GLOBAL WATER SECURITY SEMINAR

BEST PRACTICES ON DROUGHT AND FLOOD MANAGEMENT: ENGINEER’S CONTRIBUTION

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WCCE-World Council of Civil Engineers
WFEO-World Federation of Engineers Organizations

2013 Chengdu Forum of International Water Organizations

Global Water Security Declaration

Water scarcity is on the rise

Water resources, people and economic activities are unevenly distributed around the world, which makes freshwater scarce in many areas. Water scarcity in most arid and semi-arid areas is intensifying with time, due, in large measure, to population growth and economic activity. Many parts of the world face water scarcity due to the lack of adequate water resources, human and institutional capacities to adequately govern and manage water and/or the economic means to develop water resources. The Global Risks 2013 report of the World Economic Forum identifies the water supply crisis as one of the two most likely high-impact risks of current times.

Water security means minimizing water related risks

Water security can be defined as the capacity of a population to safeguard access to adequate quantities of water of acceptable quality for sustaining human and ecosystem health, and socio-economic development and to ensure efficient protection of life and property against water related hazards (floods, landslides, land subsidence) and droughts. Hence, water security is the assurance of uninterrupted water supply in sufficient quantity and adequate quality to meet the water needs of domestic water consumption, food production and water-dependent economic activities that are essential for the welfare of a community, and in conformance with the principles of sustainable development. Globally increasing demand and competition for limited water resources, including groundwater, has drawn increasing attention to water security. Climate change has also accentuated the need for managing hazards associated with extreme hydrologic events, such as floods and droughts, but also to increase the reliability of the supply for all uses, including the environment.

Water security hinges upon balancing water supply and demand, both of which change over time, and avoiding the unsustainable over-abstraction of water. The supply of water can decrease due to the depletion of non-renewable water resources or degradation of water quality, climate change, or various other anthropogenic activities such as land use changes that affect the hydrologic cycle, such as land use changes. Water supply can increase through the development of new water resources. Water demand can increase as a result of population and economic growth. It can be managed through conservation, increased water use efficiency, economic measures, and agricultural and trade policies and practices. Achieving the optimal equilibrium between water supply and water demand, without compromising future water security, is the central goal of water management. Achieving this goal requires adequate human and institutional capacities, as well as cooperation between stakeholders at the local, regional and international levels.

Demand management is essential for water security

The Integrated Water Resources Management (IWRM) approach has now been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands. In general, water supply augmentation is challenging and often not an option. Many countries and regions, other than sub-Saharan Africa, facing water scarcity have already fully developed their water resources beyond sustainable levels, resulting in rivers running out of water by the time they reach the sea, lakes shrinking in size and groundwater wells running dry. Non-conventional ways to augment the water supply include recycling, desalination and, at a small scale, water harvesting. Theoretically, desalination offers the potential of unlimited water supply to areas near the ocean, or other saline water bodies, but its feasibility depends on the availability and cost of energy which remains high, despite technological advances in membrane technologies based on reverse osmosis. In many areas, demand management offers the only viable solution for sustainable development. Demand management aims at influencing attitudes and consumption patterns towards more efficient and cost effective water use. It is often practiced through a combination of economic, technical and administrative measures, with educational and social interventions also playing a role. Economic measures include valuing and pricing mechanisms and other incentives for reducing water use. Technical measures include conservation and increasing water use efficiency and water reuse. Adopting such measures is critical for the viability and community acceptability of new projects built in parts of the world where water is scarce.

In parallel with demand management, the sustainable use of existing and future water supply infrastructure, where reservoirs and dams play an important role, is essential for water security, especially in developing countries, and to face global challenges associated with increasing demand due to population growth and climate change. Governance, maintenance and sedimentation management are key issues for securing adequate water supply in the future.

In developing countries, the need to speed up the development of water storage and sustainable water related infrastructures is of utmost importance, to address the critical need for water supply, energy, food production and sanitation, but it must be pursued in according with the principles of sustainable development. In many countries of the sub-Saharan Africa, the real use of renewable water is less than 10% of the known potential due to a lack of investment for water storage and water supply infrastructure, which is worsened by the rural characteristic of these regions.

In 2050 the world population will reach nine billion, with a corresponding increase in the demand for water, food and energy which will double impacting on the need to speed up and augment water storage infrastructure development worlwide.

Several factors threaten water security

Several factors threaten water security or make its future status uncertain. Such factors include:

- Population and economic growth, including urbanization and land use change;
- Lack of water resources mobilization and appropriate water supply infrastructure in some developing countries;
- Unsustainable water use, often driven by poorly thought-through development goals;
- Inefficient and wasteful water use;
- Climate change.

We, the undersigned associations, therefore call for joint action to improve global water security

Policy. There is an urgent need to increase cooperation on water by working together and with other global organizations, such as UNESCO, FAO, the Global Water Partnership and the World Water Council, to inform policy makers about current and emerging threats, and promote solutions and strategies to ensure water security.

Education. Promote formal education on water issues at all levels and raise capacities among key stakeholders and the general public. Academic and association members will be encouraged to contribute to the strengthening of educational systems, including curricula and teaching materials that would serve this goal. The concepts of virtual water and the water footprint can be used to help the public better understand the impact of everyday choices on global water security.

Research. Promote thematic research (including the development of modeling techniques) in areas including climate / land / surface water / groundwater interactions, monitoring systems and methods for water management, increased water use efficiency in domestic appliances, industrial equipment and processes, and agriculture; water recycling and reclamation and management of the byproducts formed during the management of the water cycle.

Practice. Engineers and other professionals can contribute to greater water security through the design of sustainable hydro-environmental systems, including enhancing water use efficiency in agriculture and industries, such as power generation, mining, and oil and gas production and processing.

We endorse the above principles and commit to collaborating with all partners and stakeholders that share this common vision.

Approved on the 9th of September 2013 in Chengdu, China.

Signed on the occasion of the 35th IAHR World Congress by:

International Association for Hydro-Environment Engineering and Research (IAHR)

International Commission on Large Dams (ICOLD)

International Commission on Irrigation and Drainage (ICID)

World Association for Sedimentation and Erosion Research (WASER)

World Council of Civil Engineers (WCCE)

International Water Resources Association (IWRA)

International Association of Hydrological Sciences (IAHS)

United Nations Secretary General's Advisory Board on Water and Sanitation (UNSGAB)

In the presence of UNESCO's Natural Sciences Sector

01. WATER SECURITY IS ON THE RISE

CHENGDU 2013 GLOBAL WATER SECURITY DECLARATION

Seven global water organizations uder the auspicious of UN Water:

- IAHR
- ICOLD
- ICID
- WASER
- IWRA
- IAHS
- WCCE

Index

1. Introduction

- The Standing Committee on Water (SCoW) of the World Council of Civil Engineers (WCCE) covers water engineering initiatives and its relations with United Nations’ bodies and agencies, primarily with UN-Water and UNESCO. WCCE is an UN-WATER partner

- The Working Group on Water (WGoW) of the World Federation of Engineering Organizations (WFEO), shows with its Reports the contribution of engineering to the accomplishment of United Nations’ Sustainable Development Goals (SDG 6 specially). SCoW Chair is the Executive Director of the WGoW

- WFEO’s WGoW was created by its Executive Council at the meeting held in October 2018 in London on the occasion of the Global Engineering Congress.

- Such Working Group on Water has committed to deliver three monographs during its 2019-2021 three-year mandate regarding the following topics: Best practices on Drought and flood management: Engineer’s contribution, 2019; Achieving SDG 6 on Water: Engineer’s contribution, 2020 and Adaptation to climate change - Water: Engineer’s contribution, 2021.

Learn the ABCs of disaster risk reduction
http://www.unisdr.org/we/inform/terminology

UNISDR
The United Nations Office for Disaster Risk Reduction

2 Objectives

- Main goal: to describe the best practices for the risk management of droughts and floods, highlighting the engineer's contribution to such practices taking into account:
  - economic impacts caused by extreme hydrological events
  - Climate change
  - Evolution from crisis-based approach to risk management or adaptive management approach


Ministerio de Medio Ambiente

Secretaría de Estado de Aguas y Costas.
Dirección General de Obras Hidráulicas y Calidad de las Aguas.
Subdirección General de Gestión del Dominio Público Hidráulico

GUÍA TÉCNICA PARA LA ELABORACIÓN DE LOS PLANES DE EMERGENCIA DE PRESAS

FECHA: JUNIO 2001


BOLETÍN OFICIAL DEL ESTADO

Núm. 19 | Viernes 22 de enero de 2016 | Sec. III. Pág. 6086

III. OTRAS DISPOSICIONES

MINISTERIO DE LA PRESIDENCIA

604 *Real Decreto 18/2016, de 15 de enero, por el que se aprueban los Planes de gestión del riesgo de inundación de las demarcaciones hidrográficas del Guadalquivir, Segura, Júcar y de la parte española de las demarcaciones hidrográficas del Miño-Sil, Duero, Tajo, Guadiana, Ebro, Ceuta y Melilla.*

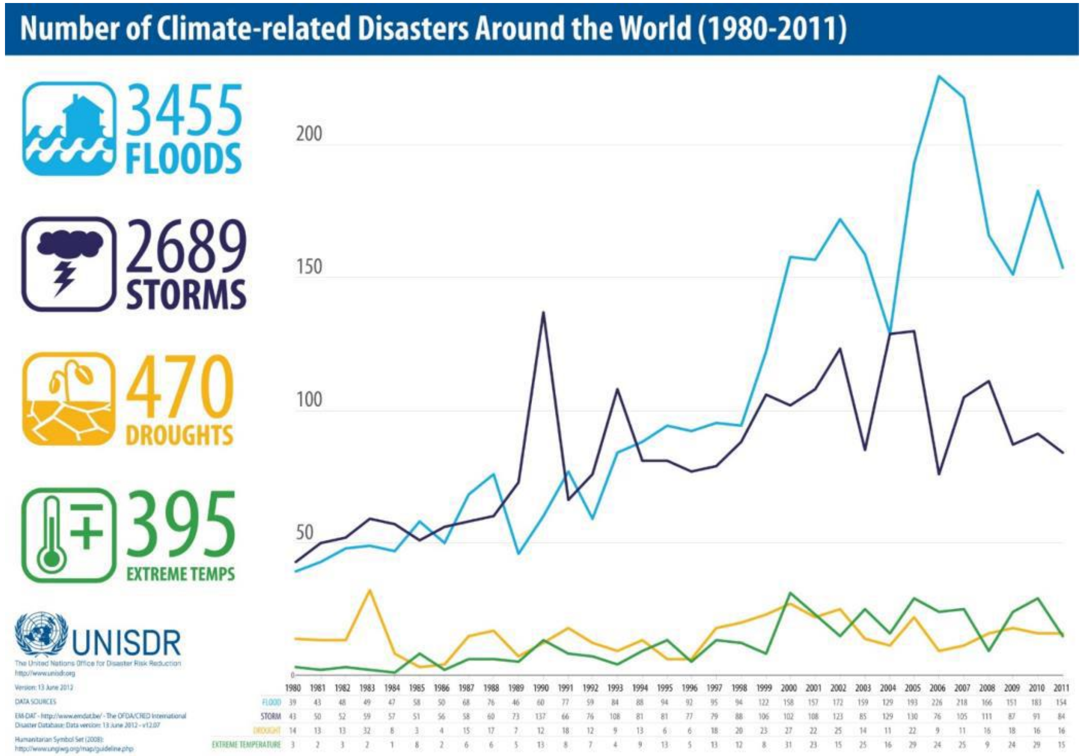
2001: Crisis-based approach

2016: Risk management approach

3. General framework (1/2)

- Number of people living at risk-flooding areas will increase from 1.2 to 1.6 billion people by 2050 (OECD)

- The greatest number of weather-related disasters is due to flooding, followed closely by storms (UNDRR)



3. General framework (2/2)

- The total elimination of the risk of flooding is not possible, no matter how many population protection measures are implemented.
- Therefore, it is necessary to promote awareness of self-protection in citizens.
- Unlike floods, droughts are an extreme hydrological phenomenon of low water availability, which take place slowly and imperceptibly and that sometimes when detected, is too late and can cause very high social, economic and environmental impacts.
- Extreme hydrological events - droughts and floods - have become current global topics regarding water issues, as reflected in the United Nations’ 2030 Agenda (UN). (SDG 6 & SDG 11)

4. Floods and droughts in the World

- The economic impacts caused by extreme hydrological events - floods and droughts - have been increasing around the world causing high social, economic and environmental impacts.

