (徐驰)[a,1], Timothy A. Kohler[b,c,d,e], Timothy M. Lenton[f], Jens-Christian Svenning[g], and Marten Scheffer[c,h,i,1]

[a]School of Life Sciences, Nanjing University, Nanjing 210023, China; [b]Department of Anthropology, Washington State University, Pullman, WA 99164; [c]Santa Fe Institute, Santa Fe, NM 87501; [d]Crow Canyon Archaeological Center, Cortez, CO 81321; [e]Research Institute for Humanity and Nature, Kyoto 603-8047, Japan; [f]Global Systems Institute, University of Exeter, Exeter, EX4 4QE, United Kingdom; [g]Center for Biodiversity Dynamics in a Changing World, Department of Bioscience, Aarhus University, DK-8000 Aarhus C, Denmark; [h]Wageningen University, NL-6700 AA, Wageningen, The Netherlands; and [i]SARAS (South American Institute for Resilience and Sustainability Studies), 10302 Bella Vista, Maldonado, Uruguay

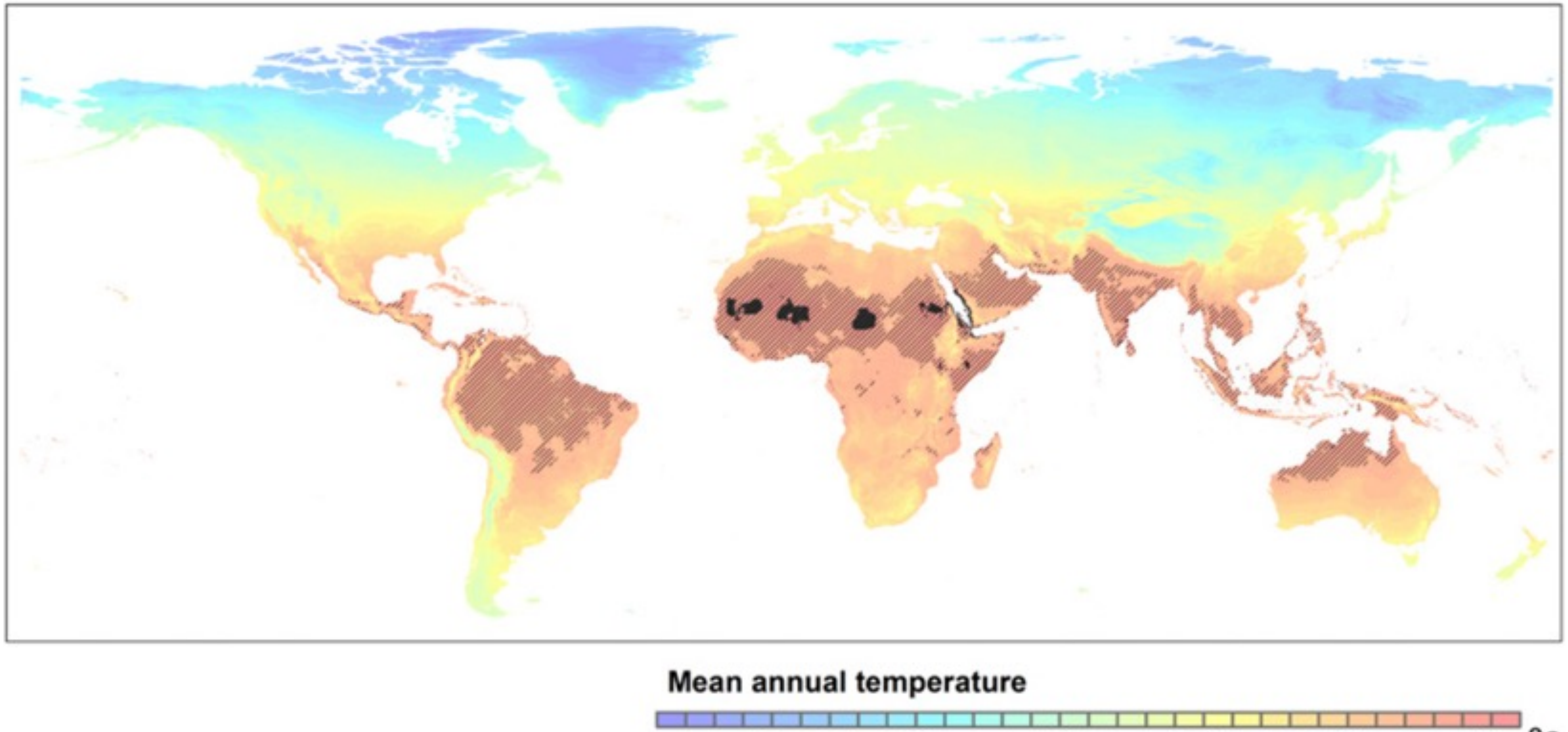
HUMAN CLIMATE NICHE

(mean annual T)

11-15 ºC

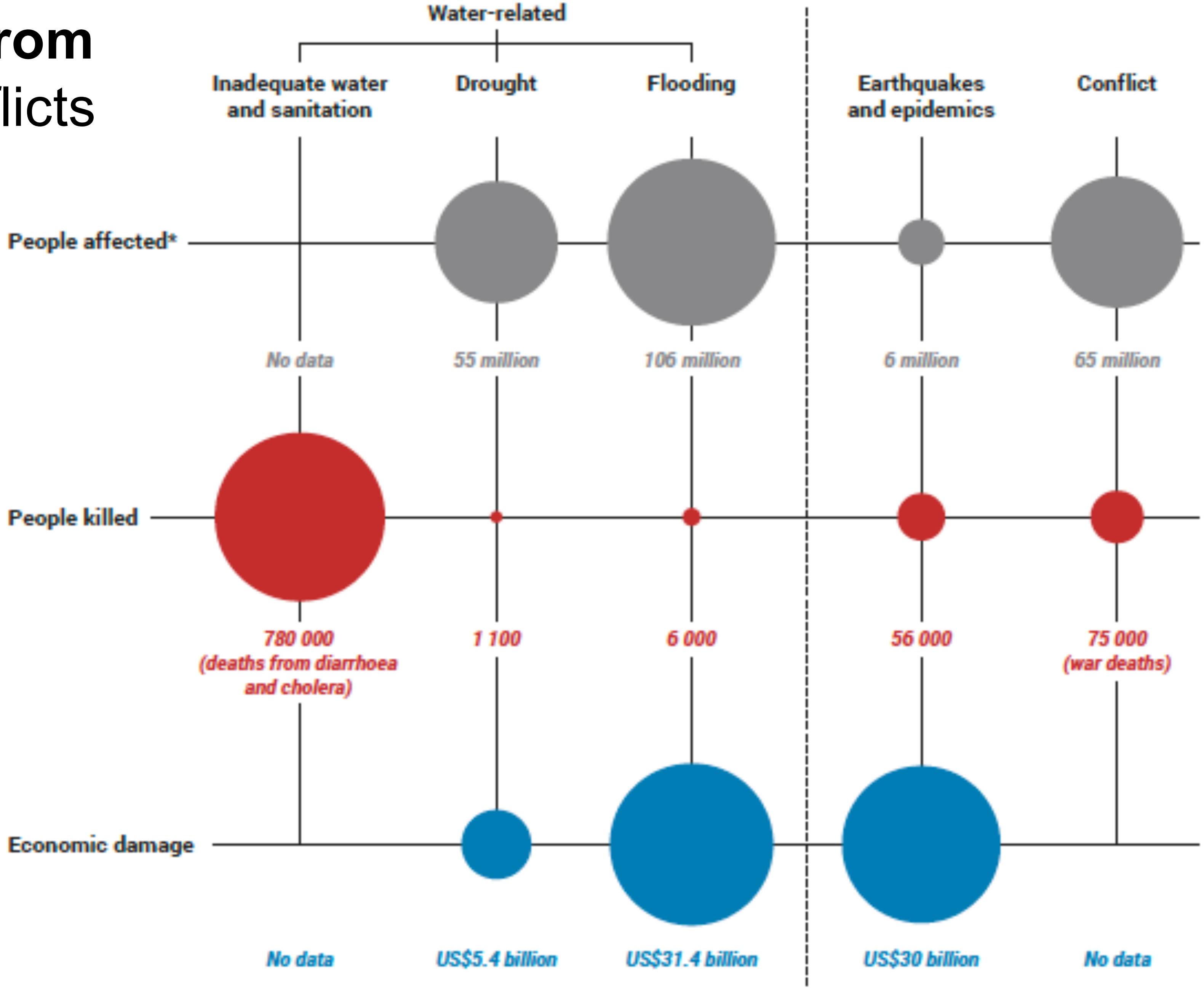
MAT > 29ºC

50 year scenario



PNAS May 26, 2020 117 (21) 11350-11355; first published May 4, 2020 https://doi.org/10.1073/pnas.1910114117

Average **annual impact from water problems** and conflicts



PBL Netherlands Environmental Assessment Agency, 2018

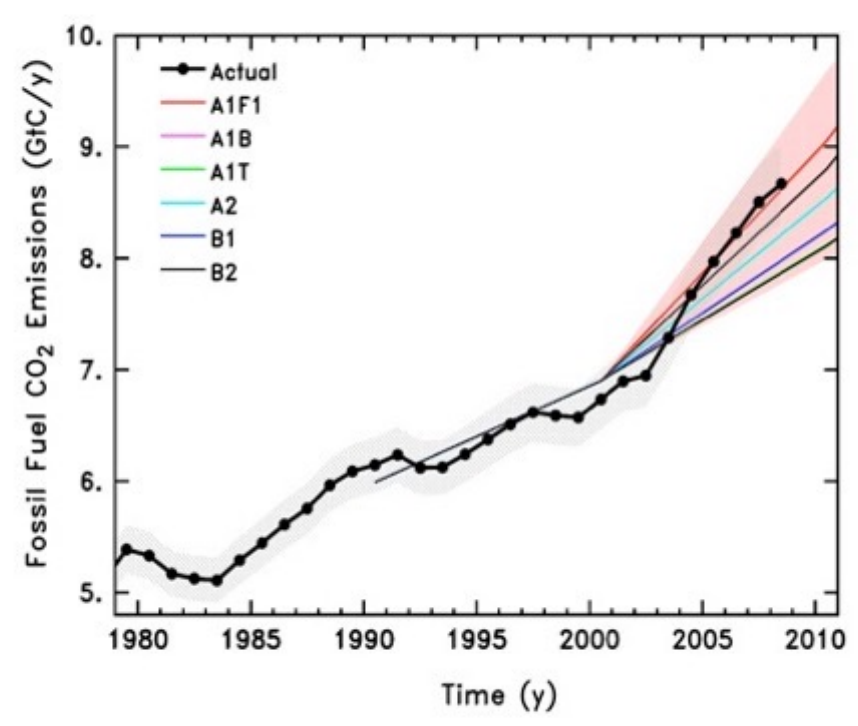
Territorial model that spreads and expands to exploit resources

City as a consumption system

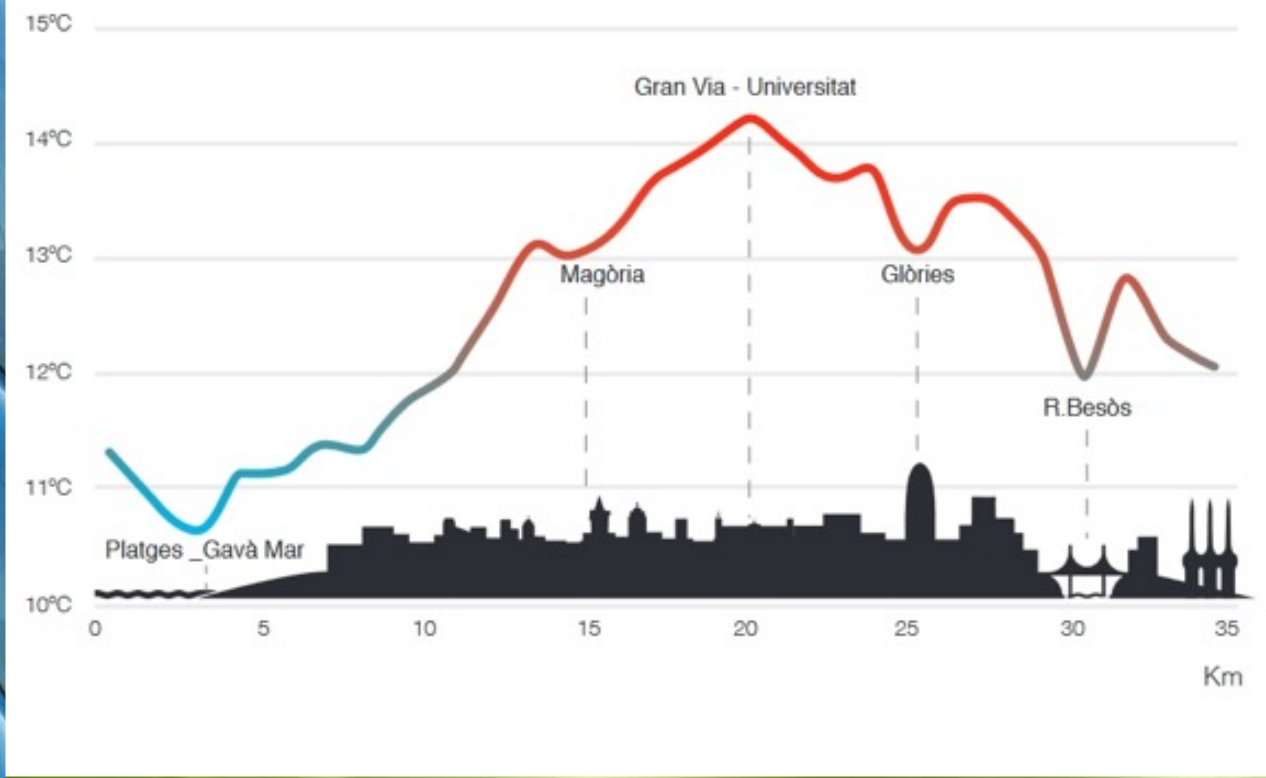
2% surface

50% population

>75% GHG emissions



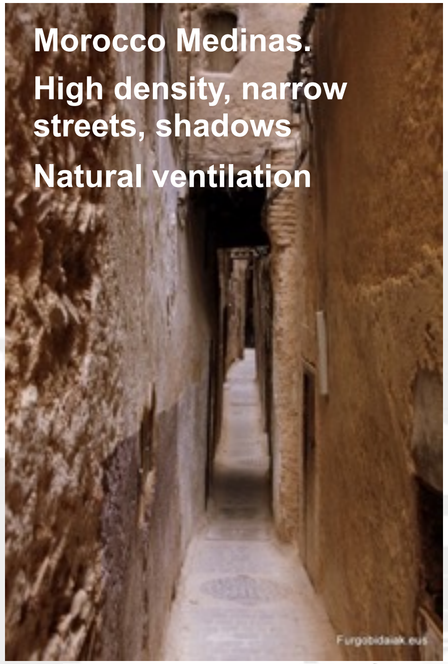
HEAT ISLAND EFFECT



UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
UNESCO Chair on Sustainability

unesco
Chair

CAN WE LEARN FROM THE PAST TO ADAPT TO FUTURE?