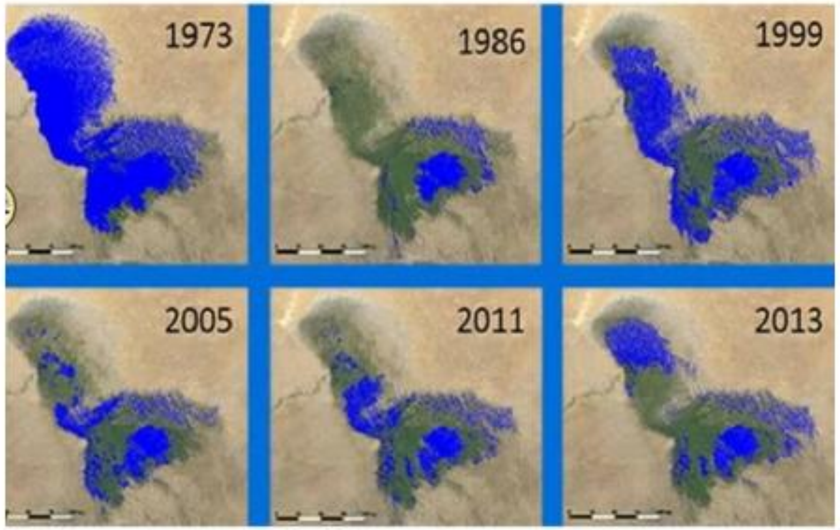


Figure 2. Evolution of water Surface in the Lake Chad [2]

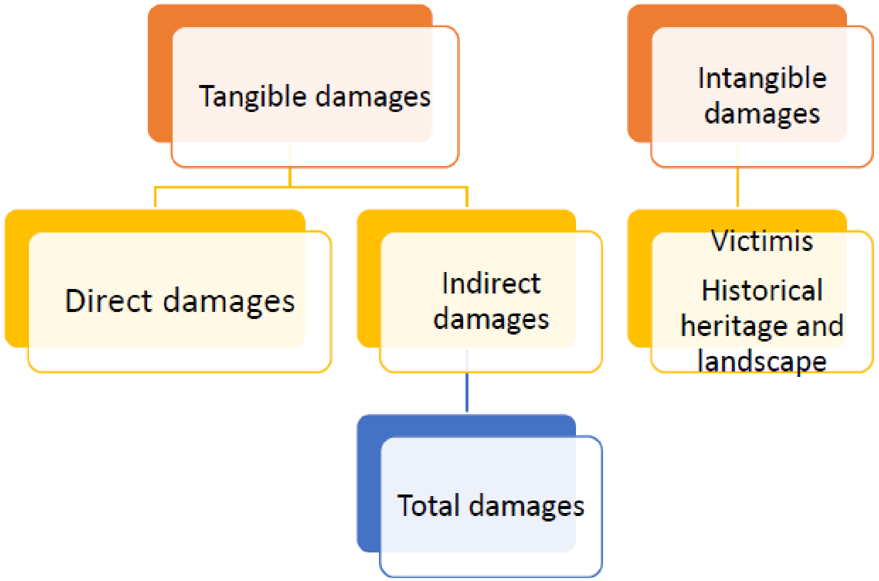
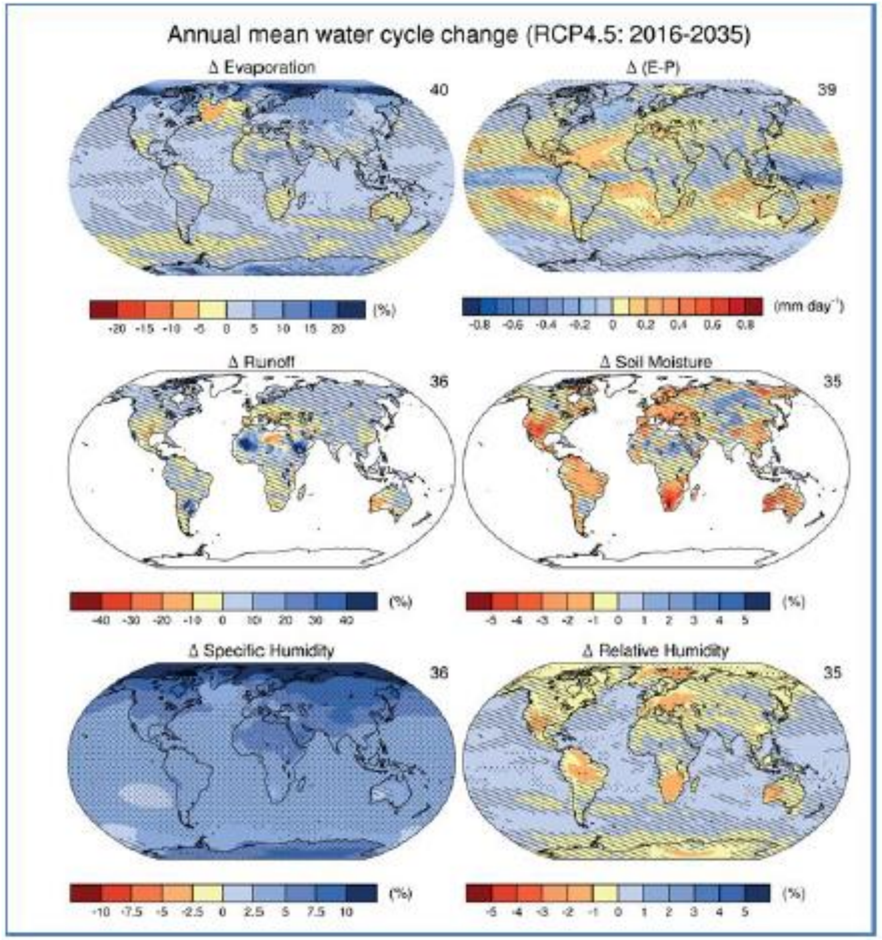


Figure 3. Type of damages due to floods

5. Effects of climate change

“Climate change is part of other global changes of greater scope, which causes negative effects on the availability of resources and the frequency of presentation of extreme hydrological events, such as droughts and floods”

(Intergovernmental Panel on Climate Change, 2014).

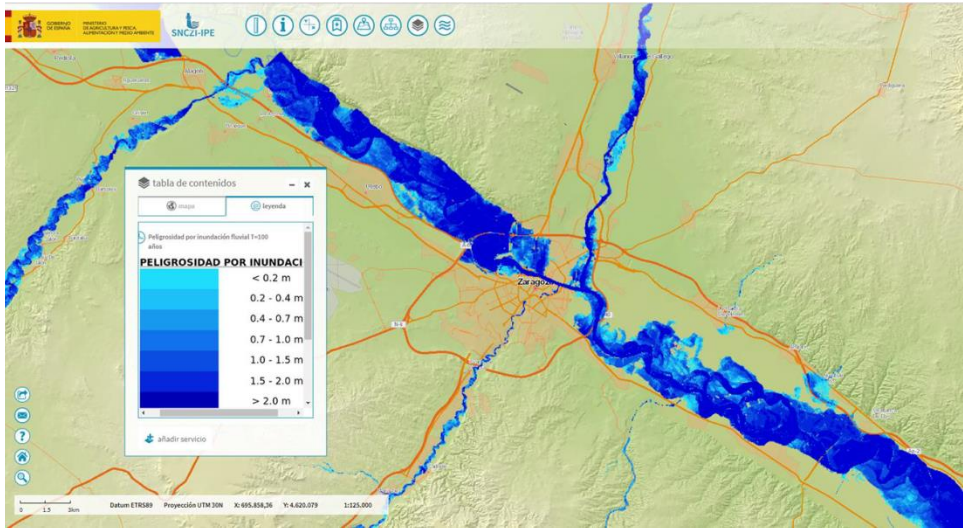


6. Evolution of water policies to manage extreme hydrological events (1/2)

1. Traditional approaches: reactive. Measures and actions that are only triggered after the extreme event has occurred.
2. Approaches based on risk reduction:

	Prospective	Corrective	Compensation
Disaster risk management	Avoid the risk	Reduce/mitigate risk	Enhance resilience to disaster (economic and social)
Climate change	Climate change mitigation	Climate change adaptation	Enhance resilience to extreme events associated to climate change.
Sustainable Development	Contribute to future sustainable development	Enhance the sustainability of the current development framework	Enhance resilience to all common risks.

Table 1. Relationships between disaster risk management, climate change and sustainable development. Source: UNDDR, 2019



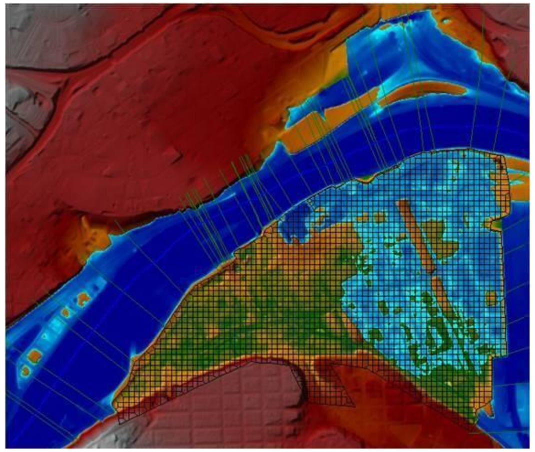
6. Evolution of water policies to manage extreme hydrological events (2/2)

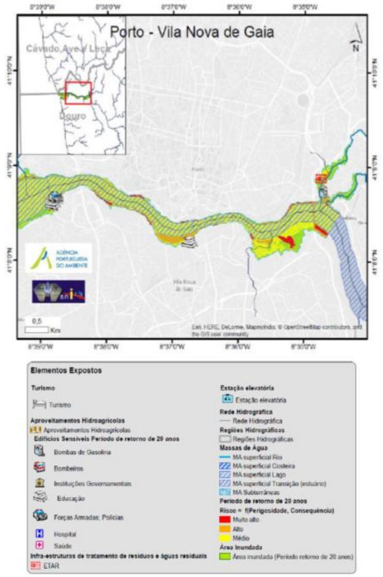
3. Governance in the management of extreme hydrological events: stakeholders, mechanisms, regulatory and legal frameworks
   - Coordination between different levels of government
   - Administrative, hydrological and political boundaries
   - Stakeholder engagement
   - Public and private insurance systems