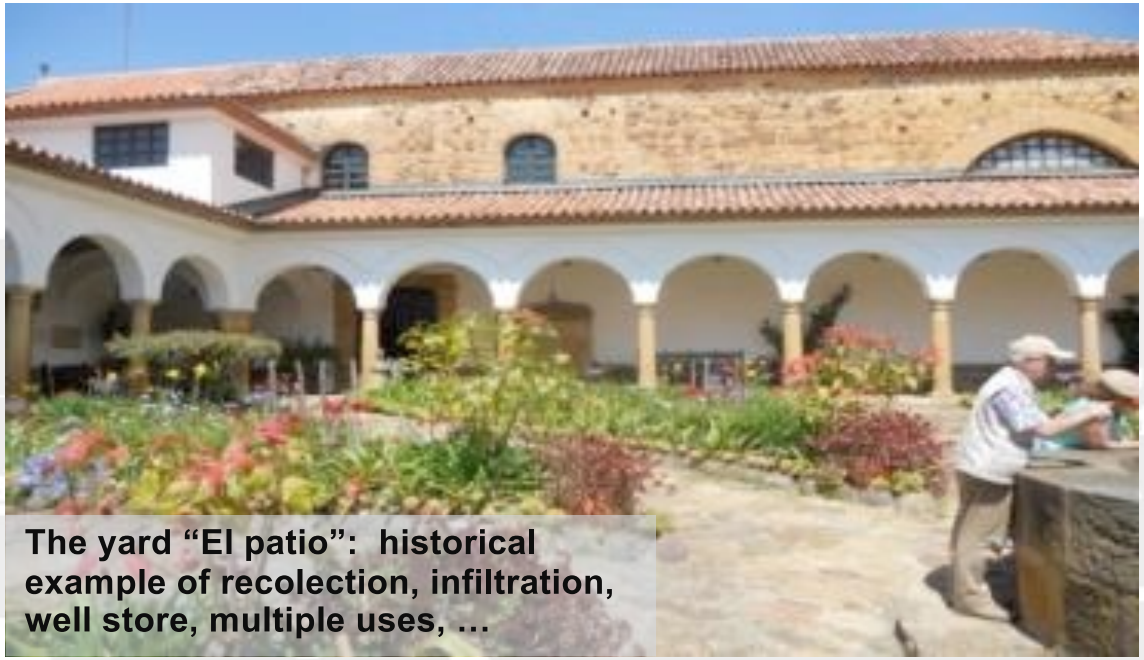
Morocco Medinas.

High density, narrow streets, shadows

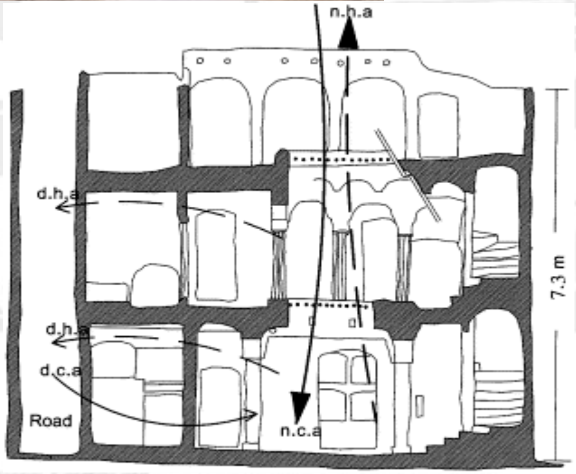
Natural ventilation

Human beings have been historically able to adapt to extreme conditions.

Understanding **how a local population have been co-existing with extreme events and conditions in the past, managing and adapting to their environment.**



The yard "El patio": historical example of recolection, infiltration, well store, multiple uses, …



Recover, understand and transfer the specific socio-ecological-cultural and technical systems (SETS), the **intangible heritage, basic to improve climate adaptation**

LEARNING FROM THE PAST

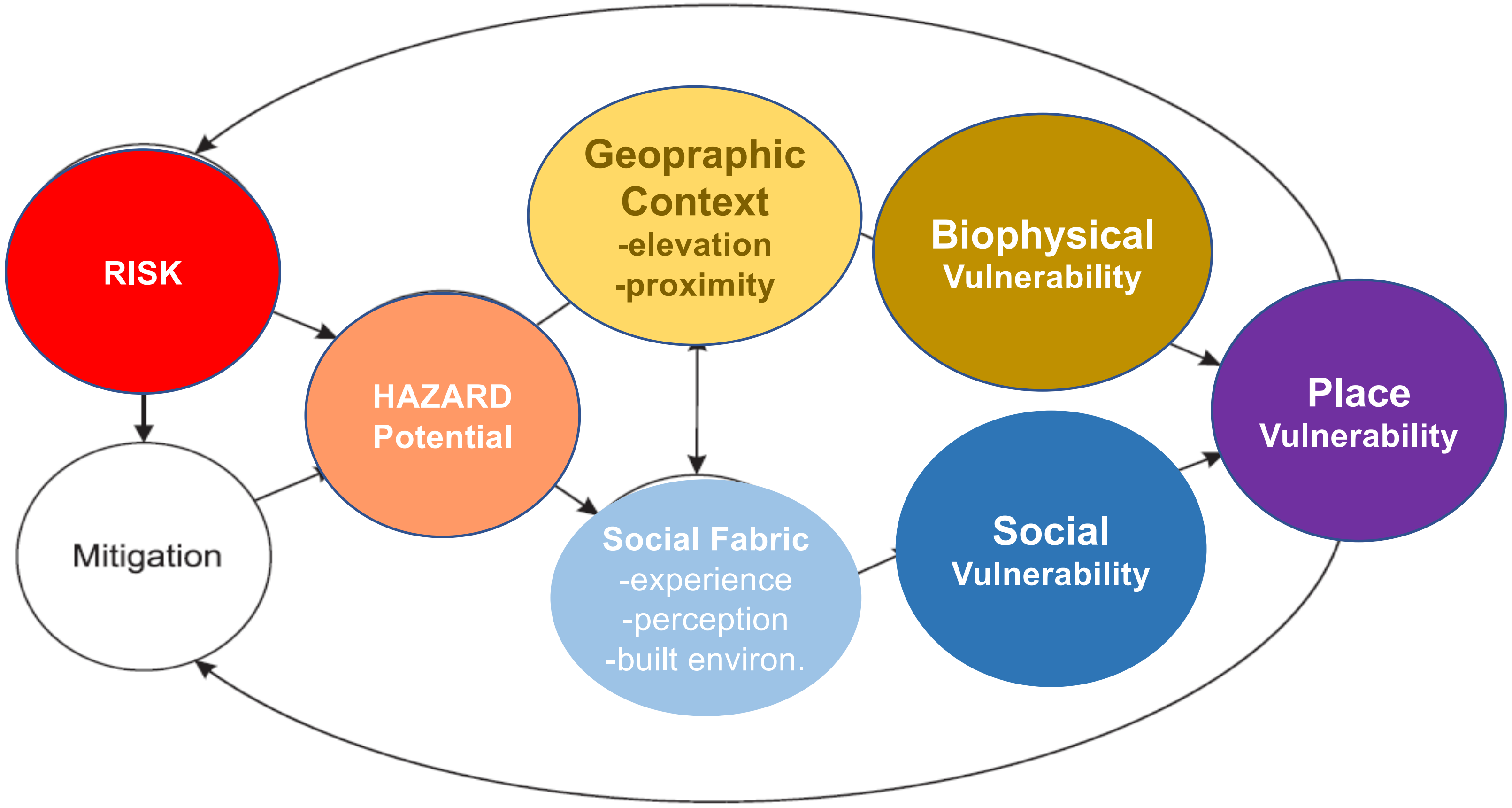
Knowledge of the specific socio-cultural and technical system of an area is essential to understand how a **local population has coexisted with extreme events** in the past, **managing their adaptation to the environment.**

Chia, Colombia - 2010

SOCIAL FABRIC – VULNERABILITY

Social Fabric: Experience of community with different threats, and its capacity to confront them, to recover and to adapt (to the presence and to the effects).

The place: Physical geography and its characteristics of built territory.



Cutter, S.L., Boruff, B.J. & Shirley, W.L. (2003). 'Social Vulnerability to Environmental Hazards', *Social Science Quarterly*, Vol. 84, No. 2: 242-261.

Web of Science Search

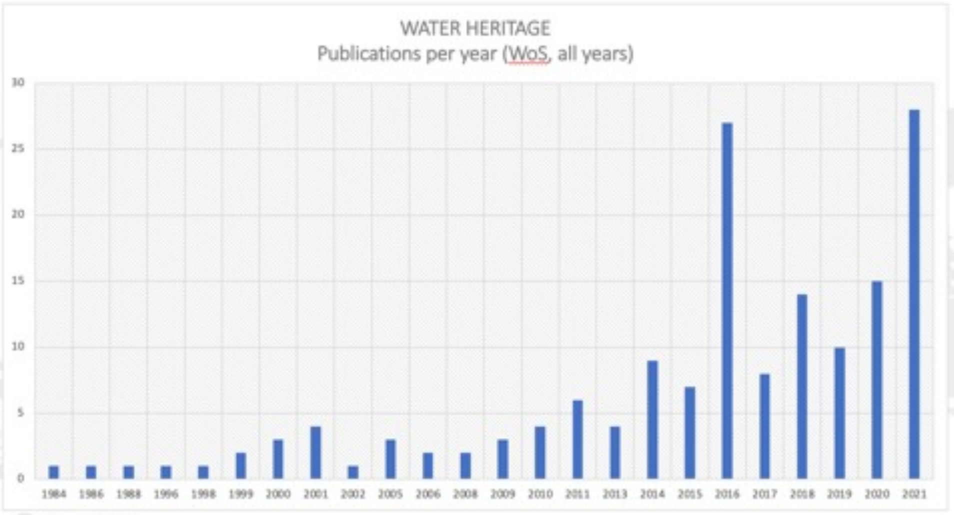
Hydro-Technologies (45)

Water Heritage (172)

Hydraulic Heritage (21)

Ancestral Water (24)

Ancient Water (24)

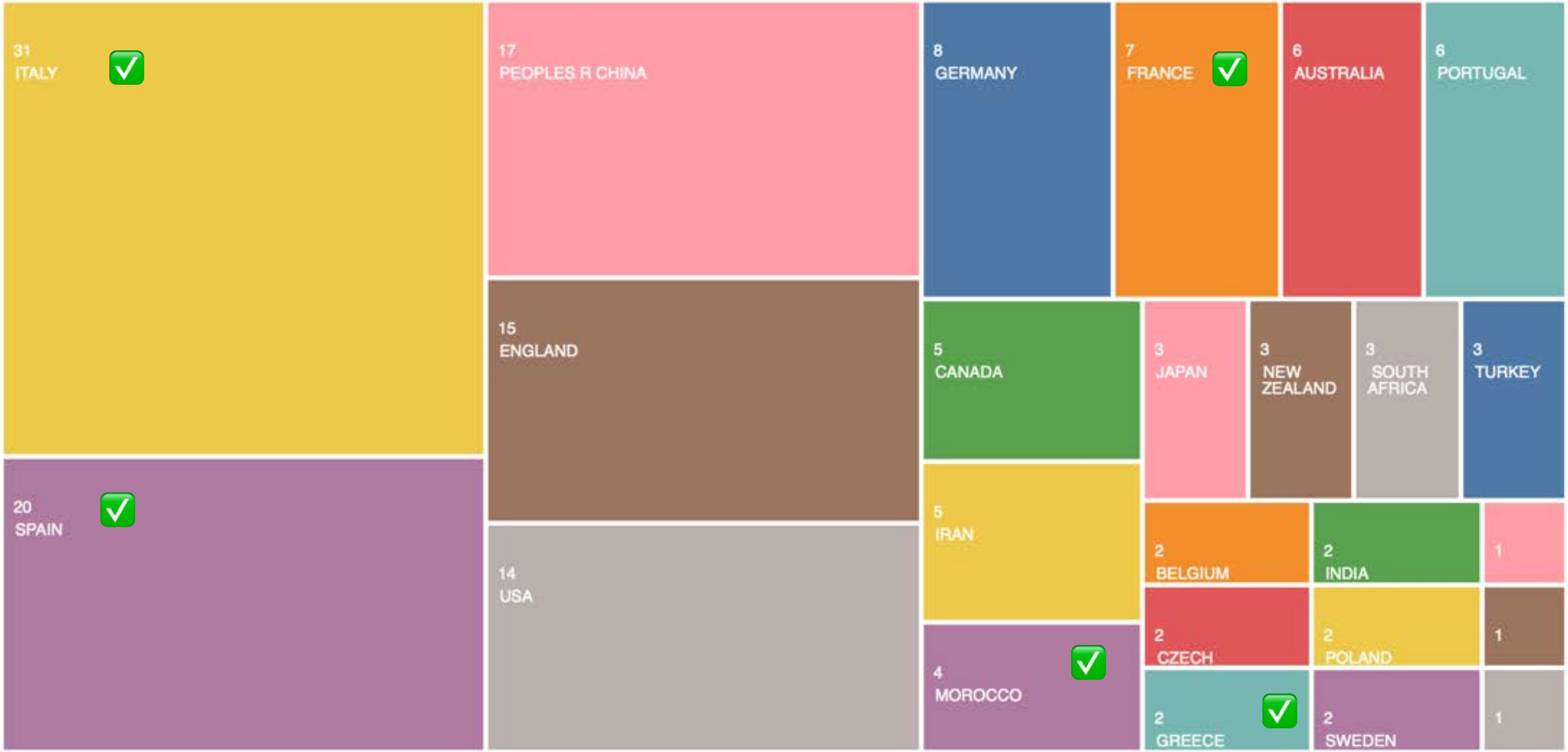


UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
UNESCO Chair on Sustainability

unesco Chair

MEDITERRANEAN AREA WATER HERITAGE

Water Heritage (172) by country



Hydraulic heritage – 21

Hydro-technologies – 45

Ancient Water - 24

Ancestral Water - 24

EGYPTIAN **Water Culture** (ca 3150-31 BC)

ETRUSCAN **Civilization –**
Tuscany, Umbria, Latium - Italy
(Iron Age, ca 800-100 BC)

ROMAN **Period**
(146 BC-AD 330)

MEDIEVAL **Period**
(5th – 10th Century)

MINOAN **Civilization**
Southeastern Greece
(Bronze age, ca 3200-1100 BC)

CLASSICAL AND HELLENISTIC **Times**
Greece (ca 480-100 BC)

INDUS VALLEY
Pakistan
(Bronze age, ca 3200-1100 BC)

ZENU SOCIETY
Colombia
(ca 600-400 BC)

PREHISPANIC AMUNAS
Peru
(XII-XIII Century)