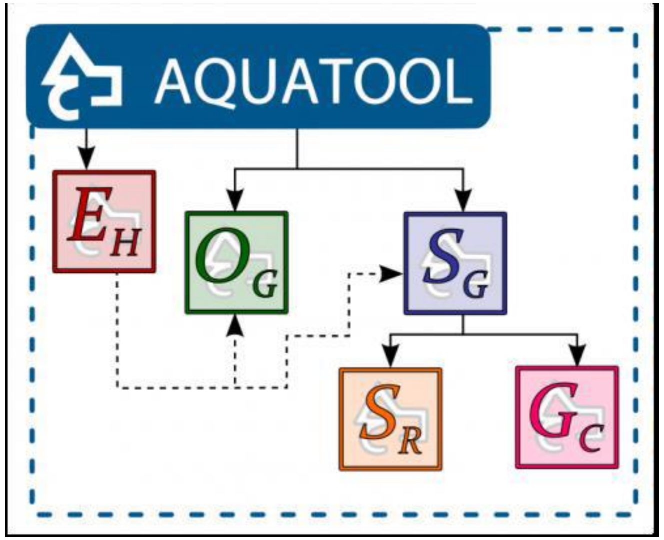
OECD Principles of water governance. Source: OECD (2015) and www.oecd.org/governance/oecd-principles-on-water-governance.htm

7. Knowledge, technology and innovation

1. Hydrological and hydraulic models.
2. Hazard and flood risk maps.
3. Actions: technology and innovation
4. Advances in warning systems







8. Cases and experiences - Box in the Report

Box 1.- Lake Chad Crisis

Box 2.- European SUFRI Project

Box 3.- Managing Droughts in Portugal

Box 4.- Principles of EU Flood Directive

Box 5.- State of art on Flood Damage Assessment

Box 6.- Flood Mapping Project for key areas China

Box 7.- Drought Risk Management through AQUATOOL DSS

Box 8.- Cooperation in Drought Planning and Management in Iberian Peninsula

Box 9.- Drought Management Plans in Spain

Box 10.- La Paz (Bolivia) Drought Management Plan

Box 11.- Flood Risk Management and Ecosystem Restoration in Arlington, Texas, USA

Box 12.- Flood Risk Protection through Reservoirs Management – Ebro River Basin, Spain

Box 13.- Nature Based Solutions to prevent Urban Flooding (USDS)

Box 14.- International experiences in the protection of buildings and constructions

Box 15.- Flood Warning Systems in Spain

Box 16.- China's Flood Forecast and Warning System

Box 17.- USA National Flood Insurance Program

Box 18.- Measures in Cyprus during 1996-2000 Drought Period

Box 19.- Reuse of Urban Water for Wetland Conservation in Dry Periods, Apuria, Italy.

The most ignored crisis in the world: Lake Chad has lost more than 90% of its original surface in four decades.

Such has been called the great environmental and humanitarian crisis caused by the effective disappearance of Lake Chad, which in the 1960s - with 25,000 km^2 of surface -, ranked sixth largest lake in the world. Only two decades later, in the 80s, lake Chad's surface reduced to just 2,500 km^2, that is, 10% of its original dimension. By 2013, the lake recovered slightly, because of an exceptional increase in rainfall, which returned its surface to 5,000 km^2, only 20% of its former surface, currently reduced to an immense set of loosely connected ponds, surrounded by a great desert.

The current situation affects around 40 million people, who depended on the lake to obtain drinking water, fish and cultivate the nearby lands, and who now migrate massively southwards to Guinea's savannah, search for better life conditions. United Nations estimates that almost 11 million people need humanitarian assistance because of this situation. The cause lies in a situation of prolonged drought, because of the general decrease in rainfall. Concurrent to this cause, other factors such as the guerrilla war affecting these 4 countries (Niger, Nigeria, Chad and Cameroon) and an unsustainable increase in water withdrawals for different uses contribute to worsen such crisis.

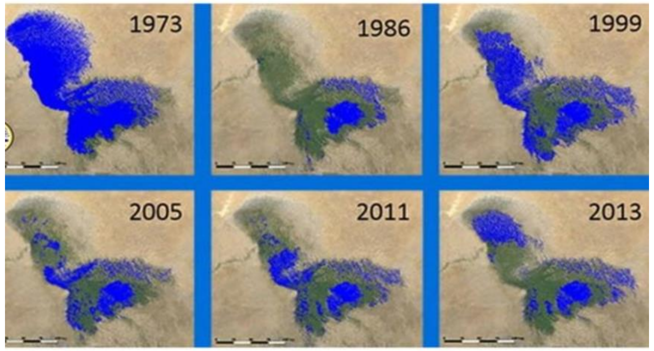


Figure 1. Evolution of water Surface in the Lake Chad [1]

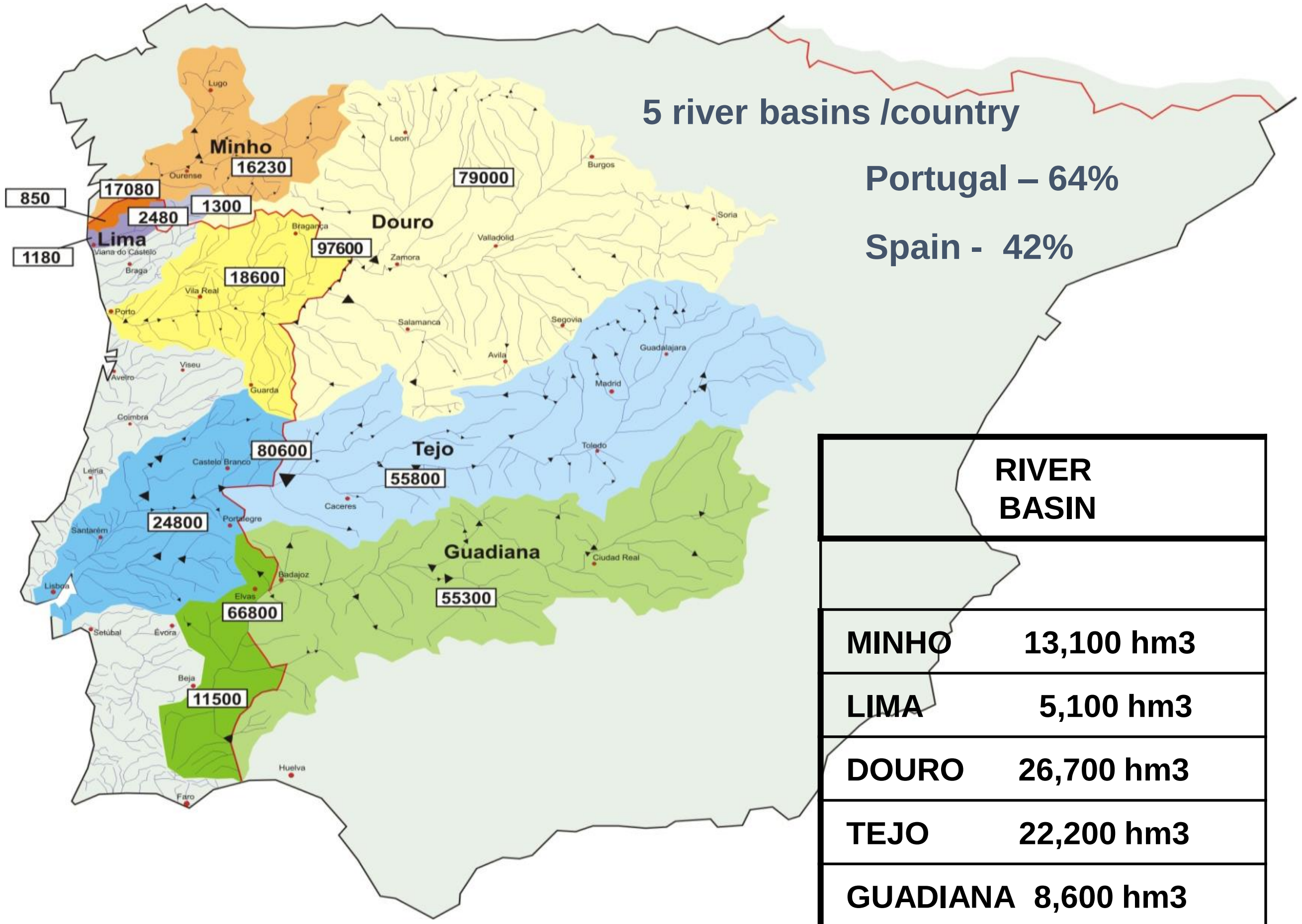
[1] http://documents.worldbank.org/curated/en/489801468186879029/pdf/102851-v2-WP-P149275-Box394847B-PUBLIC-v2-main-report-Lake-Chad-Development-and-Action-Plan-English.pdf

Reuse of urban water for wetland conservation in dry periods. The case of the Torre Guareto Reserve in Apulia, Italy.

Apulia and the coastal areas of Basilicata, in southern Italy, are exposed to frequent problems of water supply due to a historical problem of scarcity not well resolved. In recent decades, efforts have made to improve infrastructure and to build large dams to enhance water resource management, also increasing the extraction of groundwater, which has led to a critical situation its aquifer status. It has also endangered the survival of the Torre Guaceto Reserve, a wetland of international interest included in the Ramsar Convention, Special Protection Area (Directive 79/409 / EEC), marine reserve and Site of Community Importance LIC (Directive 92 / 43 / EEC).

The overexploitation of the aquifer constitutes the fundamental risk for the survival of the "Torre Guaceto Reserve". The very high concentration of salt in groundwater has led to the reduction and even the extinction of some very particular and rare macroinvertebrate species. This situation has become critical during drought periods. On such grounds, it was necessary to apply measures to prevent the deterioration of its current state during those episodes. The Wastewater Treatment Plant (WWTP) of Carovigno represented a potential source of unconventional water available in the agricultural area to replace groundwater during periods of drought.

International cooperation: Albufeira Agreement



5 river basins /country

Portugal – 64%

Spain - 42%

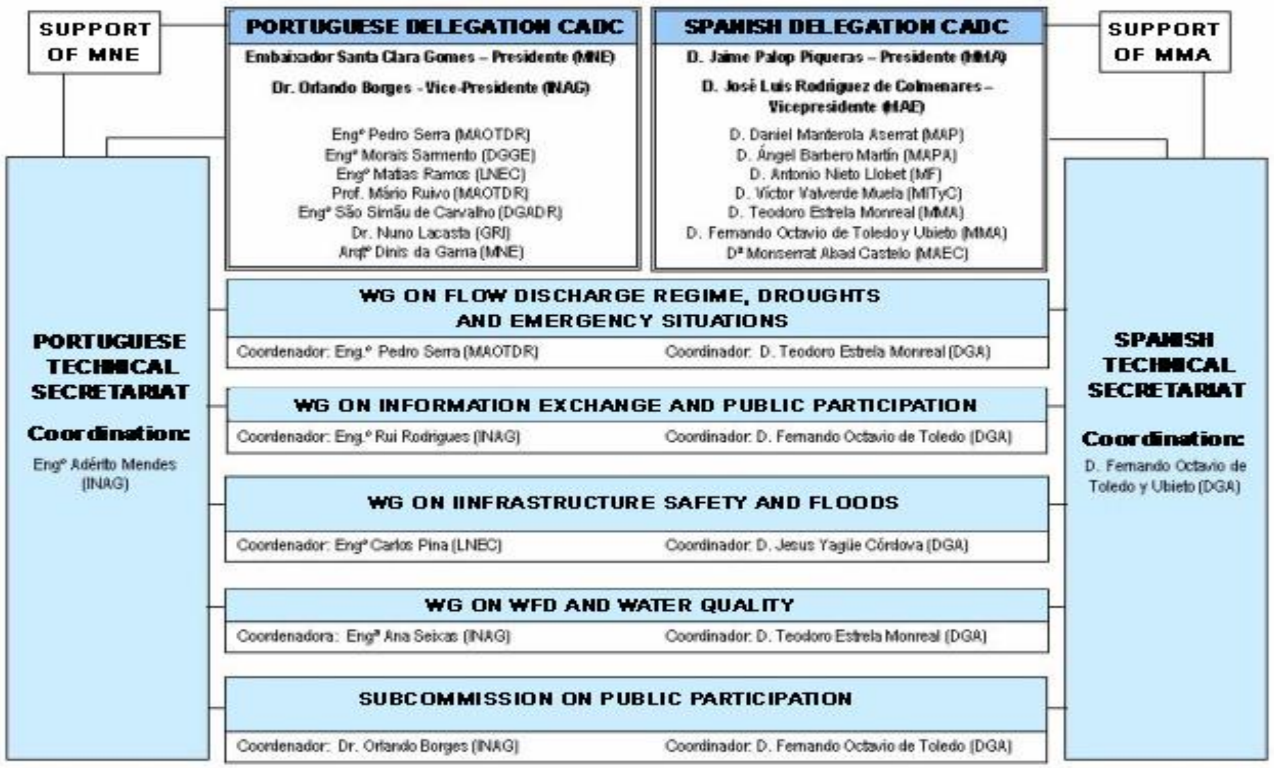
RIVER BASIN	
MINHO	13,100 hm3
LIMA	5,100 hm3
DOURO	26,700 hm3
TEJO	22,200 hm3
GUADIANA	8,600 hm3
TOTAL	76,300 hm3