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
UNESCO Chair on Sustainability

unesco Chair

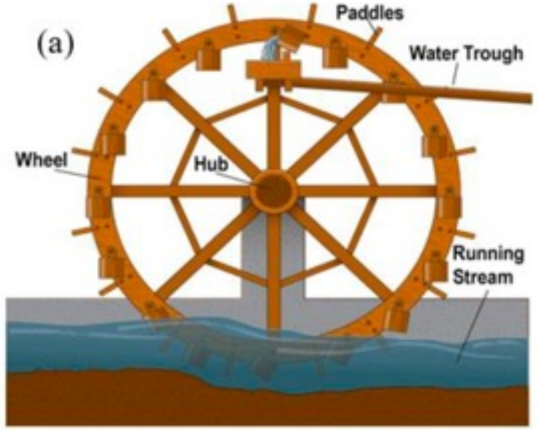
Egyptian Water Culture (ca 3150-31 BC)

Hydrotechnologies – Water Engineering

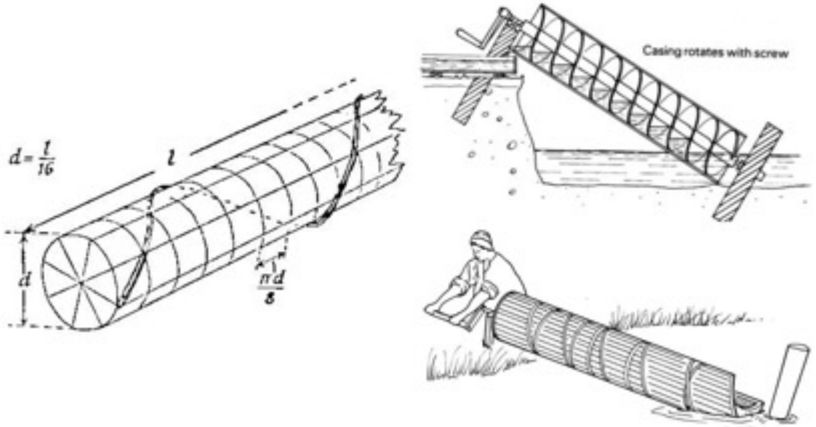
1. Water Lifting Devices for Irrigation

Shadouf for lifting water in ancient Egypt (1500 BC)

Hama on Orontes River in Syria



Paddle-driven water-lifting wheels had appeared in ancient Egypt by the 4th century BC. The Egyptians inventing the water known as sakia or Noria

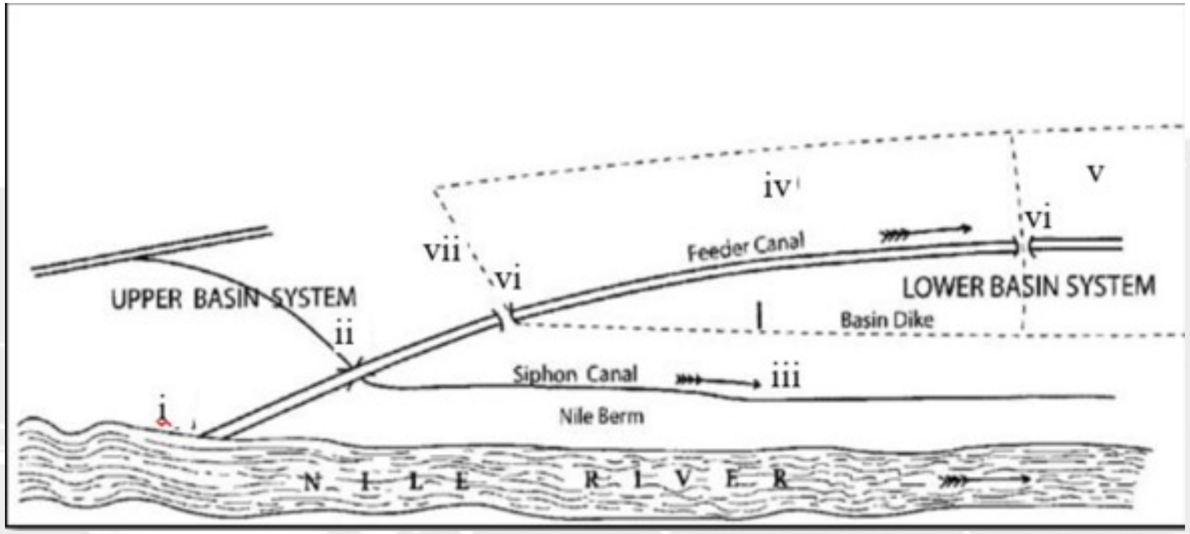


Archimedes screw, as described by Vitruvius, and similar devices

Egyptian Water Culture (ca 3150-31 BC)

2. Water Management for Irrigation

The **artificial irrigation** is considered to have been established by the 1st Dynasty in Egypt. **Artificial flooding and draining** were developed by using sluice gates and water contained by longitudinal and transverse **dikes**.

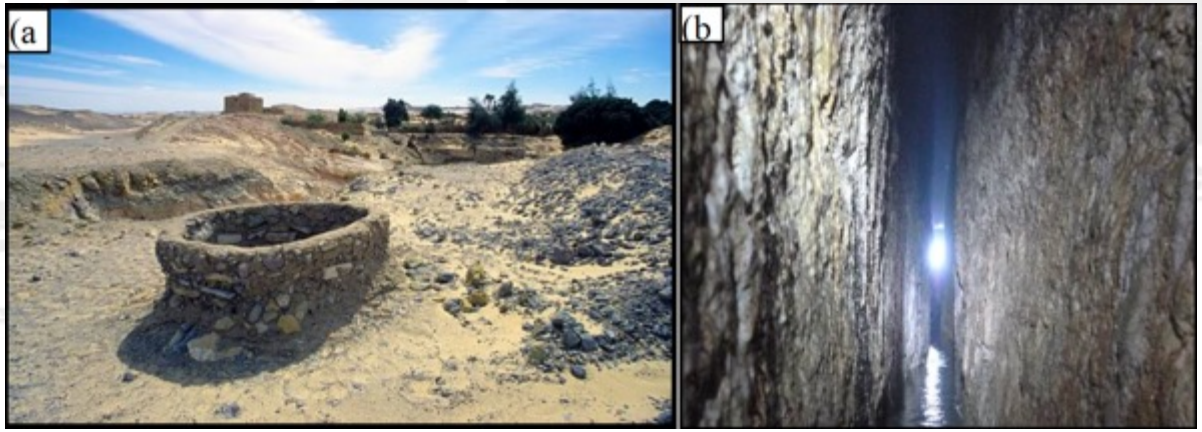


3. Agriculture

Due to their developed basin irrigation, ancient Egyptians are considered as the first people who were able to farm large-scale land.

4. Aqueducts – Underground Aqueducts (Qanats)

A qanat taps into groundwater in a manner that efficiently delivered large quantities of water to the surface without the need for pumping: The water drains by gravity, typically from an upland aquifer.

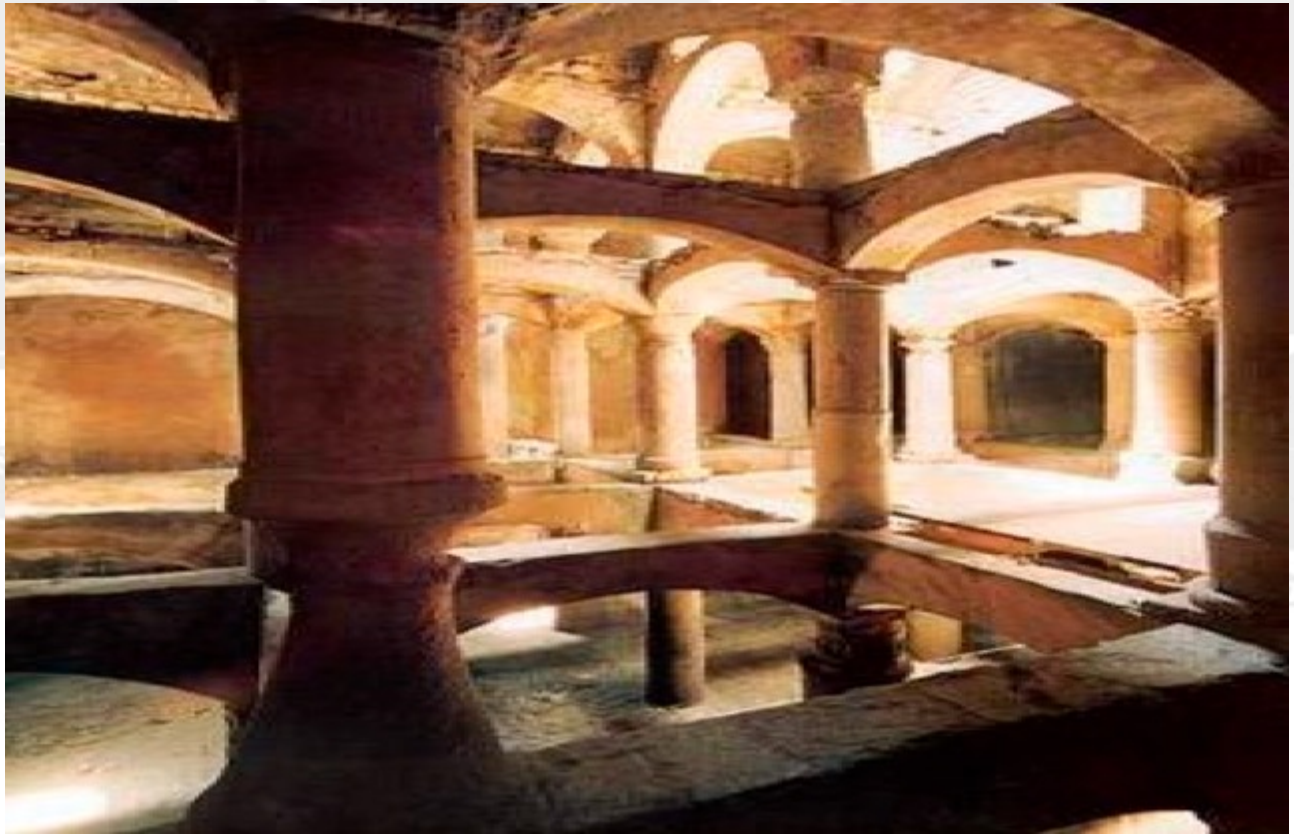


Egyptian Water Culture (ca 3150-31 BC)

5. Urban Water TReatment

The Egyptians first discovered the **principle and the basis of coagulation** (after ca. 1500 BC). They used a chemical alum to settle suspended particles This device caused settlement of "pollutants" of the water and purified water was siphoned and collected for reuse.

Alexandria's water supply was carried out through the Nile river of 12 km apart. The Nile water was stored in **hundreds of cisterns** through channels (500 cisterns). Sedimentation cisterns were probably used at that time.



6. Water Supply & Drainage System

7. Rainwater Harvesting

Minoan Civilization – Southeastern Greece (Bronze age, ca 3200-1100 BC)

Urban Hydrotechnologies - Hydraulic operation of water supply, sewerage, and drainage systems in Minoan palaces, cities, and other settlements

First evidence of the use of water and wastewater technologies such as aqueducts, water cisterns, water harvesting and distribution systems, as well as sewerage and drainage systems is in the Minoan Era.

These technologies were further developed by the Greeks over time, peaking during the Etruscan and Hellenistic periods.

Minoan **central sewerage and drainage systems**: at palace of Phaistos (left) and at palace of Knossos (right).

Minoan Civilization – Southeastern Greece (Bronze age, ca 3200-1100 BC)

Network of roads, which were well drained, and had **water and sewage distribution systems.**

Streets with paved roads including rainwater drains

Advanced water supply and sanitation technologies were practiced in Minoan Greece and the Indus Valley during the Bronze Age

Minoan Civilization – Southeastern Greece (Bronze age, ca 3200-1100 BC)

URBAN HYDRO-TECHNOLOGIES: Water Supply & Distribution

1. Cisterns, Reservoirs, and Rainwater Harvesting

Cisterns to store both rainwater and spring water

Dry climates are generally more convenient and healthier as they protect resident populations from water-related diseases. Technology of storage of surface runoff rainwater as well as that of transporting water by aqueducts was advanced.

2. Aqueducts

Long-distance systems for transporting water to the urban areas. Conduits carried water from mountain springs to cities, using open channels and closed pipes.

3. Dams

Make the cities more adaptive to flood hazards, and to improve the living standards of the people. Stones/clay mortar

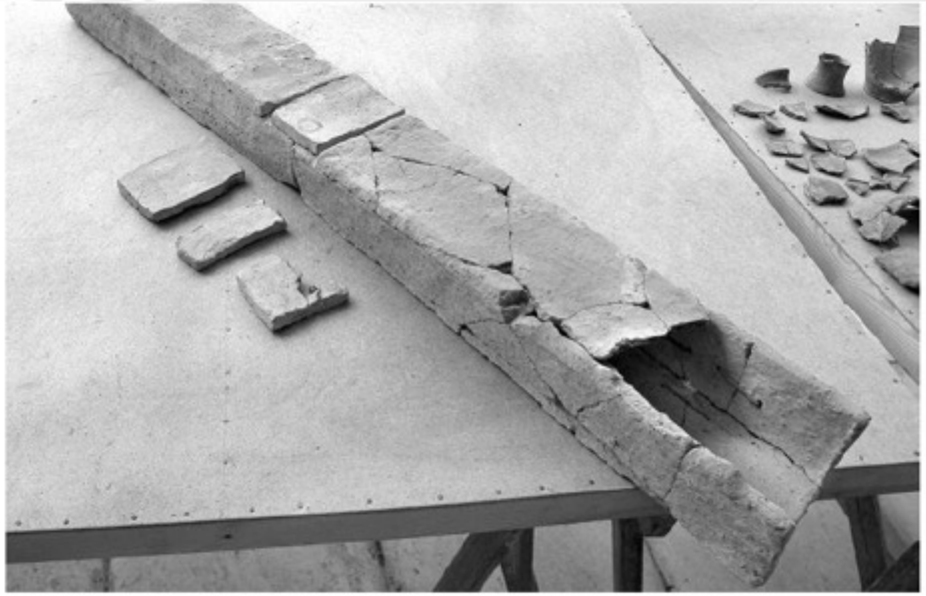
(a) small dams to intercept runoff waters in the seasonal streams
(b) larger dams for collecting and storing wáter
(c) dams for diverting surface water, mainly from rivers