- 5 SHARED RIVER BASINS
- 10 SPANISH INLAND WATER RESOURCES PLANNING REGIONS
- 10 PORTUGUESE INLAND WATER RESOURCES PLANNING REGIONS
- 2 SPANISH ISLAND WATER RESOURCES PLANNING REGIONS
- 2 PORTUGUESE ISLAND WATER RESOURCES PLANNING REGIONS

RIVER BASIN	Total Area (km²)	Portugal		Spain	
		Area (km²)	%	Area (km²)	%
MINHO	17.080	850	5	16.230	95
LIMA	2.480	1.180	48	1.300	52
DOURO	97.600	18.600	19	79.000	81
TEJO	80.600	24.800	31	55.800	69
GUADIANA	66.800	11.500	17	55.300	83
TOTAL	264.560	56.930	22	207.630	78

Albufeira Convention 1998

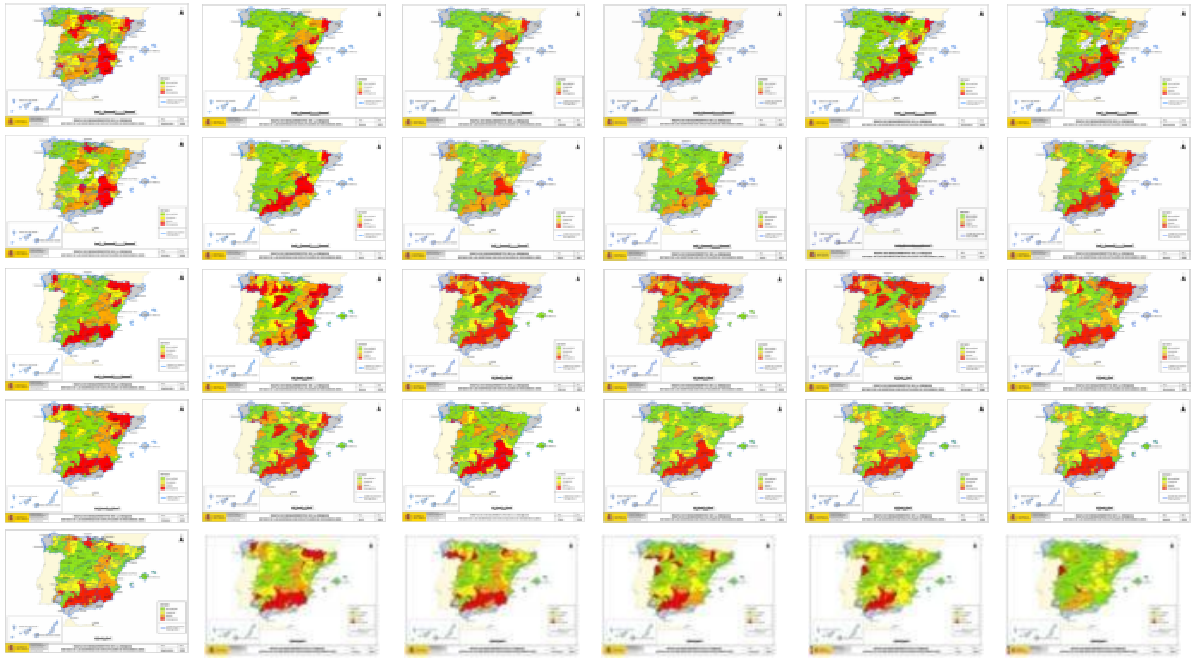
The compliance with the flow regime agreed under the Convention is being ensured, and in the case of potential drought situations, Portugal and Spain implement the measures that are considered necessary to minimize their effects.



Principles of the Albufeira Convention

- Extension of the territorial scope and reference material of the agreements in effect.
- Global perspective of cooperation and respect between the Parties.
- Coordination of water planning and management by river basin.
- Respect and compatibility with existing situations and those derived from agreements in effect.

Drought Management Plans



DROUGHT INDICATOR SYSTEM

- The National Drought Indicator System is formed by control points about volume stored in reservoirs, groundwater levels, river flows discharges and precipitations.
- A crucial and innovative aspect of DMPs in Spain is to establish an adequate link between river basin drought status and actions to be taken.

Type of mitigation measure				
Indicator	1-0.5	0.5-0.3	0.3-0.1	0.1-0
Status	Normal	Pre-alert	Alert	Emergency
Objective of measure	Planning	Information-control	Conservation	Restriction

Drought Management Plans

EXPERIENCE ACQUIRED during 2014-2018 drought in SPAIN

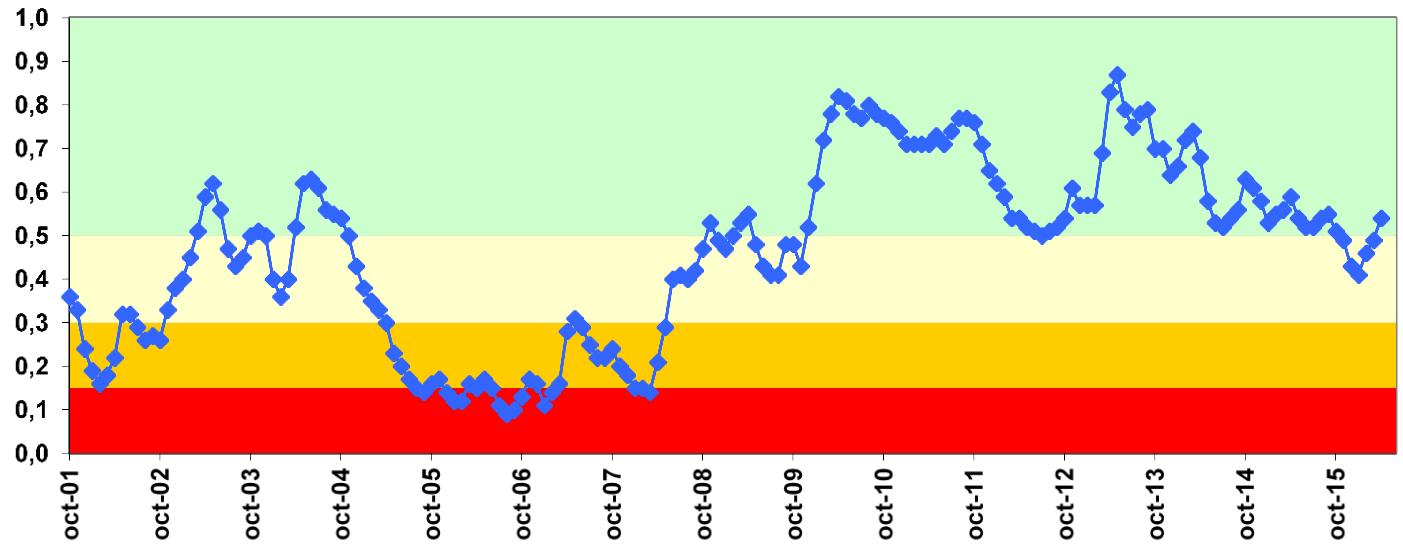


Figure 7. Evolution of drought indicator at the Júcar river basin for the 2001 – 2016 period (elaborated with data taken from the Drought Indicator System of the Júcar River Basin Authority)

- Drought management plans have revealed as an essential tool for drought management in Spain.
- Improvement of water management, coordinated use of surface water and groundwater, water saves on irrigation and improving on the monitoring networks have been key elements to cope droughts.

Drought Management Plans

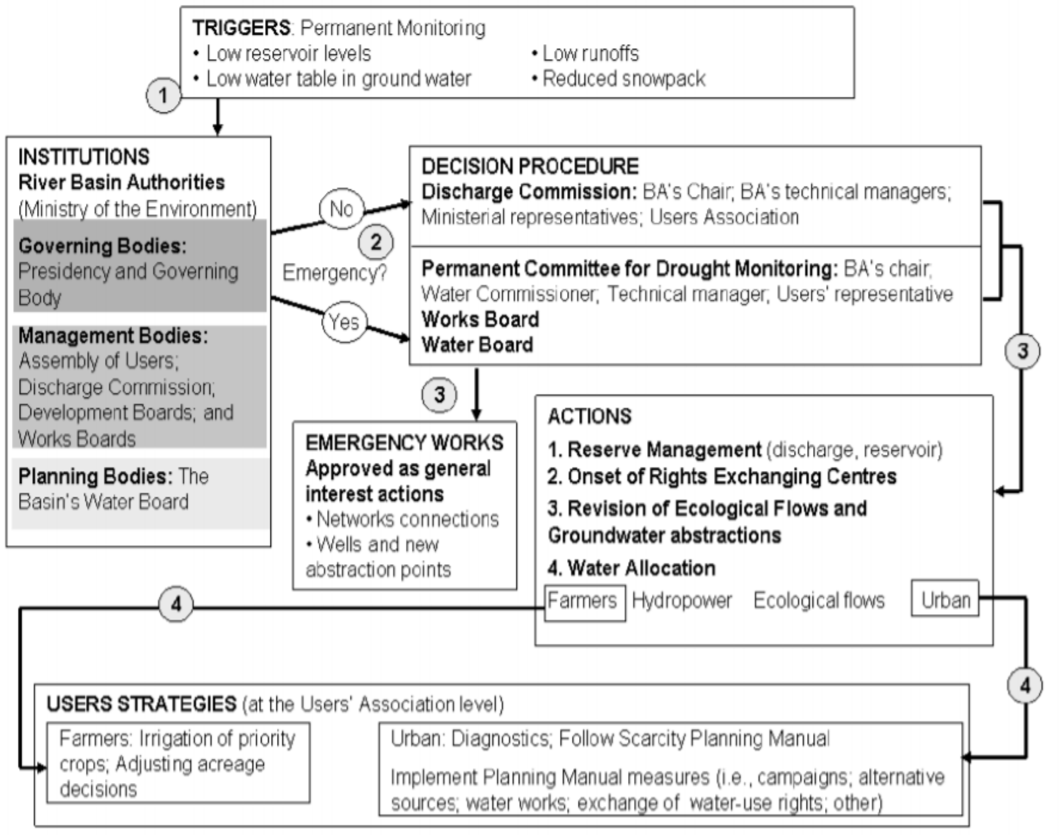


Fig. 14. Processes and institutional linkages in the pro-active responses to hydrological drought and water scarcity in Spain.