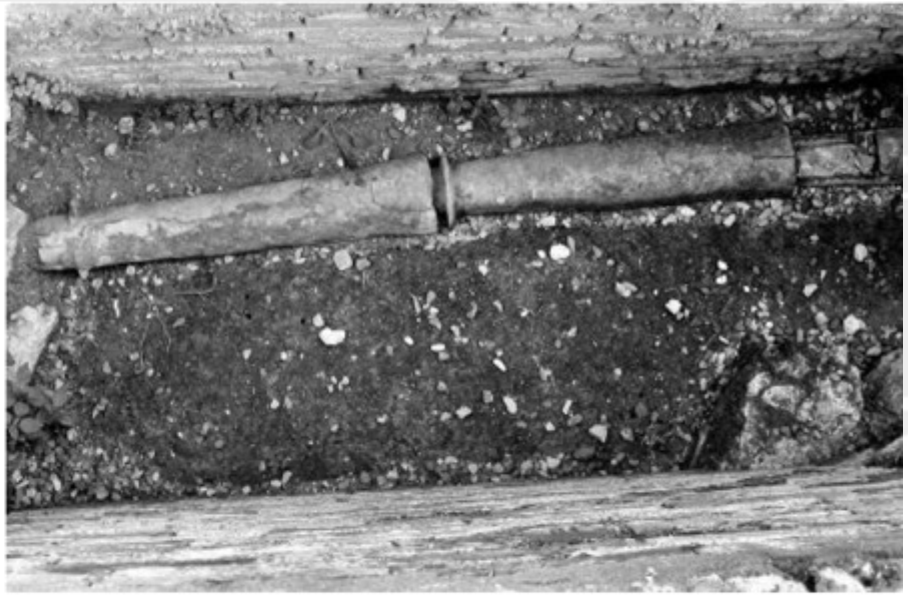
Minoan Civilization – Southeastern Greece (Bronze age, ca 3200-1100 BC)

URBAN HYDRO-TECHNOLOGIES: Water Supply & Distribution

4. Wells. The water supply in the southeastern Minoan Crete was dependent on groundwater.

5. Water Distribution and Fountains. Both the Minoan and Indus Valley civilizations used terracotta pipes for water distribution systems in entire cities, placed under the floors at depths up to 3 m





Minoan Civilization – Southeastern Greece (Bronze age, ca 3200-1100 BC)

URBAN HYDRO-TECHNOLOGIES: Water Sanitation

1. Sewerage & Drainage Systems (fully functional today!!)

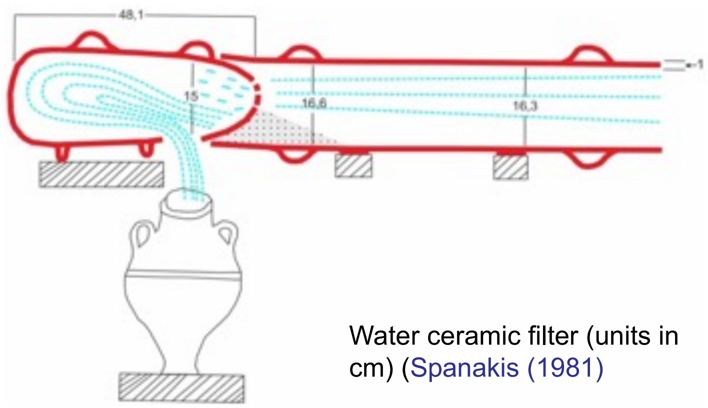
The sewers and drains were large enough to allow humans to enter for maintenance and cleaning.

2. Bathrooms

3. Toilets or Lavatories Communal lavatories constructed and controlled by the municipalities

4. Disposal and Reuse Sites
Land application of sewage for agriculture irrigation

5. Water Treatment – Hydraulic Ceramic Filter



Water ceramic filter (units in cm) (Spanakis (1981))

Minoan Civilization – Southeastern Greece (Bronze age, ca 3200-1100 BC)

LESSONS LEARNED

(a) These civilizations understood the **importance** of sanitation, water supply, and drainage and sewerage systems **for human survival and well-being** and made these an **essential part of urban planning to achieve water resource sustainability**;

(b) **Water quality and security** as one of the critical aspects of the design and construction of their water supply systems.

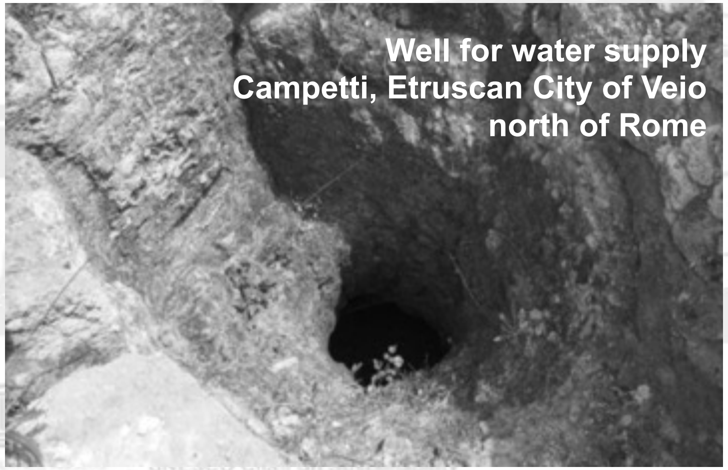
(c) A **combination and balance of smaller scale measures** (such as cisterns for water harvesting systems) **and the large-scale water supply projects** (such as reservoirs for storage of aqueduct flows) were used by many ancient civilizations thereafter;

(d) **Water technologies** were characterized by **simplicity, ease of operation,** and the requirement of no complex controls, making them more sustainable

Etruscan Civilization – Tuscany, Umbria, Latium - Italy (ca 800-100 BC)

Iron Age (ca 800-100 BC)

Drainage and sewerage systems *developed by the Etruscans were based both on a coordinated and comprehensive* ***planning of the slopes of drainage channels on the sides of streets as well as on a massive use of drainage tunnels.***

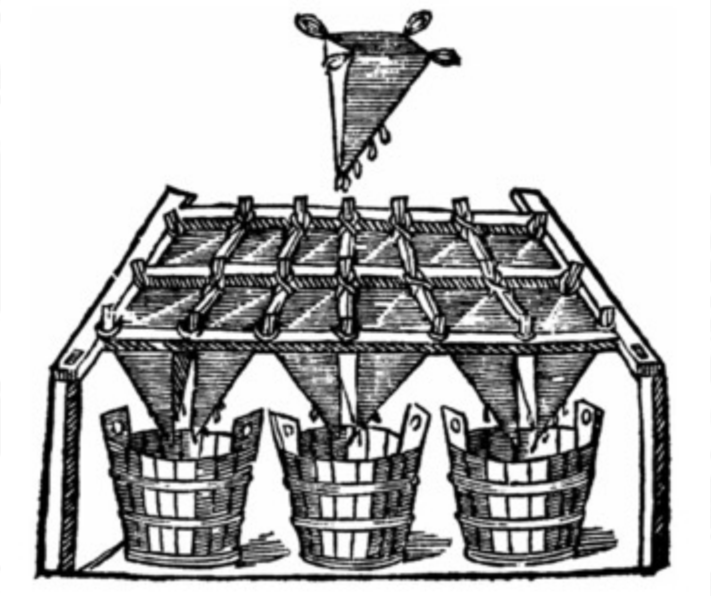


Well for water supply
Campetti, Etruscan City of Veio
north of Rome

Minoans and Etruscans lived in harmony with nature and their environment and their knowledge can play an important role in the sustainable water supply, wastewater, and stormwater management of future cities.

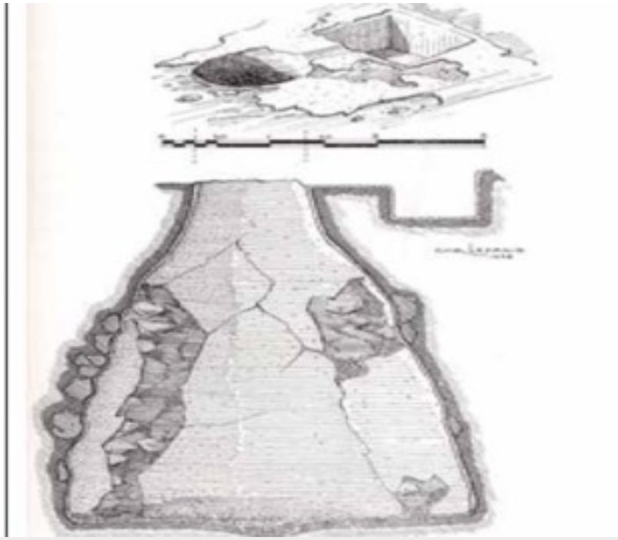
Classical and Hellenistic Times - Greece (ca 480-100 BC)

Hippocratic Sleeve. Hippocrates invented and used the **first water filtering system**, in the form of a cloth bag about 500 BC. It was used for removing the impurities from drinking water after it was boiled.



Hippocratic sleeve (Mays 2013).

Olynthus (northern Greece) bottle-shaped **cistern with a small tank for pretreatment** including the capture of debris and sediment



(Left) plan and (Right) cross-section (Klingborg & Finné 2018).

Classical and Hellenistic Times - Greece (ca 480-100 BC)

In all Asclepieia (medical center) the role of water and its cleanliness were crucial. In the Asclepieion in the Hellenistic city of Emporiae in the northwestern coastal area of Catalonia (Spain), the major water source was rainwater, which was stored in cisterns

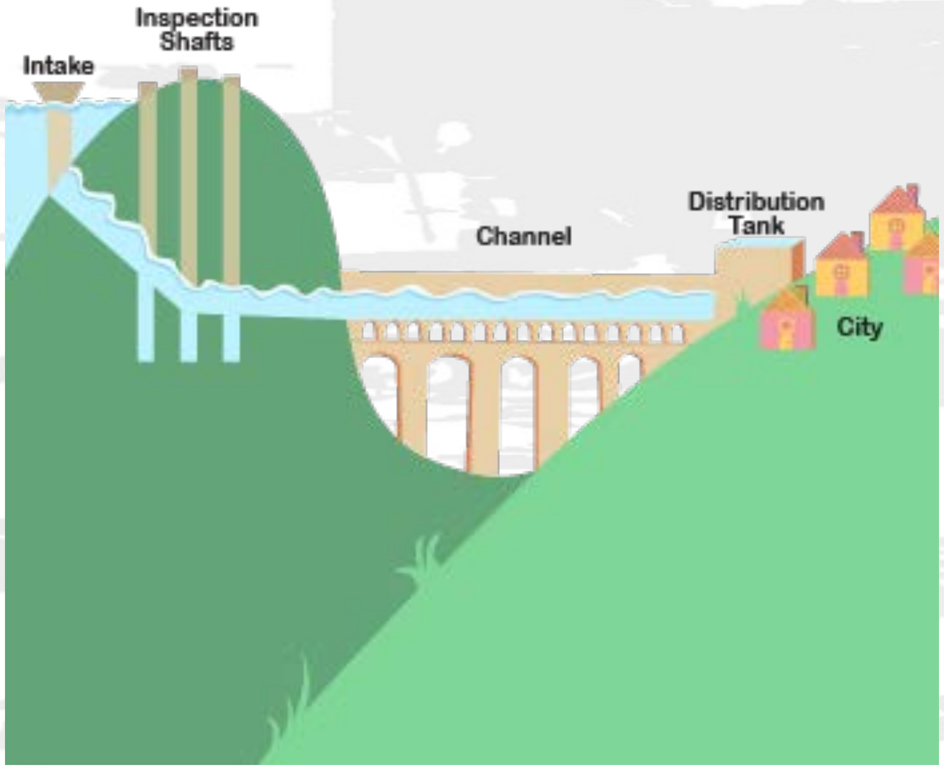
The **stored water in the cisterns was treated by ceramic filters**, before its use in the Asclepieion.

It is probably the **first use of ceramic filters for water treatment in the world.**

Cistern and ceramic water filters from the Asclepieion (medical center) in the Hellenistic city of Emporiae in northwestern Catalonia, Spain

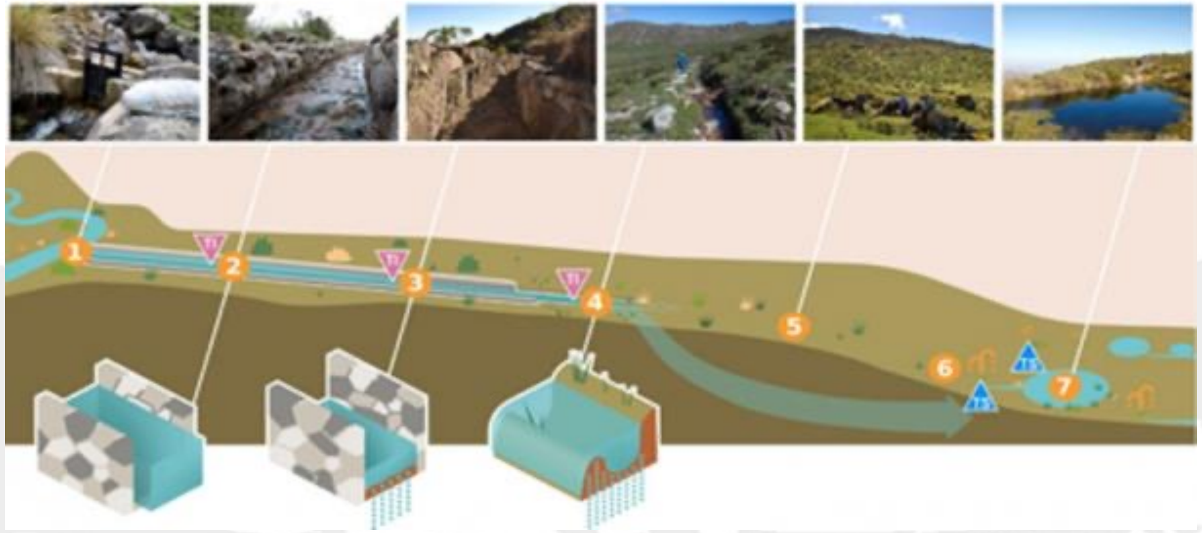
Roman Period (146 BC-AD 330)

Romans developed and improved the technology of the Hellenistic period **from small to large scale**. **Aqueducts** were the most common technology of water supply in Roman cities. Water sources included springs, percolation wells, dams, and weirs on streams.



Segovia aqueduct, Spain

ANCESTRAL HYDROTECHNOLOGIES: AMUNAS



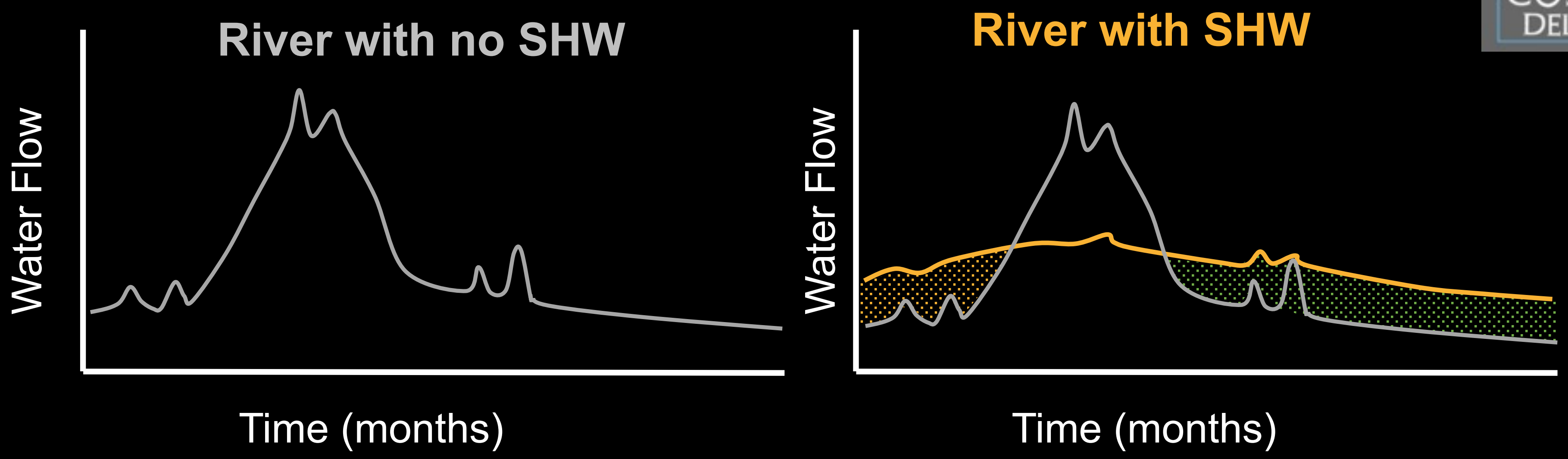
AMUNAS - Raining harvesting above 4,400 meters through **ditches,** taking water to previously identified areas with fractured rocks on the mountain.

Upon entering the rock, the **water slowly moves within it to emerge, months later, through the springs (springs or puquios),** that are between 1,500 and 1,800 meters below.

1 km Amuna
225.000 m3 /year

ANCESTRAL HYDROTECHNOLOGIES: AMUNAS

SOWING AND HARVESTING WATER

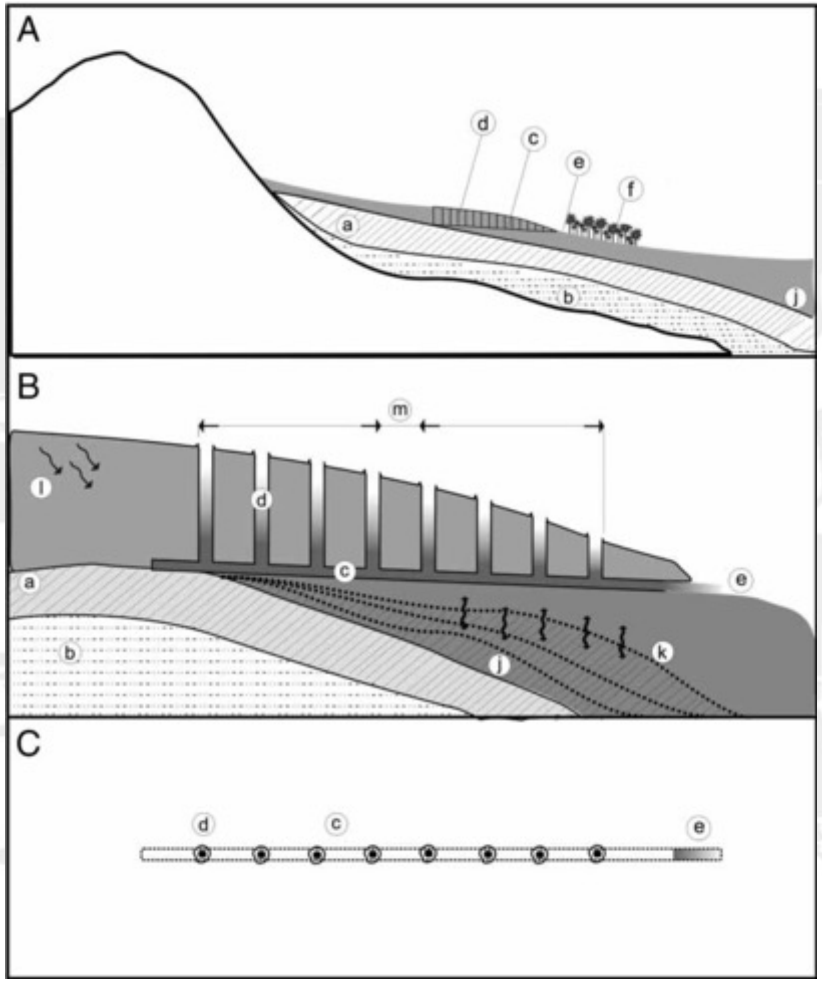


RED CYTED SIEMBRA Y COSECHA DEL AGUA

"Khettara" sustainable alternative for arid regions

Located in semi-arid region in the south and east of the country, the Moroccan oases are characterized by **severe aridity and scarcity of water resources.**

Adaptation to aridity constraints through the development of knowledge and heuristic expertise on a traditional **water supply system called 'Khettara'.**



Longitudinal section of a Khettara (Loureano 2005).

A: position of the tunnel, section view;
B: detail of the section view;
C: overhead view;

a: aquifer;
b: impermeable layer;
c: horizontal tunnel;
d: vertical shafts;
e: surface channels;
f: settlement and/or irrigated area;
j: aquifer level;
k: fluctuations in aquifer level;
l: water influx from the slope;
m: variations of the filtering and conveying segments.)

Water Wheels – Murcia, Spain (XIX century)

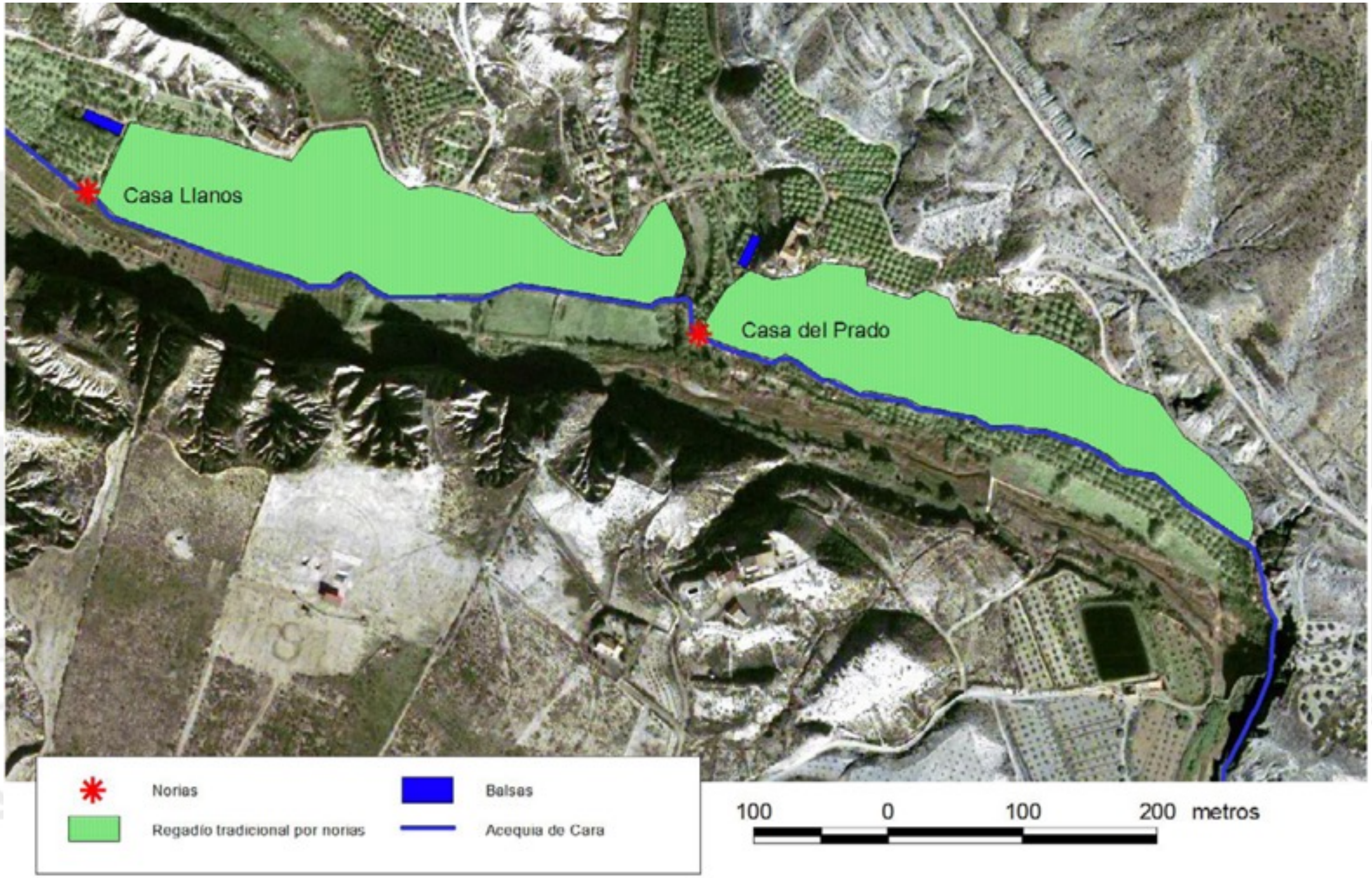
Water Wheels and rafts **adapted to the shortage of water resources** and the geographical characteristics (**semi-arid climate)**

Many of these devices stopped working during the twentieth century, presenting today a state of abandonment and ruin

Instantánea de 1925 de la Noria de Escilache, en el paraje de *Levaura* o *Levadura*

Imagen de Alfonso Férez. Archivo de Ricardo Montes.

Traditional irrigated landscapes

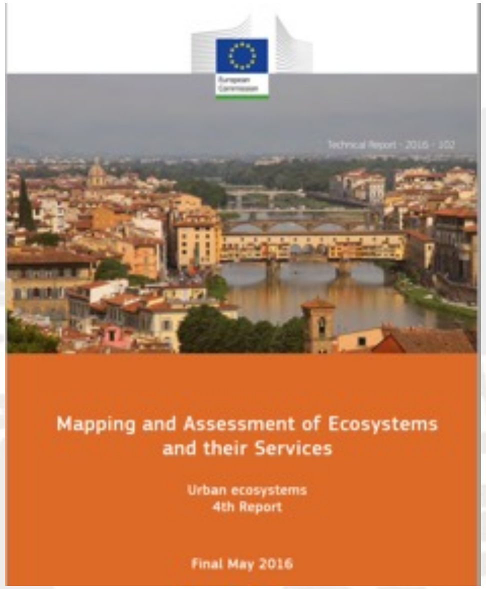


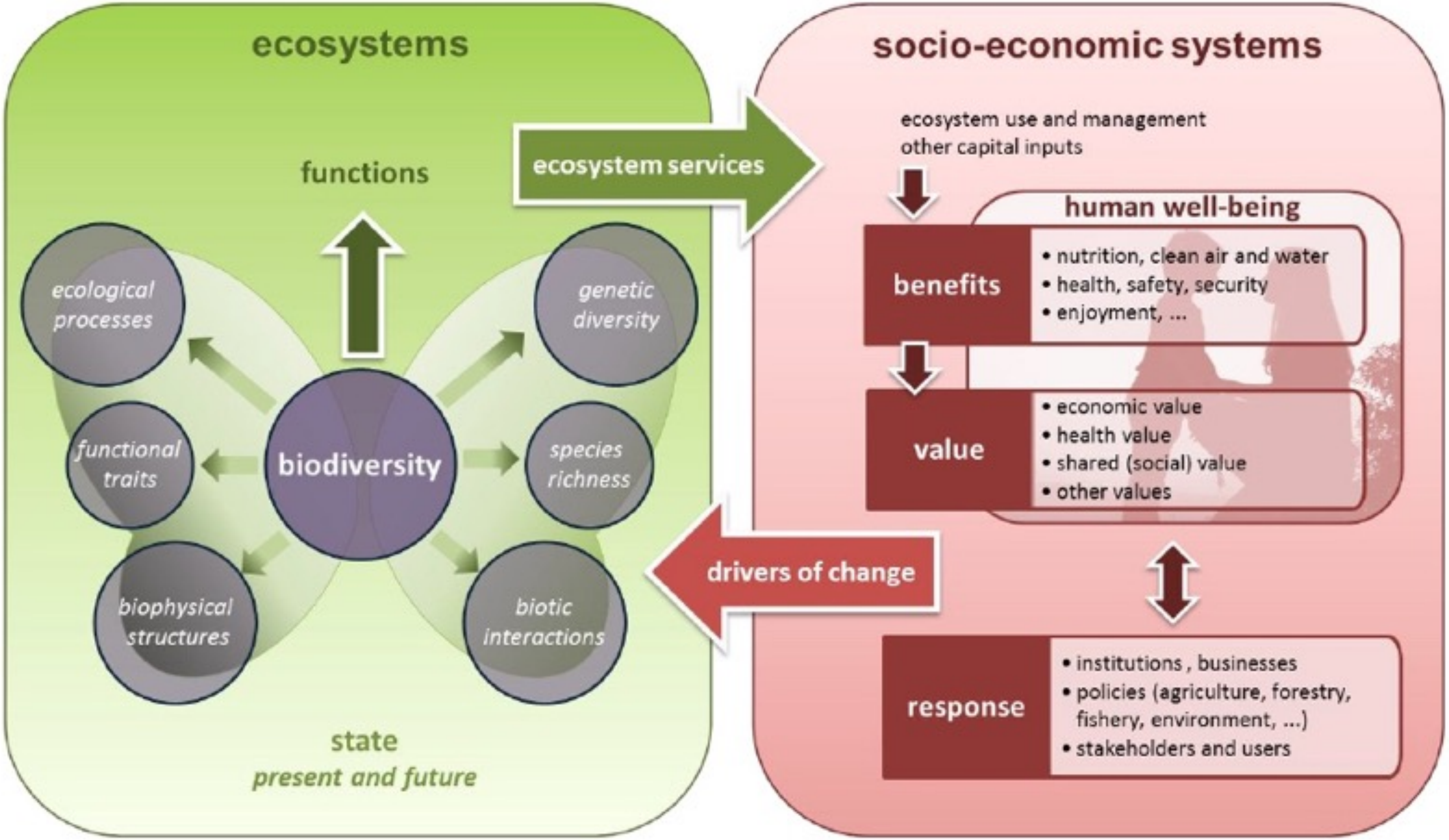
First part of XIX century

HOW CAN WE EXTEND THE USE OF ANCESTRAL HYDROTECHNOLOGIES FOR CLIMATE EMERGENCY?