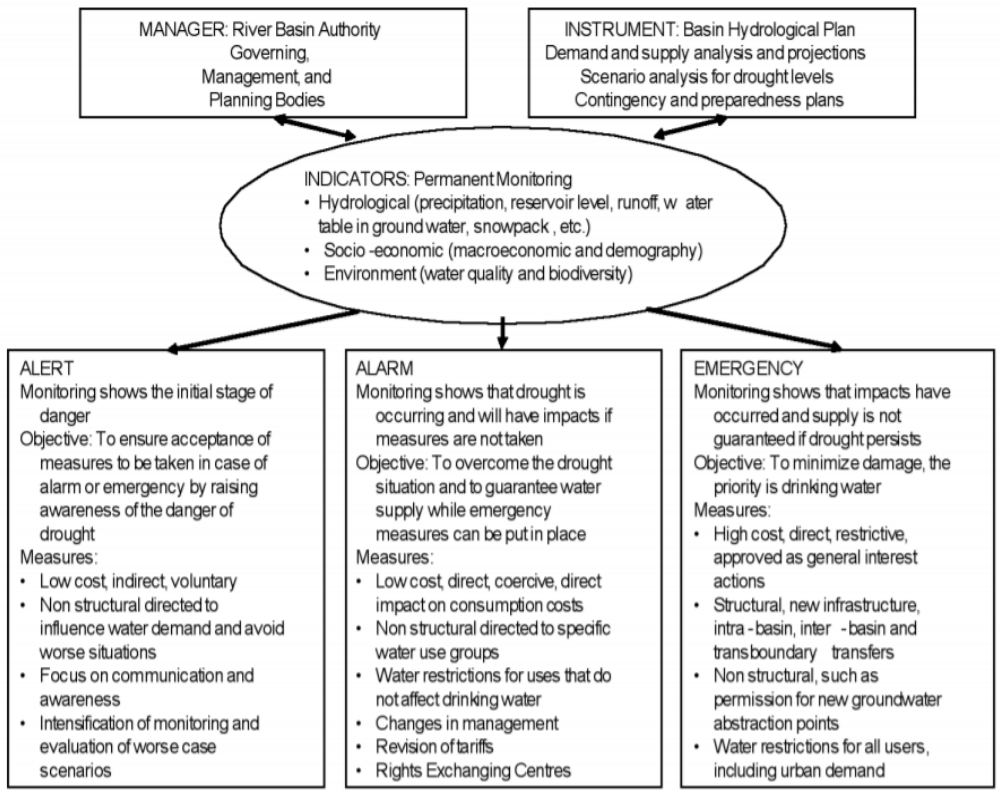


Fig. 17. Drought management at the basin level: Indicators and measures for different levels of drought intensity.

Drought Management Plans

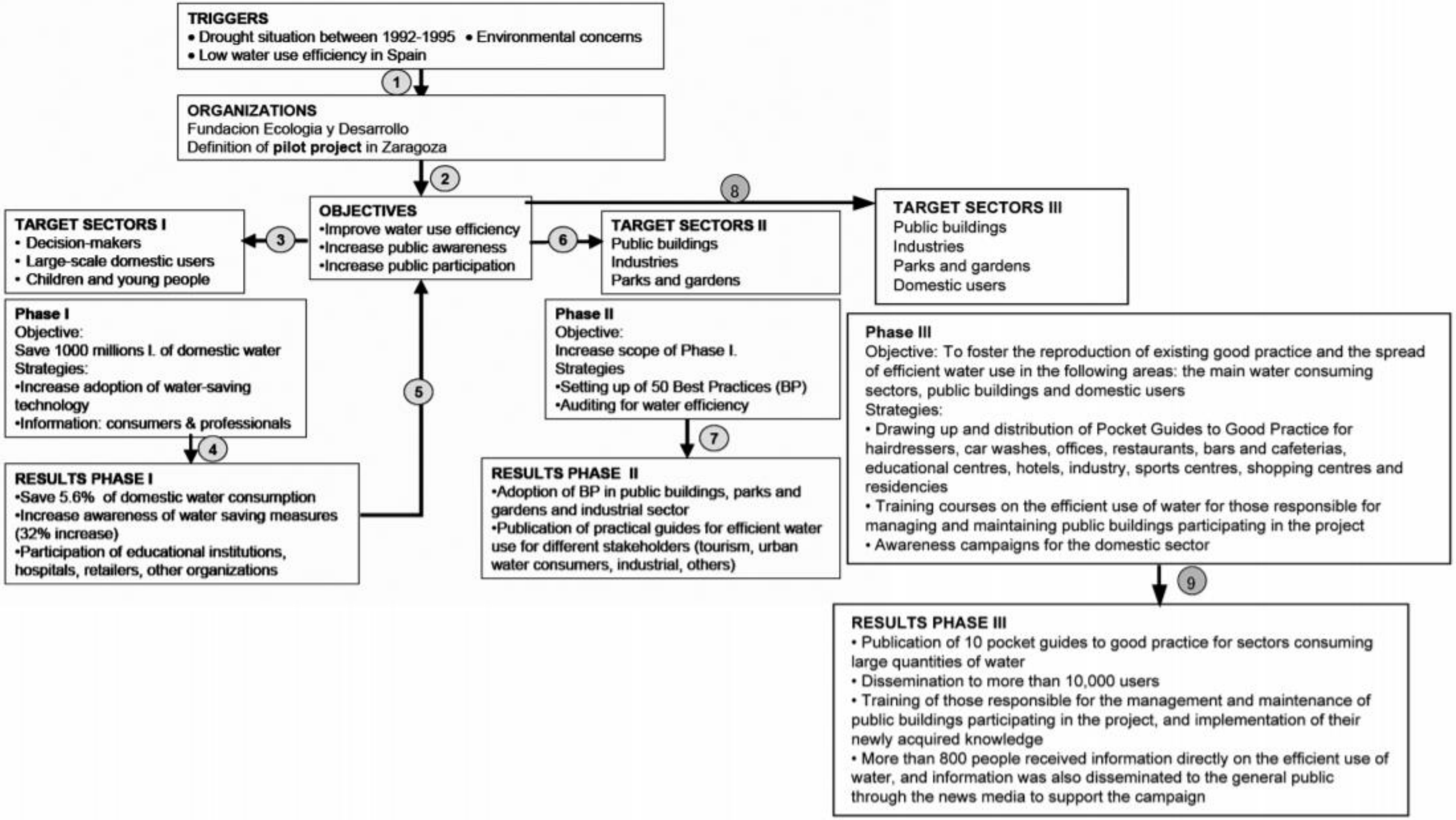


Fig. 18. Summary of the NGO Fundación Ecología y Desarrollo (ECODES) program to save water in the city of Zaragoza, Spain.

9. Experiences and Best Practices (1/5)

1. Risk management plans: floods and droughts.

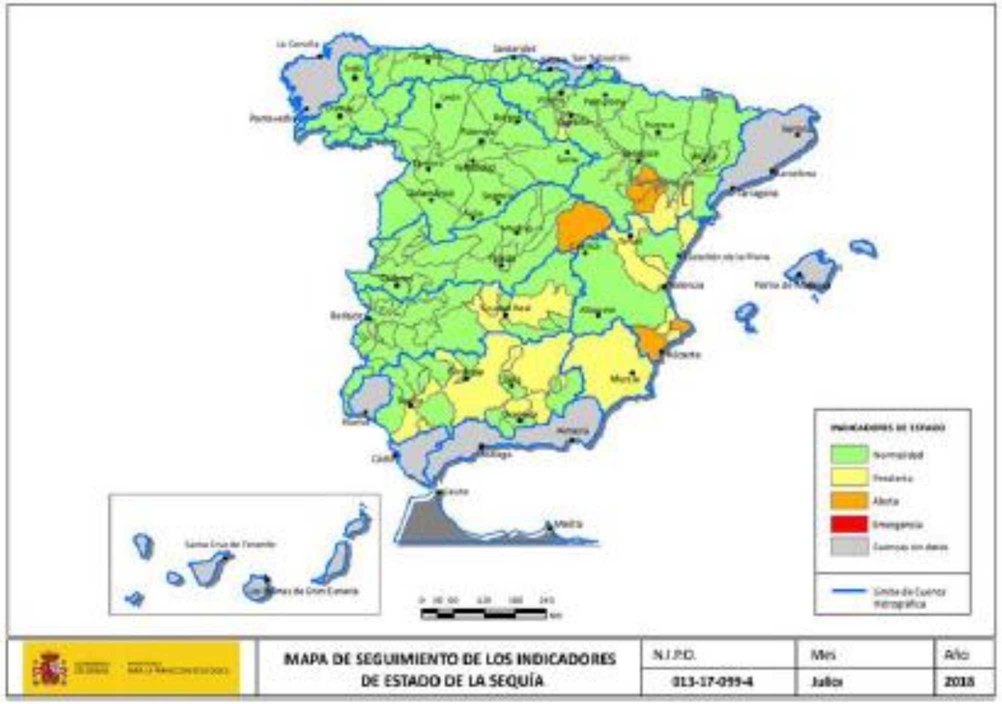


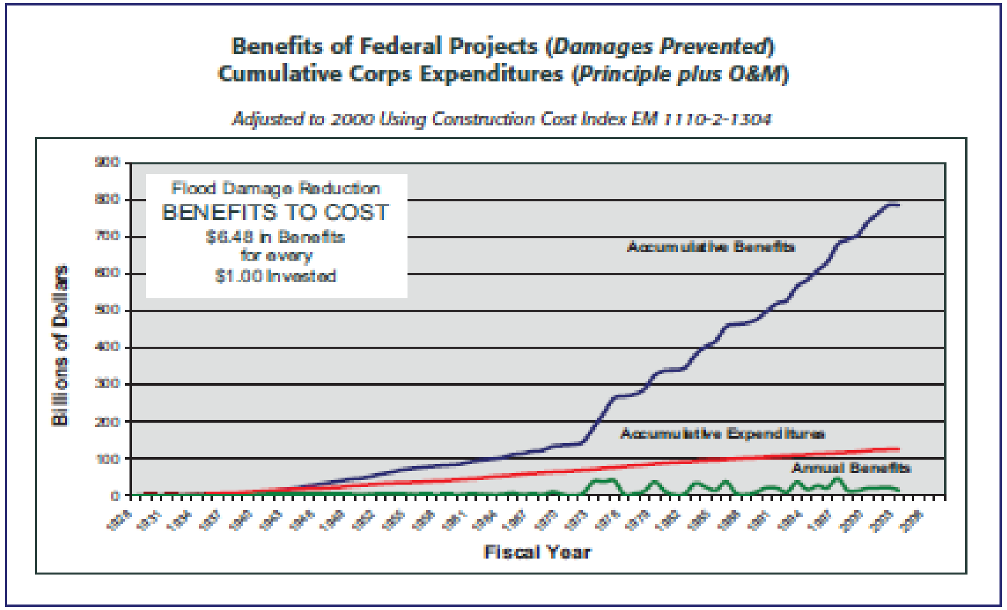
Figure 12. Drought Indicators Monitoring map in Spain, July 2018..