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
UNESCO Chair on Sustainability

Ecosystem Services





UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
UNESCO Chair on Sustainability

unesco Chair

International Agenda for Sustainability

TRANSITION TO URBAN RESILIENCE

SUSTAINABLE DEVELOPMENT GOALS

Sustainable Development

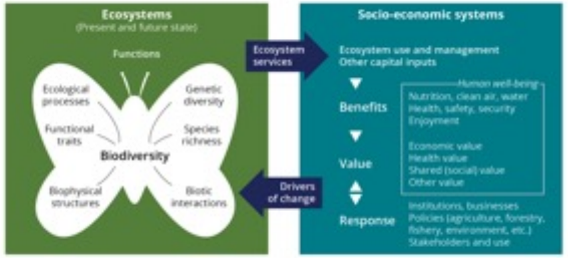
PARIS2015
COP21·CMP11

Climate Change

Circular Economy

HABITAT III
QUITO - OCTOBER 2016

Urbanization



Ecosystem Services
Nature Based Solutions (NBS)

Biomimicry – NATURE INSPIRING

Appropriate Technologies

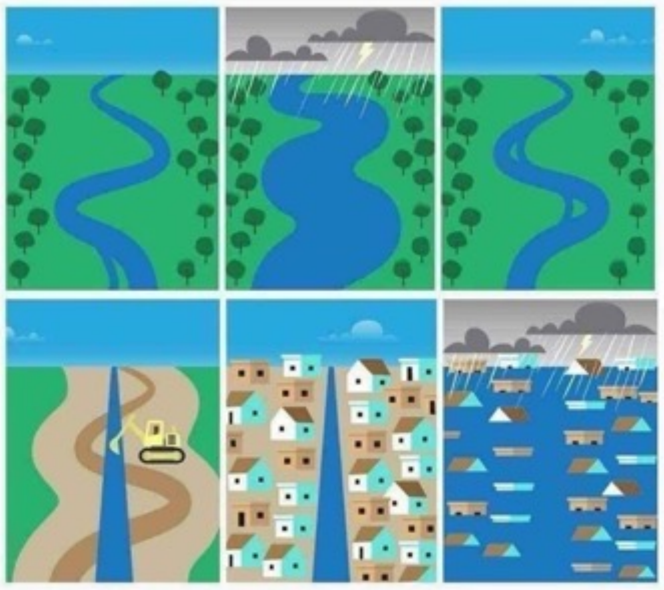
Nature-Based Solutions

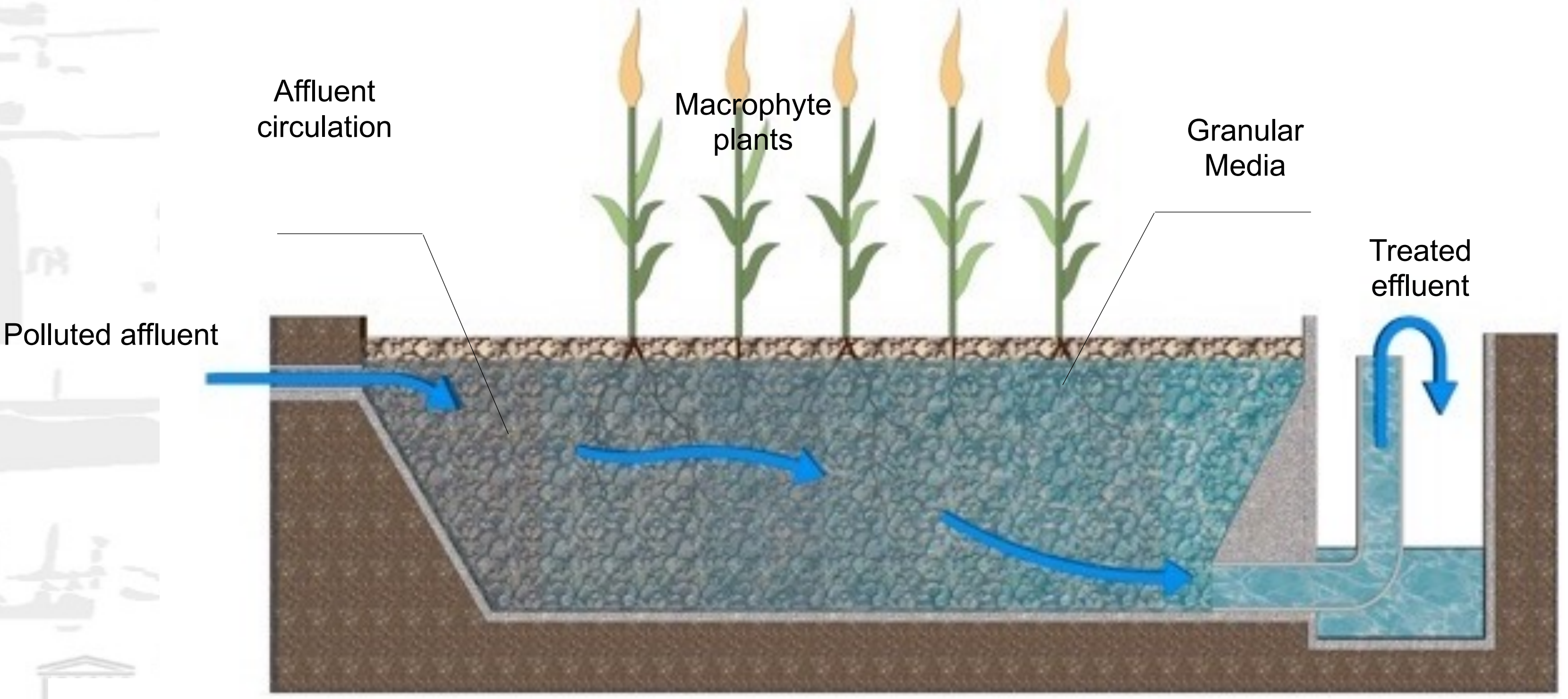
Ecohydrology

Ecotechnologies

Phytotechnologies

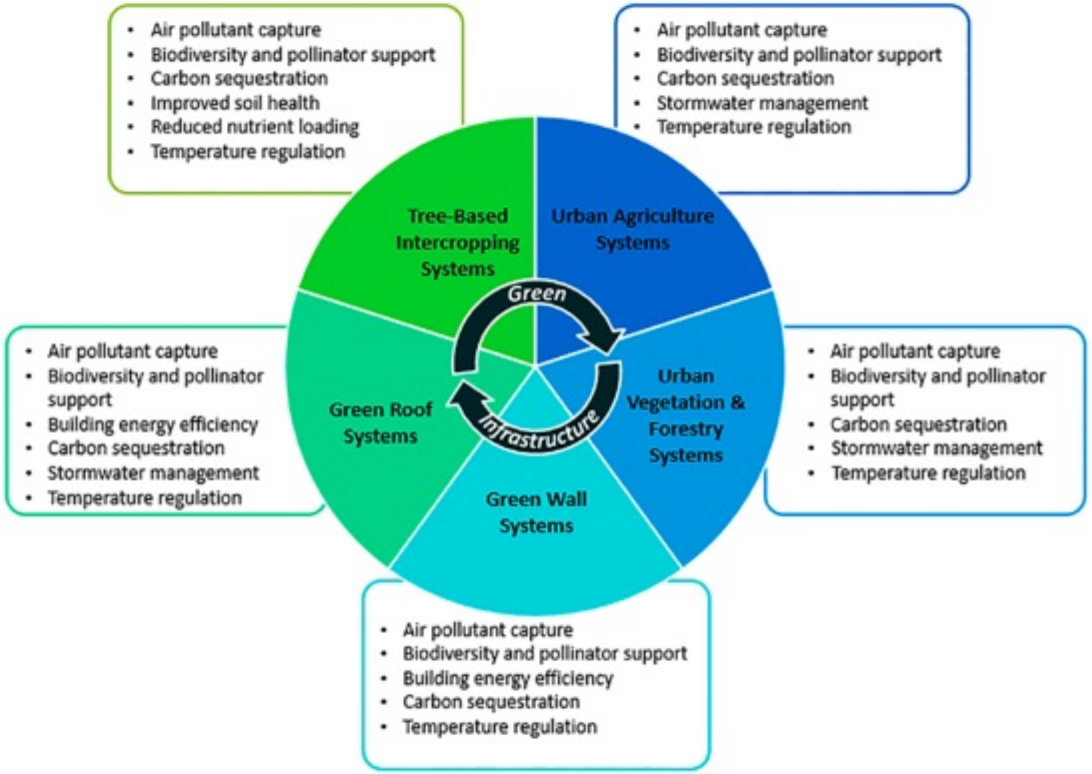
Bioengineering





TREATMENT WETLANDS FOR POLLUTED EFFLUENT TREATMENT

NATURE BASED SOLUTIONS

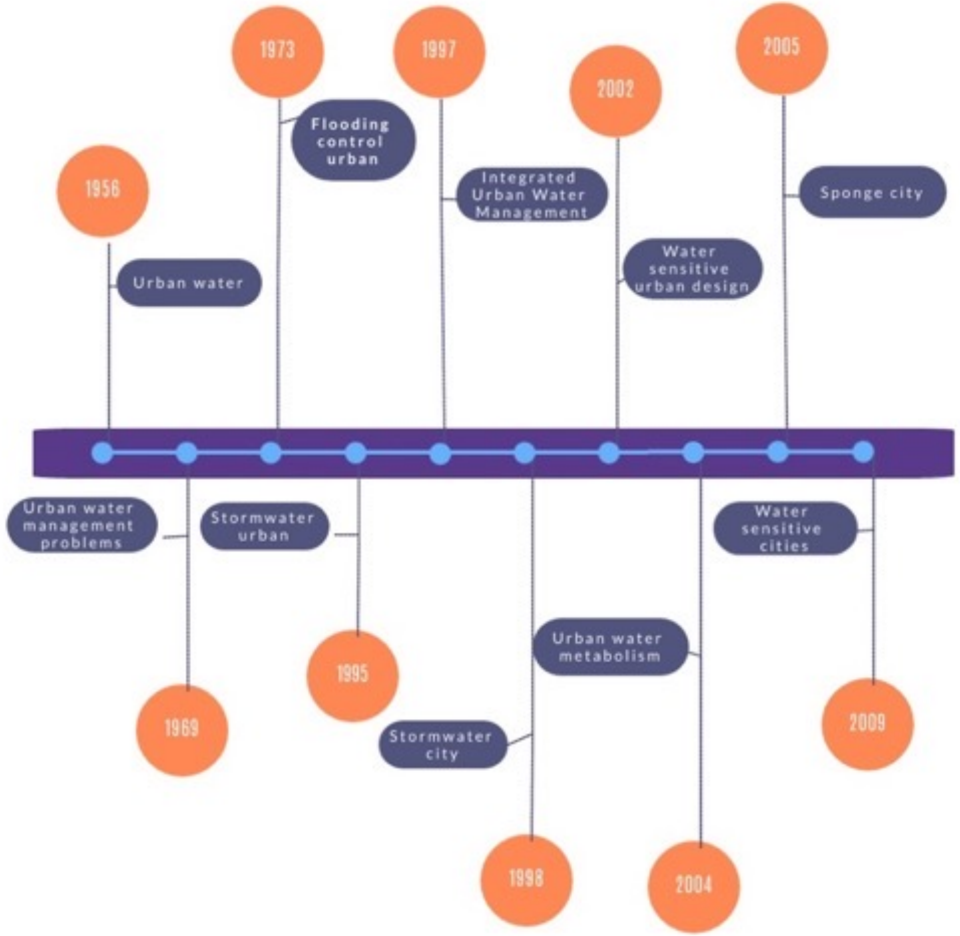


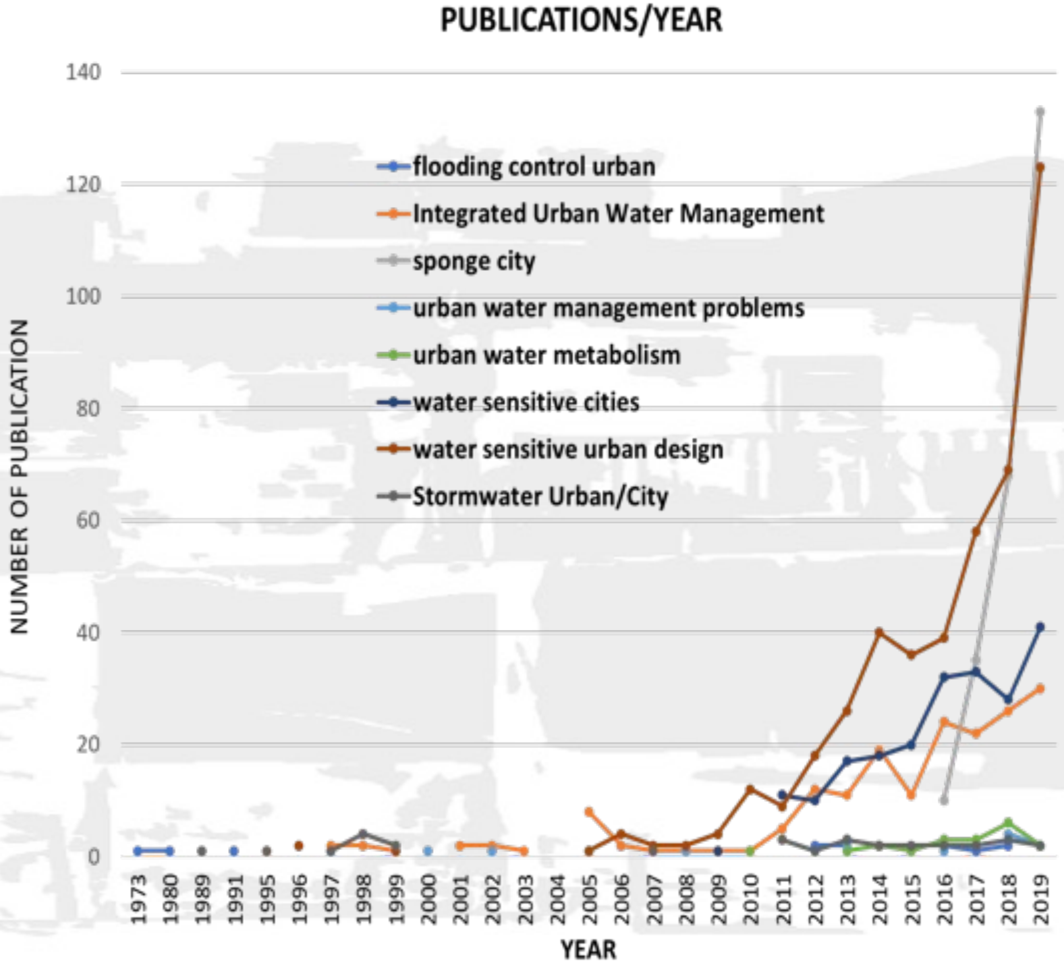
Living solutions inspired by, continuously supported by and utilizing Nature, designed **to address societal challenges** in a **resource efficient and adaptive manner**, while providing **economic, social and environmental benefits**
(EC, 2015)