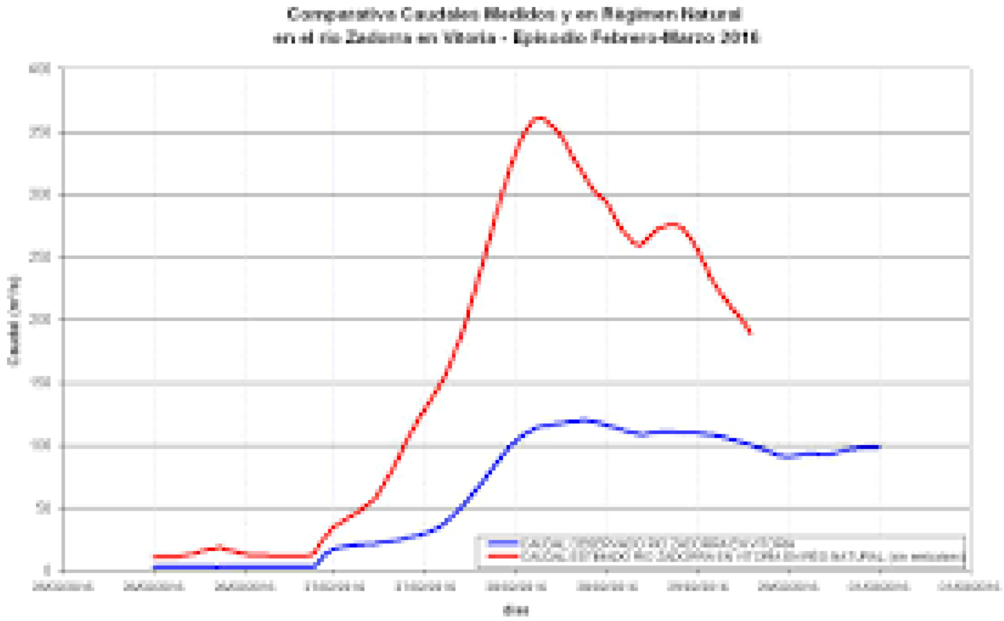
Figure 14. Johnson Creek River Basin

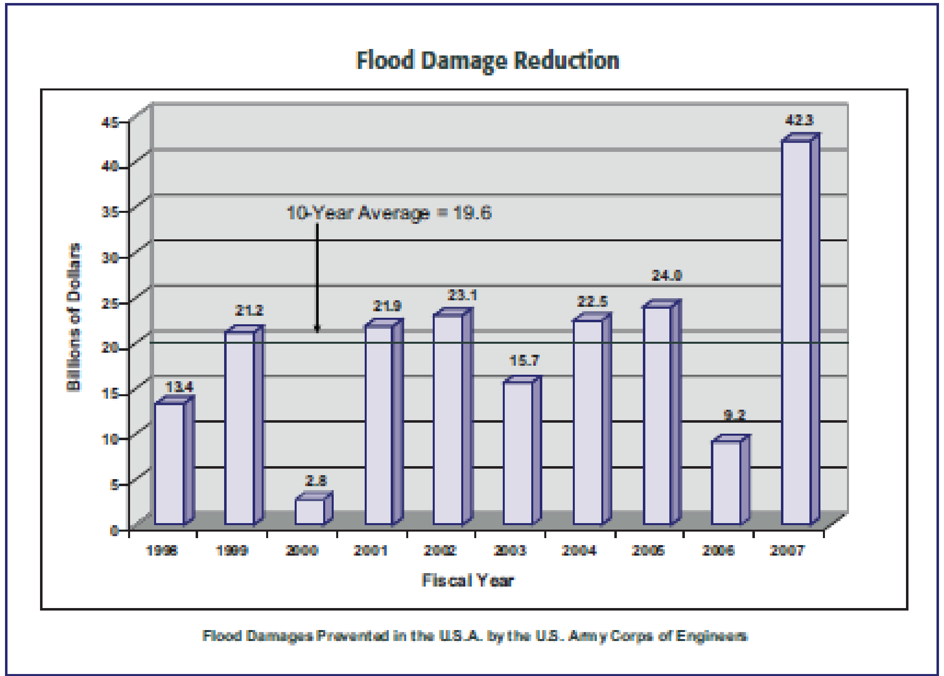
2. Structural Protection Measures.

1. Flood control reservoirs
2. Diversion channels
3. Embankments and dykes
4. Channel modification
5. Drainage of linear infrastructures
6. Green infrastructure and natural water retention measures
7. Hydrological restoration and flood zone measures
8. Non-structural or management measures: prevention, alert and response (next slide)

RESERVOIRS MANAGEMENT FOR FLOOD CONTROL







Since 1936 the Corps has completed over 400 major lake and reservoir projects, emplaced over 8,500 miles of levees and dikes, and implemented hundreds of smaller local flood damage reduction projects.

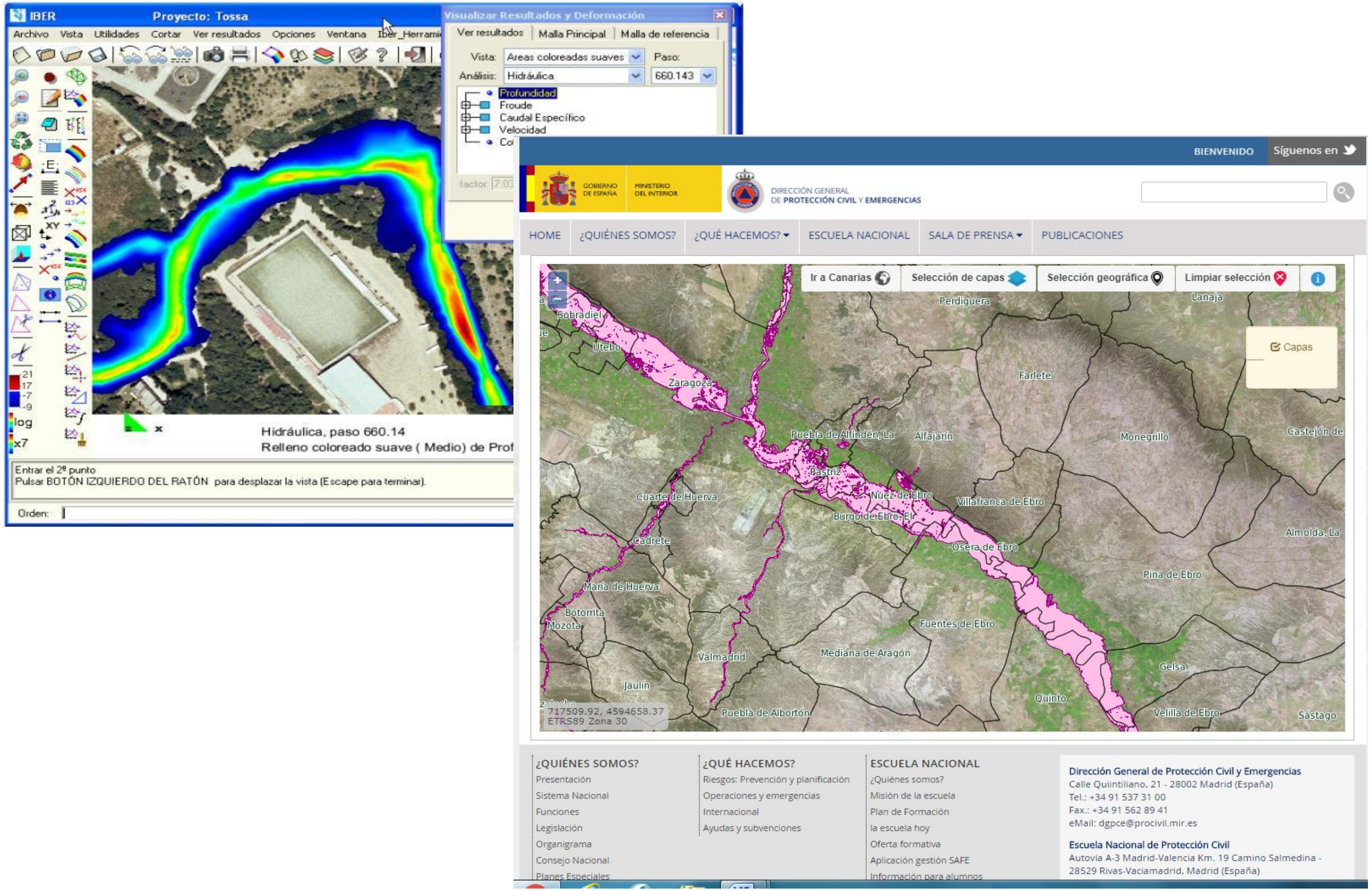
US Army Corps of Engineers ®

9. Experiences and Best Practices (4/5)

3. Non-structural or management measures: prevention, alert and response:

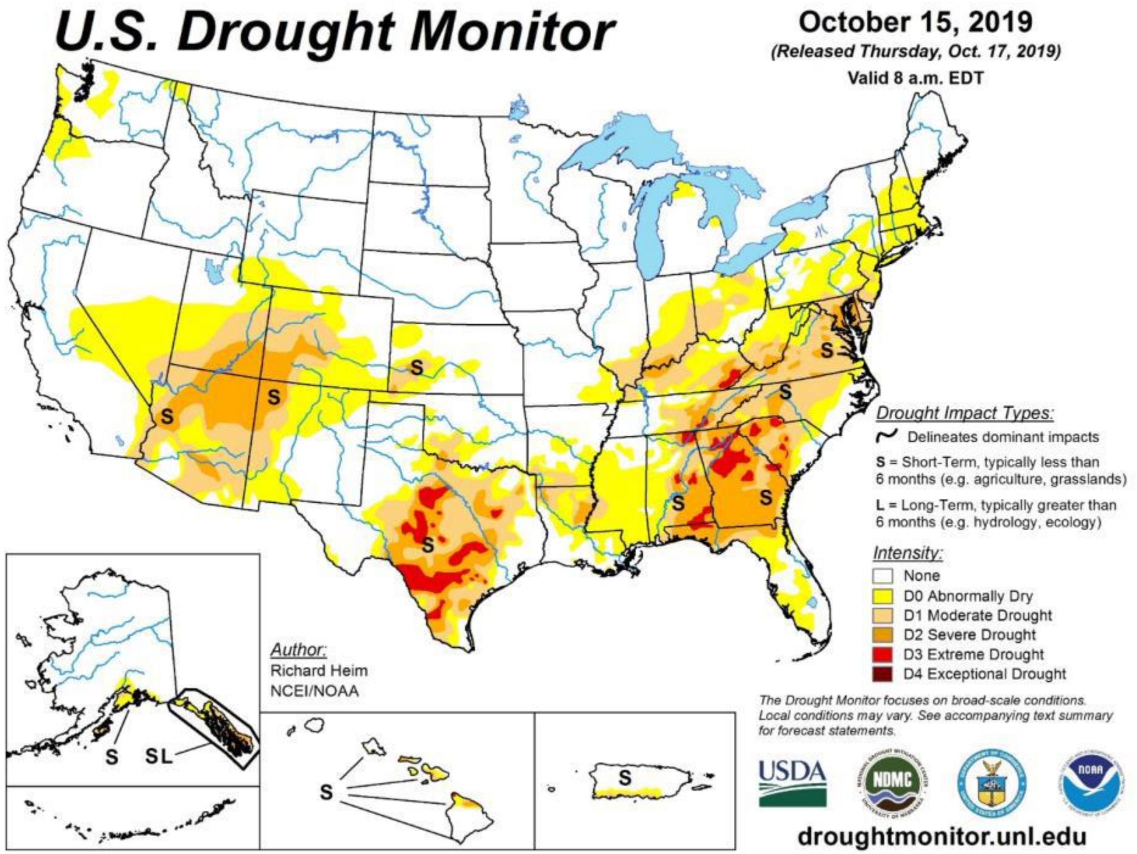
1. Adaptation measures for potentially affected assets, for damage mitigation
2. Prevention measures: land management and urban planning
3. Warning measures: flood warning systems
4. Response measures: civil protection
5. Response measures: flood insurance

Spain National Cartographic System of Floodable Areas



4. Measures to deal with drought risks.

1. Integrated Water Resources Management
2. Management and control measures: resource allocation, water savings and tem-porary transfer of rights
3. Environmental measures
4. Drought warning and monitoring system
5. Agricultural insurance



10. Lessons learned

1. **Importance of planning**: addressing the risks in a planned way. Anticipate, graduate, coordinate actions, establish actors, measures, monitoring, reviewing.

Engineering participation ensures effectiveness in measures to be studied, proposed and applied, optimizing risk management.

2. **Adaptative management:** land use, buildings and facilities, evacuation of people and property, water use.