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
UNESCO Chair on Sustainability

unesco Chair

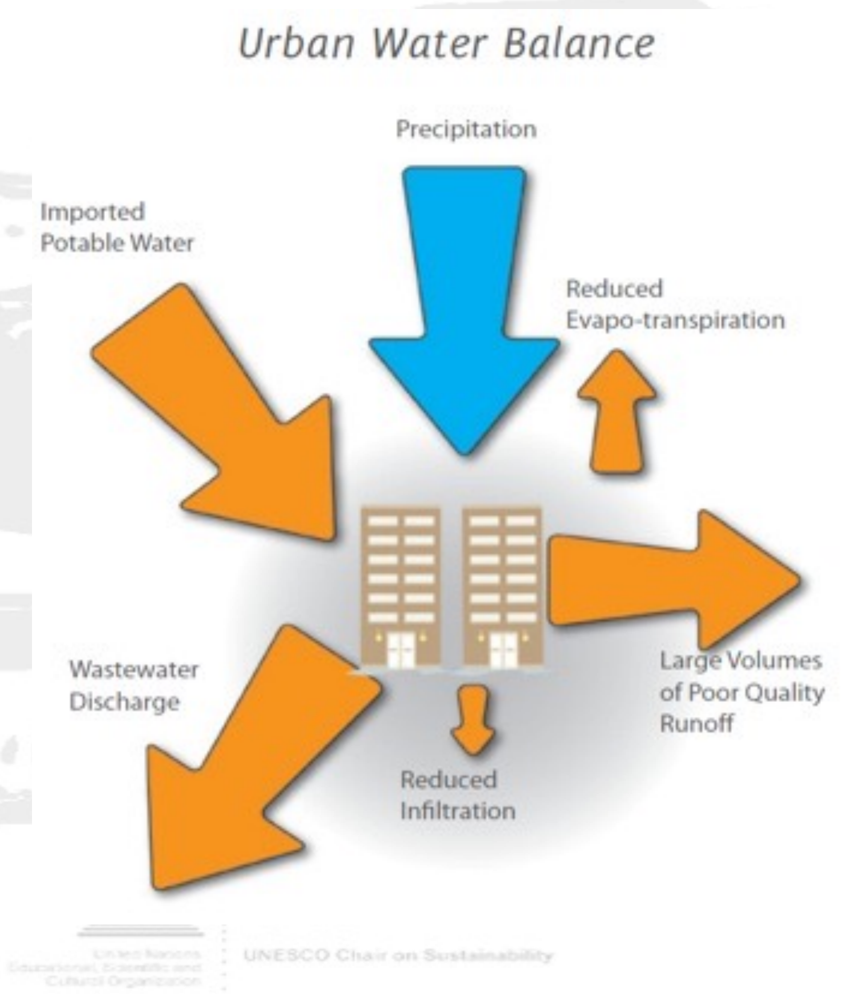
WATER SENSITIVE URBAN DESIGN– SPONGE CITIES





Restore / regenerate the natural balance of water in urban areas

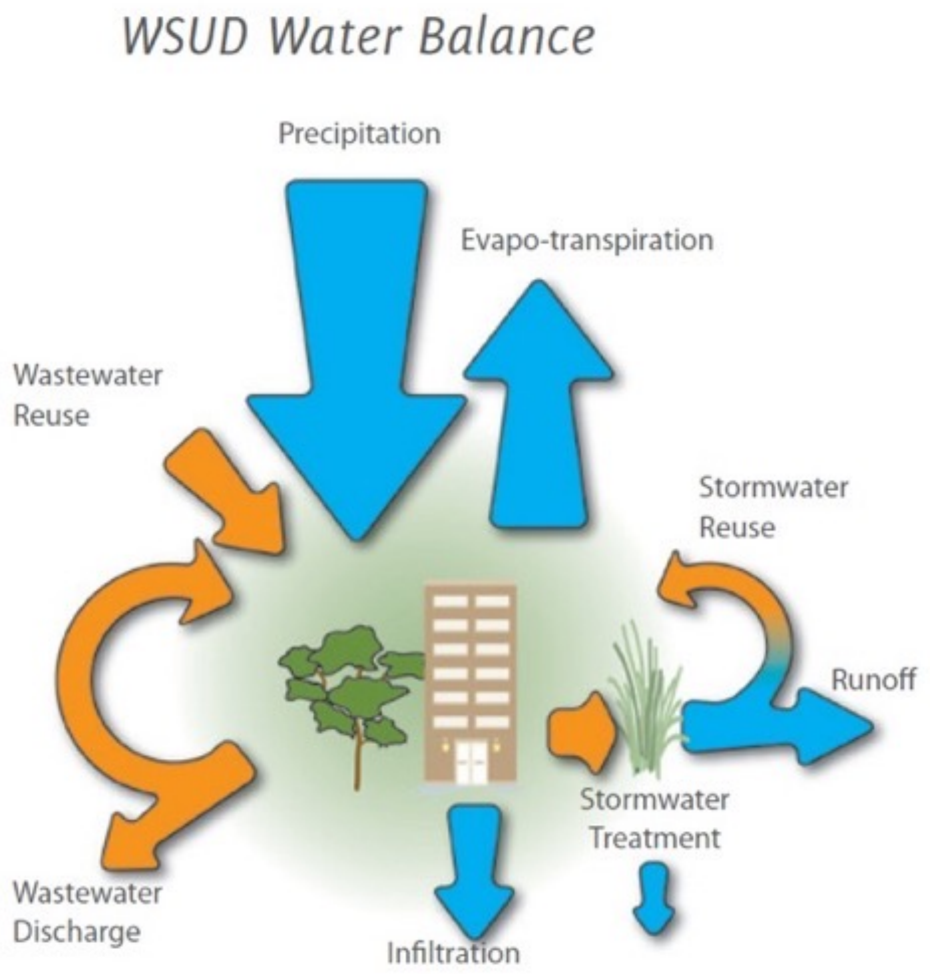
Increase technical and social resilience



+Vegetation
+ Permeability

Use of rainwater
- use of imported water

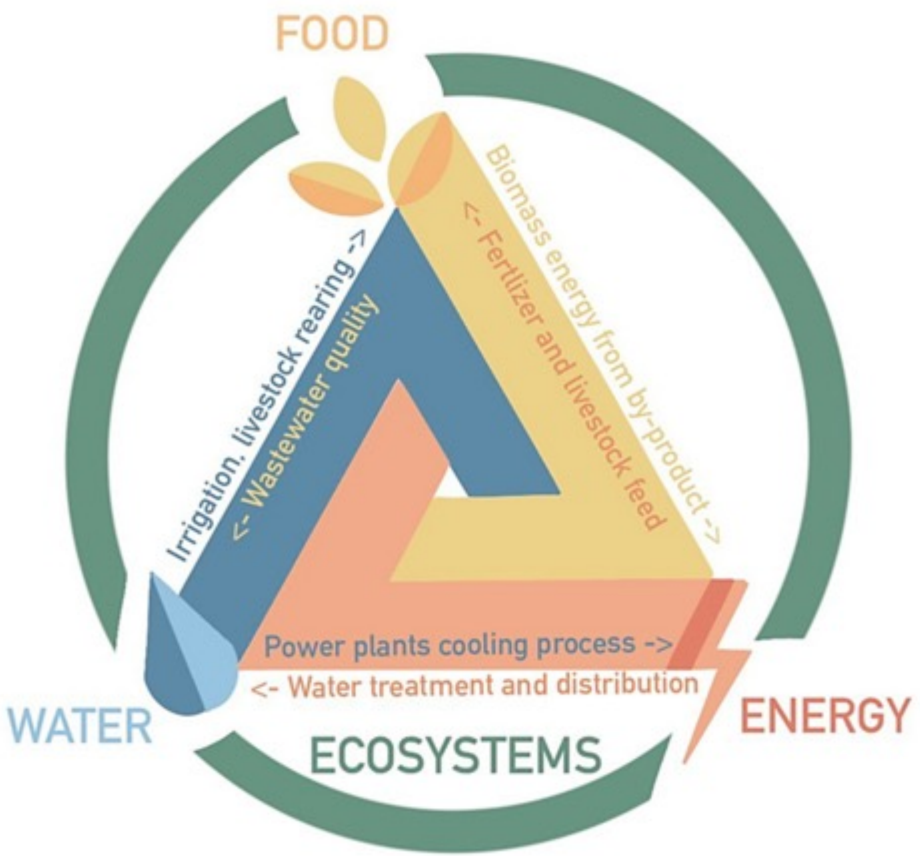
Sustainable sanitation
Close cycles
Wastewater reuse

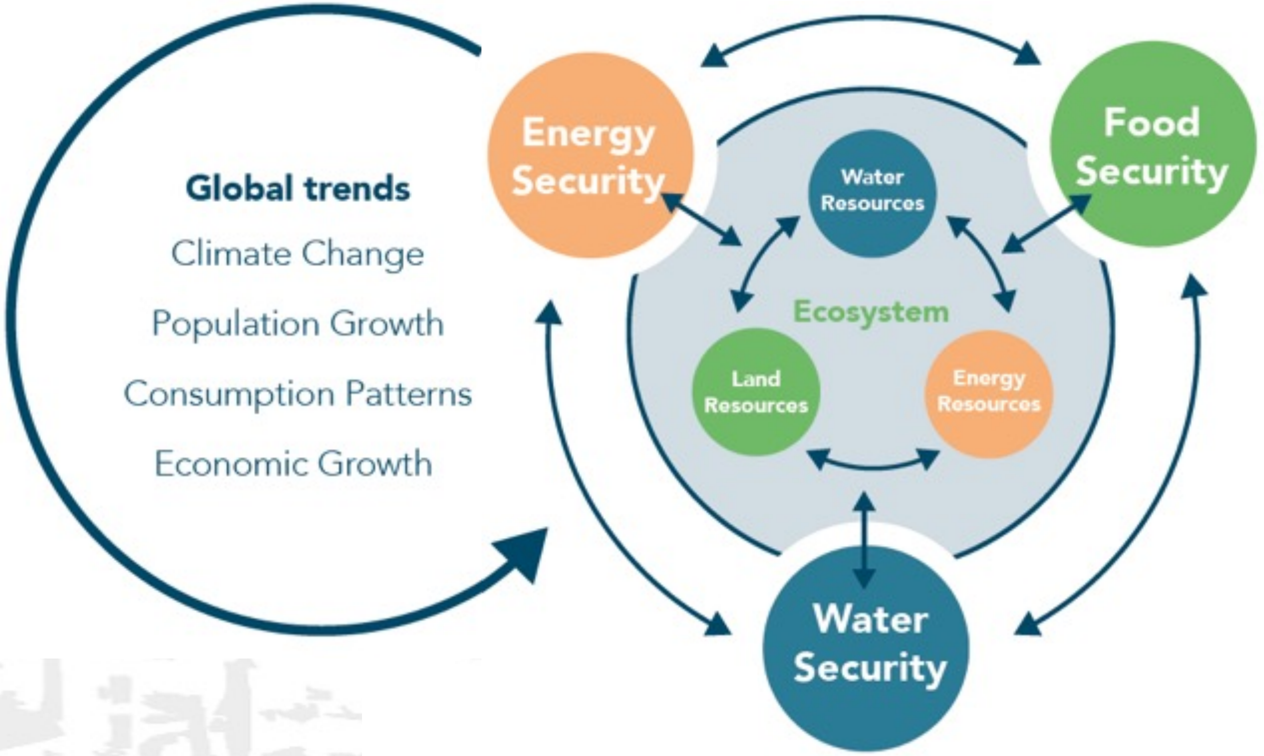


WATER SENSITIVE URBAN DESIGN

Infiltration Basins for stormwater and runoff collection

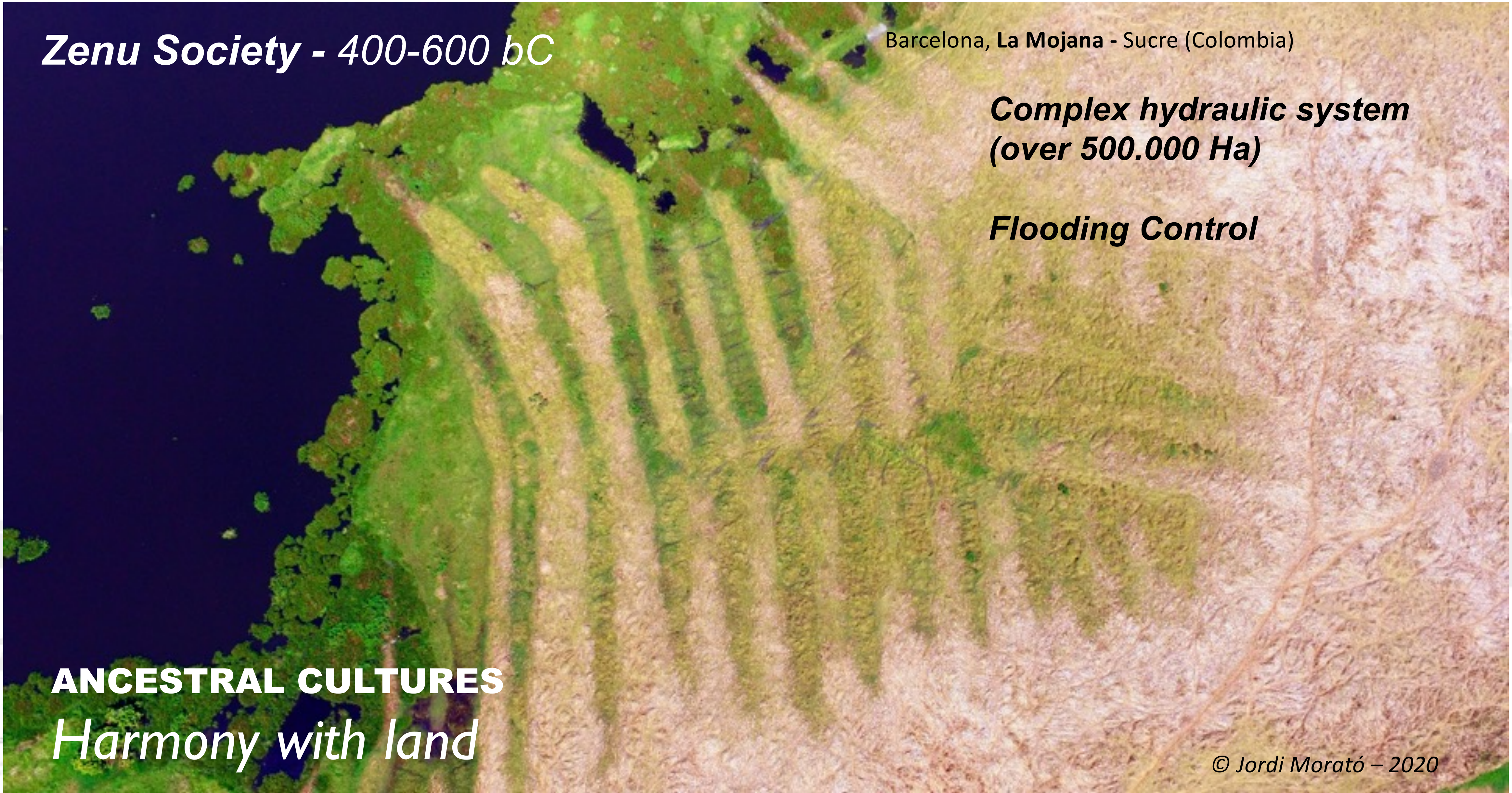
WEFE Nexus Water - Energy – Food - Ecosystems





UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
UNESCO Chair on Sustainability

Ancestral Hydrotechnologies: Hydraulic Zenú System

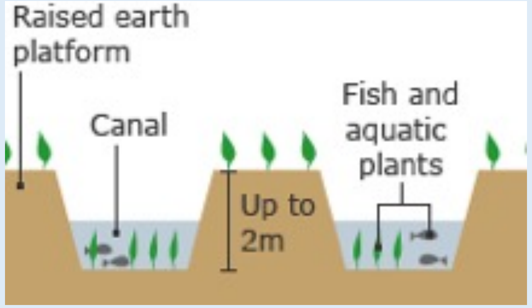


UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
UNESCO Chair on Sustainability

Ancestral Hydrotechnologies: Hydraulic Zenú System

Rainy Season

Seeds and crops are protected from being washed away



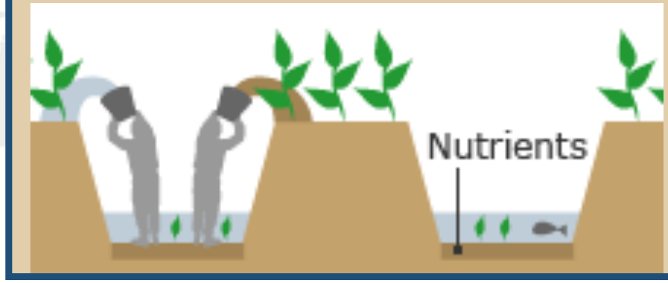
Turning excess water to advantage (400 bC)

Large expanses of land under water for several months, no crops left.