Engineering plays a very important role in estimating the occurrence of time the natural phenomena, the potential affected areas, the risks and potential damages, the definition of adaptation actions, the best evacuation alternatives to non-flood areas, the best options to guarantee the essential uses of water and limit socio-economic damages in droughts, and to establish previously appropriate guidelines and actions in flood and drought management plans.

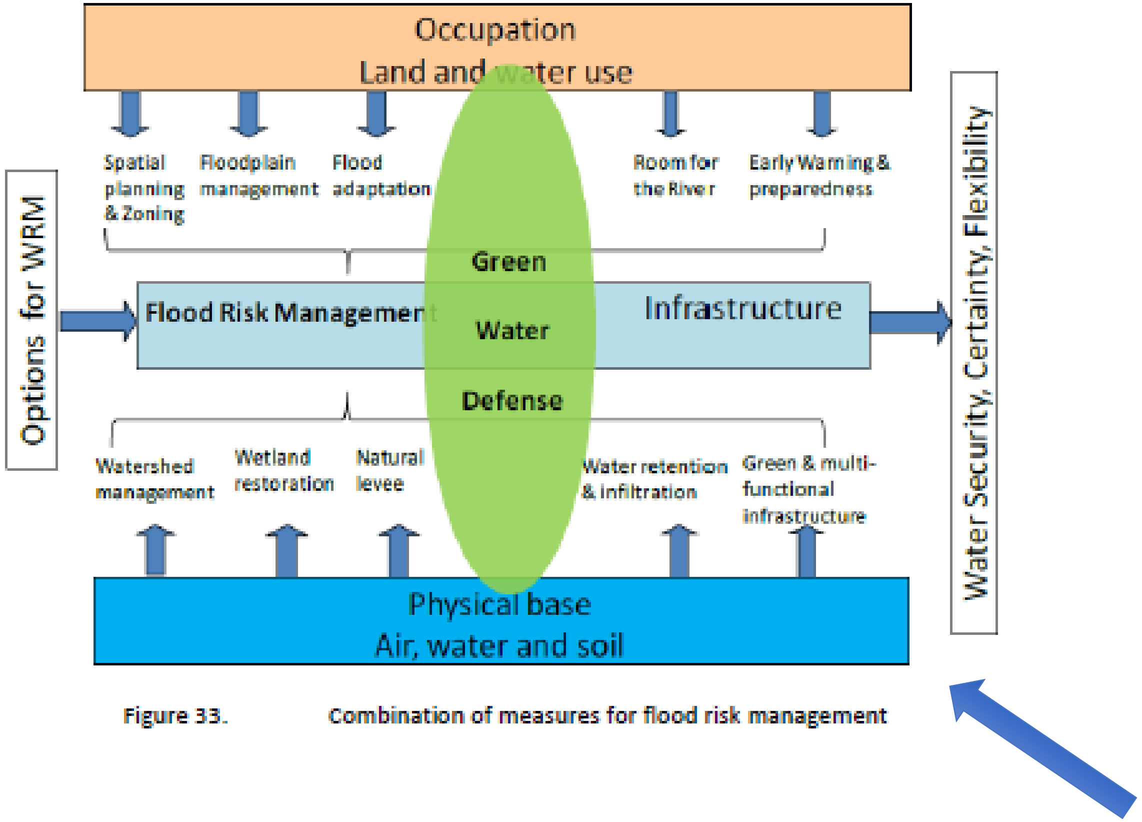


Figure 33. Combination of measures for flood risk management

3. Technology and improvement of results: Weather forecast –satellites, GIS, DTMs, Hydraulic models.

Engineering is totally necessary for its correct use and to foster its improvement. It is engineering what drives and focuses the development of Decision Support Systems, both in floods, to decide the best management options based on the existing alternatives and in situations of droughts, to study and evaluate the most appropriate integrated resource management options to mitigate their effects.

4. Combination of measures: *Sound engineering to achieve satisfactory solutions, case by case.*

1. **The current role:** *Current engineering practice has become increasingly collaborative, favouring specialization, undermining engineers' leadership roles formerly assumed by more broad-based generalist self-sufficient engineers. On the other hand, specialization provides high qualification for the operation of complex tools in the analysis of extreme events, such as Decision Support Systems (DSS) and Geographic Information Systems GIS for drought management and floods or mathematical models used in hydraulics studies and in the design of flood rolling dams and other infrastructures.*

   Another aspect increasingly present in current engineering is global practice and its corresponding demands: languages, knowledge of each region's "water culture" and adaptation to diverse local factors, as well as the cross-knowledge transfer between countries with different features and idiosyncrasies.

2. Professional practice indicators: *Proposing WFEO a survey to better global statistics regarding the number of engineering professionals dedicated to water issues*

3. Innovation and technology:

- *Technology development (BIM, 3D printing, IoT, Big Data, Machine learning, Augmented reality, Drones…)*
- *Infrastructure construction and design of resilient systems*
- *Extreme events management and restoration*

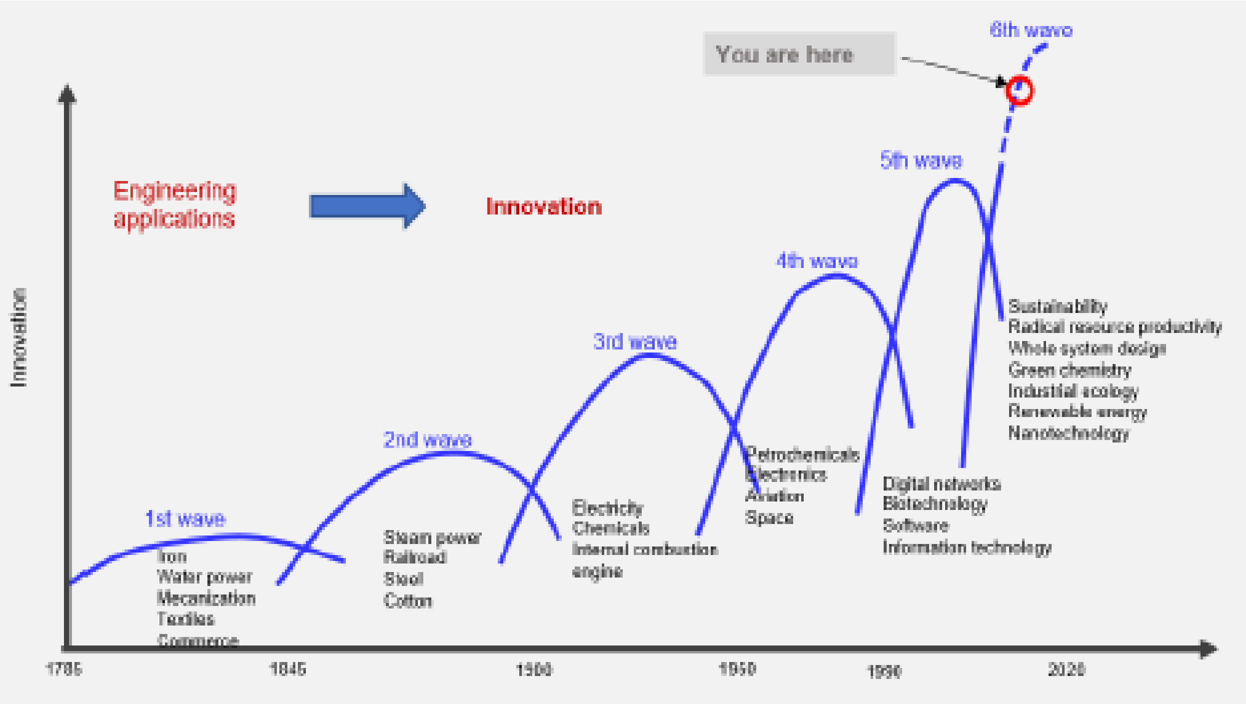


Figure 34. Historical evolution of engineering innovation. Source: Referred by Jose Vieira, OdE Portugal and President FEANI

4. Social responsibility:

- *ASCE 2025 VISION*
- *Risk assessment and its mitigation is a key principle of engineering practice. It imposes a responsible commitment to civil engineering professionals to adopt due to assess the effect of climate change on the works and the service they provide. This is reflected twofold. Firstly, engineers in charge of public facilities and infrastructure design and management will have to adapt to climate change at the local level to ensure public health and safety. Secondly, the growing level of awareness to this risk and the high visibility of the impacts derived from the most intense storms and extraordinary events raise accountability issues. Engineers who do not exercise due diligence regarding climate change, in short, may be considered personally or jointly liable for damages or failures arising from the impacts of climate change on engineering systems and water security.*

5. Emerging and future areas:

• *Deepen studies of the CC effects on resources, the water environment, droughts and floods and water demands in order to improve their consideration in planning and define and implement the most appropriate adaptation measures.*

• *Incorporate CC measures into national policies, strategies and plans, making progress in adapting and guaranteeing the resilience of the planned infrastructure.*

• *Include CC as one of the factors to consider in the design, operation and management for the safety of the new Critical Infrastructures, and for the adaptation of existing ones.*

To achieve this goals, the following actions should be implemented:

• *Develop joint initiatives to develop projects within the innovation trends regarding the fields of Information, Planning, Engineering, Technology and Water Management.*

• *Join efforts and develop R & D & I projects that, applying the available technologies and instruments (mathematical models, measurement, telemetry, remote control or remote control, remote sensing, purification treatments, generation of unconventional resources through water regeneration or desalination, etc.) allow the improvement of water management. Establish technological innovation as a key development factor.*

• *Improve governance, invest in institutional capacity building and apply integrated, transparent and effective solutions in water management.*

6. New roles and challenges:

The 2030 Agenda states that the achievement of sustainable development in its three dimensions, economic, environmental and social, must be addressed in an integrated and balanced manner. Thus, water is the SDG 6.

Access to water and sanitation, to affordable and non-polluting energy, to food security, sustainable growth, the ability to adapt to risks related to climate and natural disasters, such as droughts and floods, resilient infrastructure or international cooperation, are clear examples of interconnected issues. Today, engineers around the world are addressing global challenges, such as climate change, locally. When they carry out studies or project works, they must take these global challenges into consideration.

Engineers face decentralized teamwork often. Leading multidisciplinary teams in droughts and floods, is a great challenge. Furthermore, increased globalization requires engineers to overcome any cultural bias in its professional practice, a skill that should be exercised.

Engineers must best practices worldwide such as 2013 WFEO’s Codes of Best Practices for Sustainable Development and Environmental Protection "Think with a global vision and act with a local vision" (WFEO, 2013), and 2015 “Code of Good Practices: Principles of Adaptation to Climate Change for Engineers” (WFEO, 2015), expanded and adapted locally.

12. Contributions

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VIRTOUS URBAN WATER CYCLE: TECHNICAL ISSUES

- The water reserves in **dams** (or available in aquifers) is the indicator that relates to the **guarantee of supply**, and should be managed by foreseeing hyperannual drought cycles.

- **Alternative resources** (desalination, reclaimed water - regeneration and reutilization) are more expensive and increase the energy dependence, so they should be considered as complementary sources, not as a replacement alternatives.