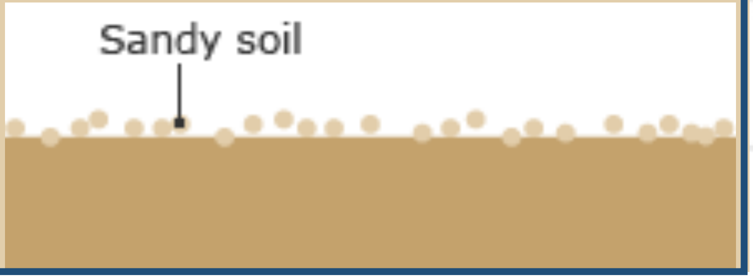
Problems in both seasons, flooding in winter, drought in dry season (Today)

Dry Season

Water and sediments are a source of irrigation and nutrients.



Floodwater drains nutrients, leaving a sandy soil in which is hard to grow crops



HOW TO APPLY?

Action for Transformation
“Action Oriented”

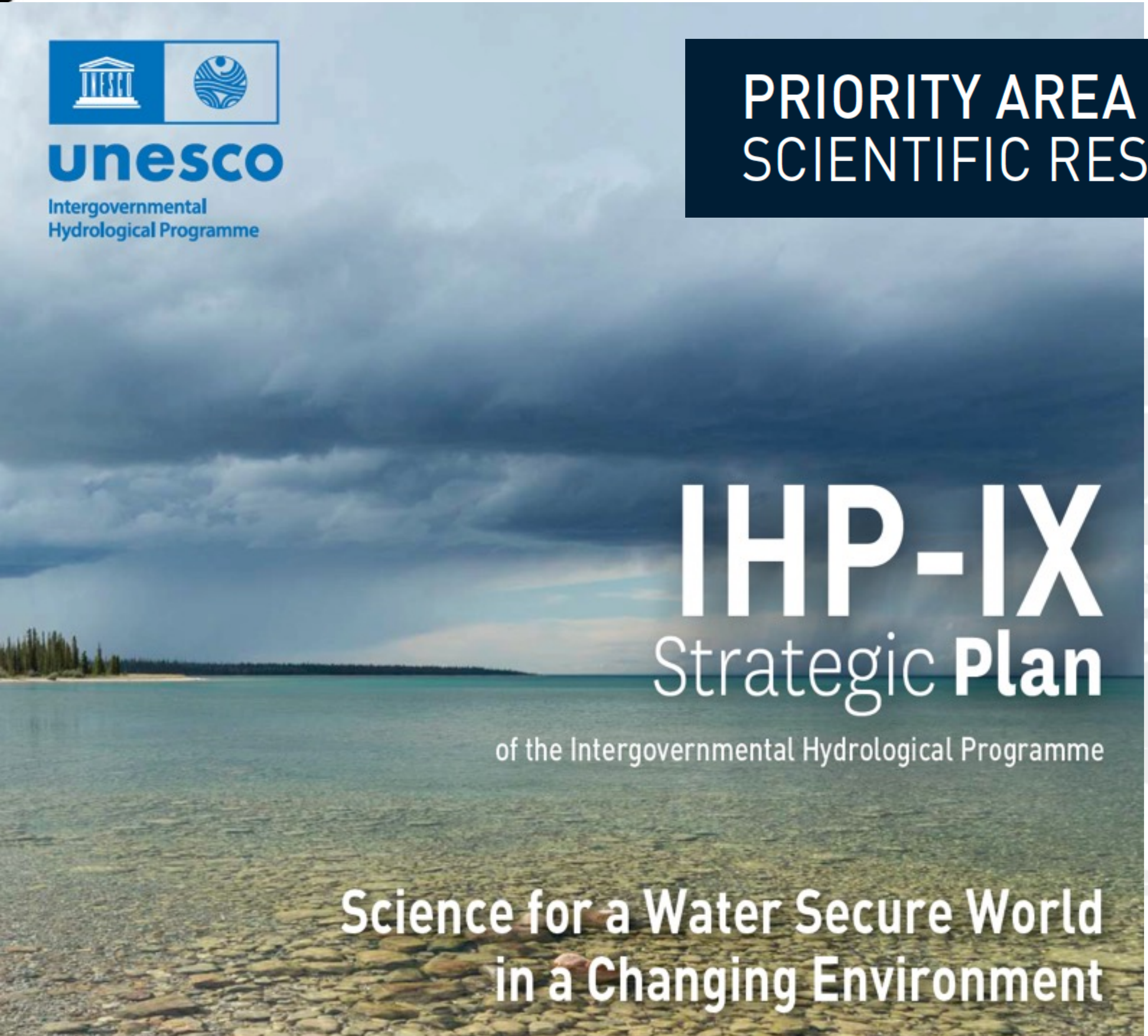
LESSONS LEARNED

What we can learn from the ancients, since the prehistoric times, using traditional knowledge, could be a significant factor in solving our water needs, especially for developing parts of the world.

Several ancestral hydro-technologies should be considered not as historical artifacts, but as potential models for sustainable water technologies for the present and the future.

There is a vast need for sustainable and cost-effective water supply and sanitation facilities.

Applicability of selected ancient water supply management systems (e.g., storage of rainfall runoff facilities) for the contemporary developing world should be seriously considered.



PRIORITY AREA 1:
SCIENTIFIC RESEARCH AND INNOVATION

1.10 Conducting and sharing of research on **integrating citizen science in the hydrological discipline by the scientific community and other stakeholders** supported, to improve understanding of the water cycle enabling science based decision making.

IHP-IX will create the enabling environment and assist citizens and scientists, through enhanced water knowledge and education programmes to ensure scientific methods are used when participating in and reporting their findings to increase the contribution of citizen science to hydrology research. Training, in particular, will contribute to enhancing accuracy and validity of data.
Additionally, scientific tools should be developed to encourage citizen participation and other social applications that can improve water management, such as **integrating modern science with ancestral, indigenous and local knowledge.**

#Action for Transformation

CULTIVATING NEW COMMUNITIES

Articulation participative transformation projects
From Local Capacity Building

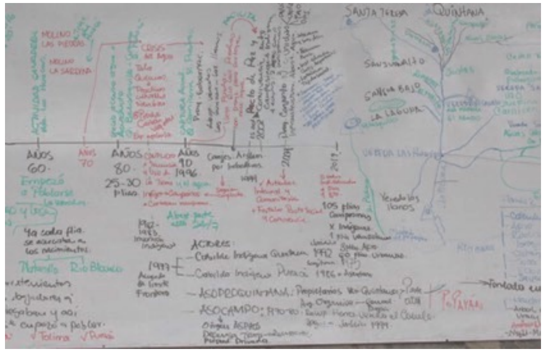
To COMMUNITY EMPOWERMENT

PARTICIPATIVE INTERVENTIONS
Community-based
Collaborative
Multinetworks (Univ. PubAdmin, Communities)

→ **CO-DESIGN**
Innovative Technol.

→ **PILOT PROJECTS**
Acupuncture Int.

→ **COMMUNITY LOCAL NETWORKS**
Water Sowers



Sustainable development of settlements with integrated systems of multifunctional eco-infraestructures and cultivation of participatory networks and social, economic, cultural and environmental networks.

International Conference

Ancestral Hydrotechnologies as a Response to Climate, Health and Food Emergencies in the Mediterranean

"Use of Cultural Heritage to Rescue the Future"

16-17 February 2023

Objectives

- Value the potential of ancestral hydrotechnologies
- Share examples and good practices and cases of ancestral hydrotechnologies
- Organize interdisciplinary dialogues
- Create awareness, promotion and information on the potential of ancestral technologies
- Identify elements to develop specific educational and capacity building programmes
- Develop project proposals for the rehabilitation of ancestral hydrotechnologies

Timeframe

1st Announcement and call for papers and case studies
(September 15, 2022)

Deadline for submitting cases and early registration
(November 30, 2022)

Final selection of papers
(December 05, 2022)

2nd Call and final program launch
(December 20, 2022)

Conference
(February 16 - 17, 2023)

Modality: Face to face/streaming

Convened by:

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH UNESCO Chair on Sustainability
unesco Chair
WATER MUSEUMS GLOBAL NETWORK
unesco

With the support of:

GOBIERNO DE ESPAÑA MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO
Ajuntament de Barcelona
Generalitat de Catalunya Departament d'Acció Exterior i Govern Obert
MedCités MedCities

Conference meeting place: BARCELONA

SURE NEXUS

First Face-to-face Meeting

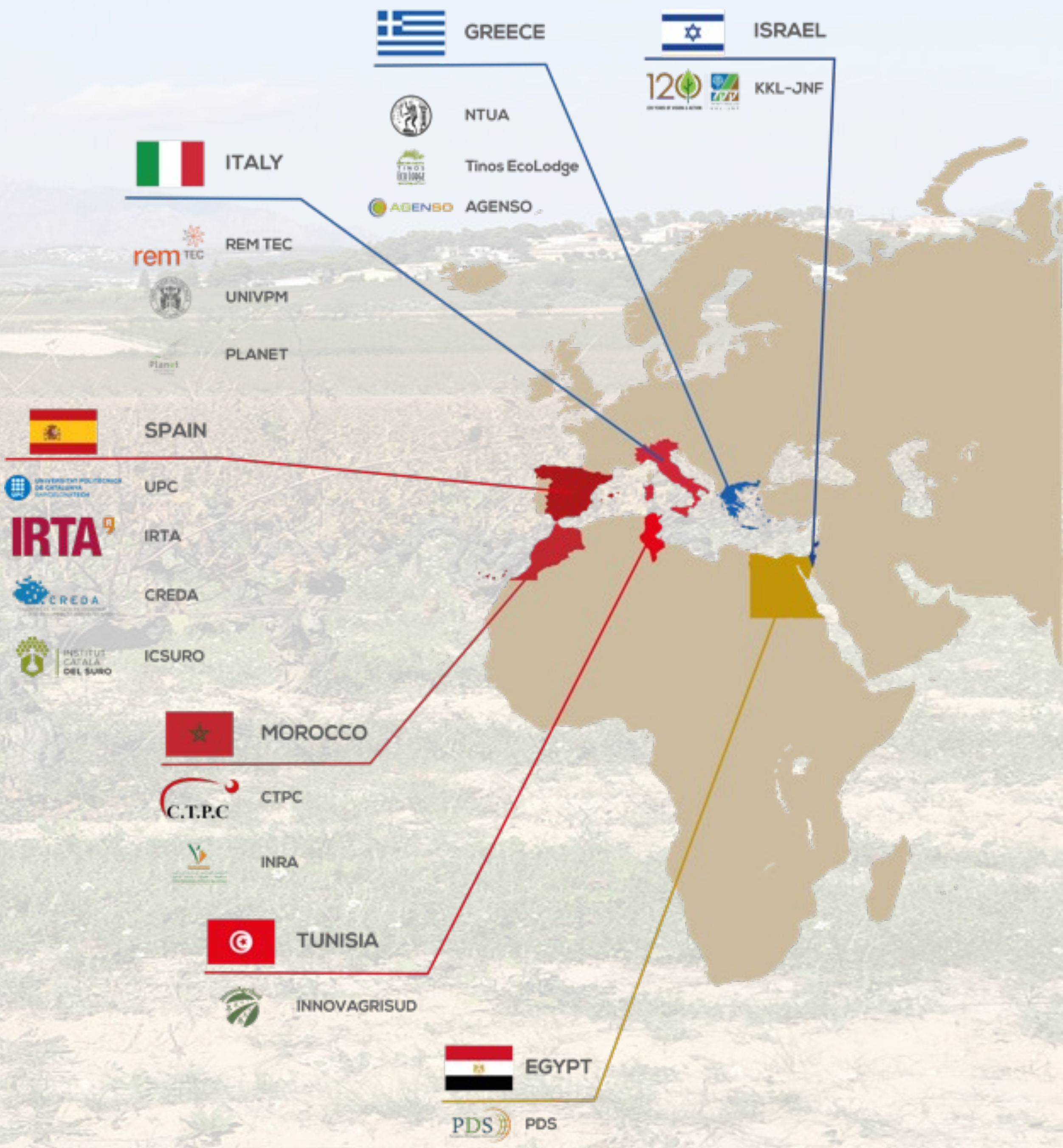
As a side event, the First Face-to-Face Meeting of the SureNexus project will be held.

Meeting place

Barcelona and Terrassa, Spain

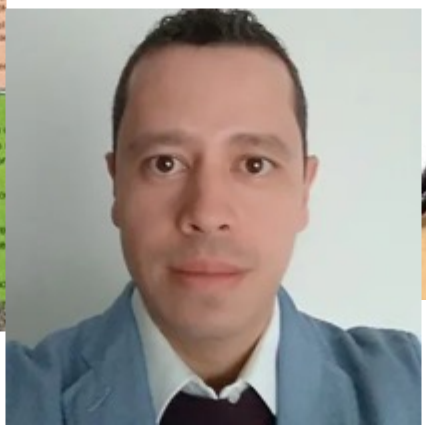
Dates

February 14 and 15, 2023



Jose Luis Martin Bordes

Rosario Pastor



Guillermo Penagos

Olga Lucía Sánchez

Luis David Díaz

Brent Villanueva

Dr. Jordi Morató
jordi.morato@upc.edu

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Cátedra UNESCO de Sostenibilidad

unesco
Cátedra

www.unescosost.org