- It is necessary to **control and monitor** the resource in quantity and quality. There is no reliable information about neither supply amounts nor supply typologies in each city. Even less reliable information is on wastewater typologies (septic tanks, sewage, sewage and waste water treatment plants)

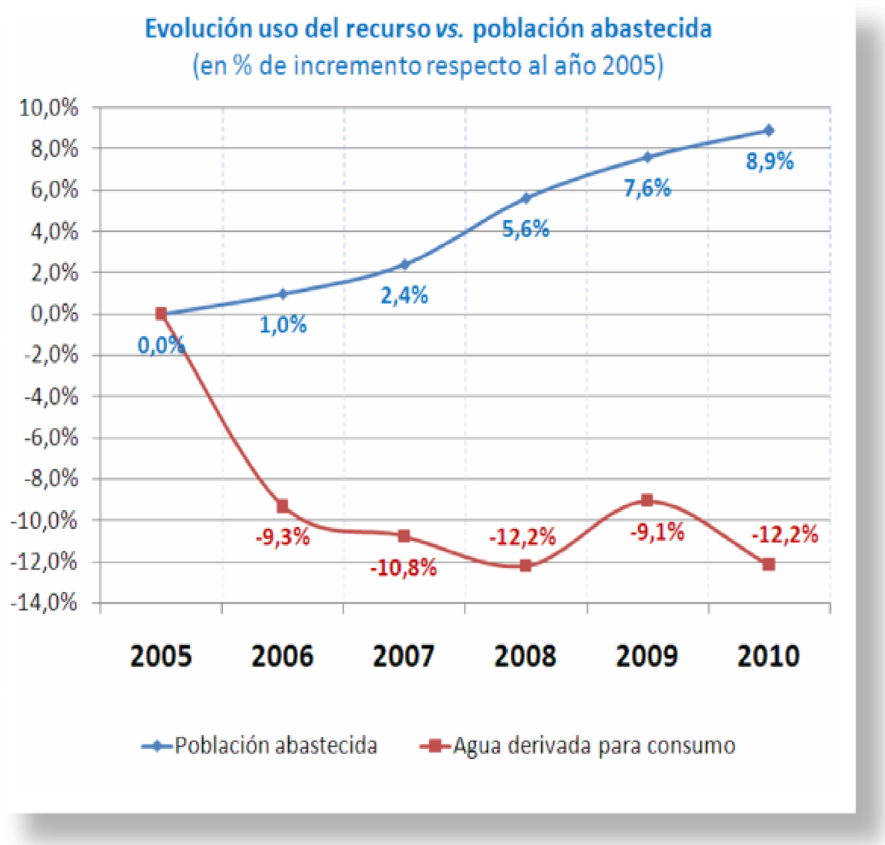
VIRTOUS URBAN WATER CYCLE: TECHNICAL ISSUES

- In developed countries an average person uses **500-800 liters** of water per day, which is 10 times more than the average in least developed countries.
- It highlights the great benefits of **network sectoritation** (for consumption control, leakage control and investment planning) and connections and distribution rings.
- The importance of **sanitation and waste water treatment**, which affects the sustainability of the resource and the health conditions of the population.
- It is very important the **technification** of the systems and provide them with "intelligence" which enables better operation and management thereof, through R&D and knowledge transfer

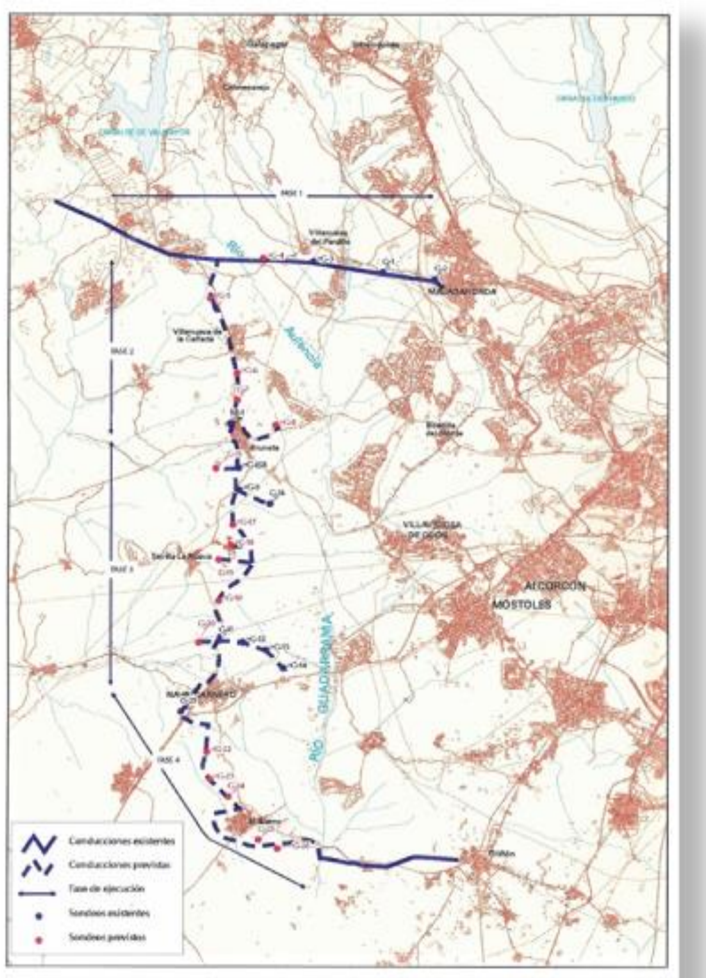
MADRID (Spain)

RECENT ACHIEVEMENTS IN MADRID

After a difficult scenario of increasing population, it is possible to reduce water consumption while keeping the supply warranty



STRATEGIES FOR WATER SUPPLY IN MADRID: local actions



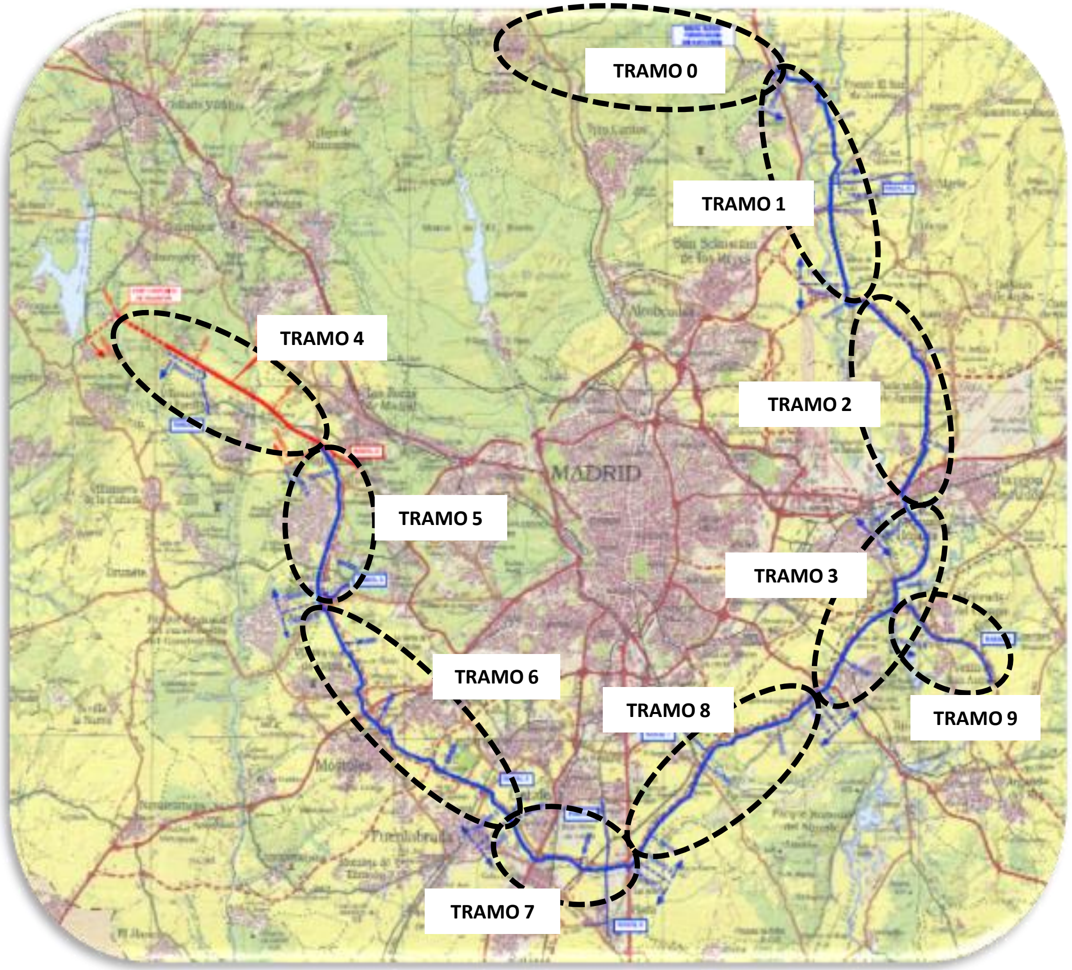
- **28 wells** with 400–700 m depth
- **56 km of principal conductions**, diameter of 800 – 1600 mm, transporting up to 2 m^3/s.
- Connections to **2 DWTP** (Majadahonda y Griñón)
- 56 km of electricity lines and 3 substations (14.MW)
- **Remote control** with telemetry using optic fiber (connection to the main water control)

STRATEGIES FOR WATER SUPPLY IN MADRID: supply ring

Enlargement and improvement of the water transport network, warranting the supply to the new consumption areas.

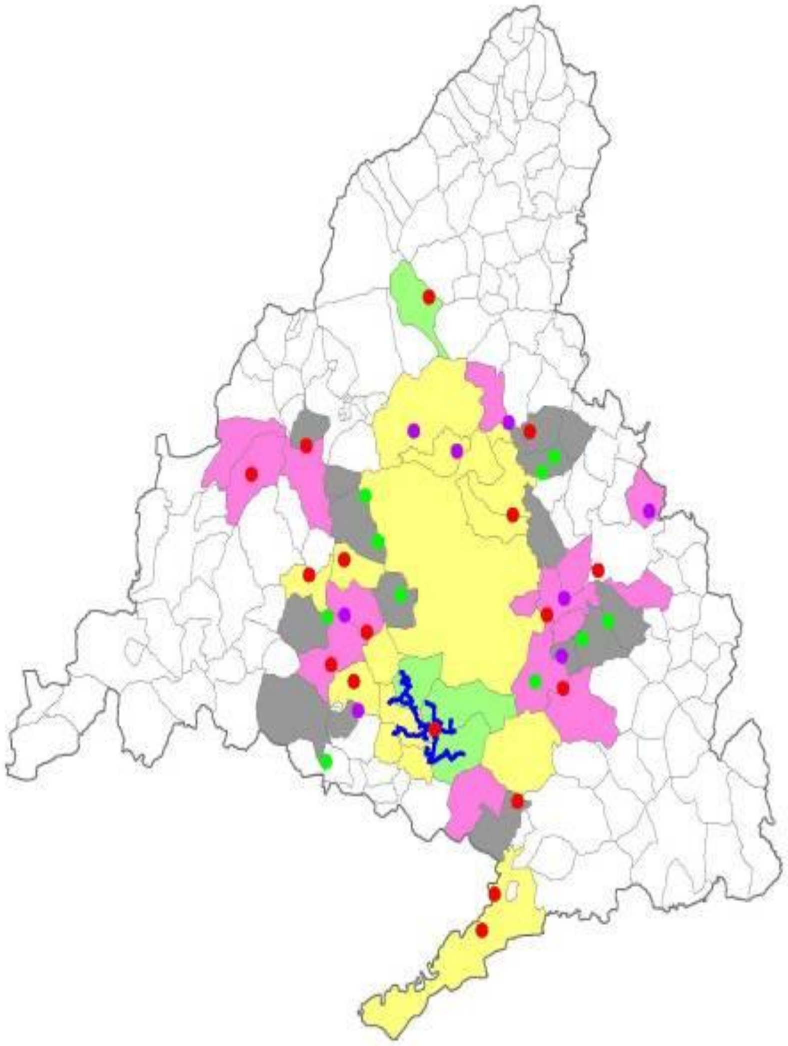
Alternative supply to the south and east regions with water taken from the west (**410 hm³/year** between Alberche and Valmayor).

- **136,4 km** (2 pipes of 1.400 mm diameter)
- Funding: **430 M€**

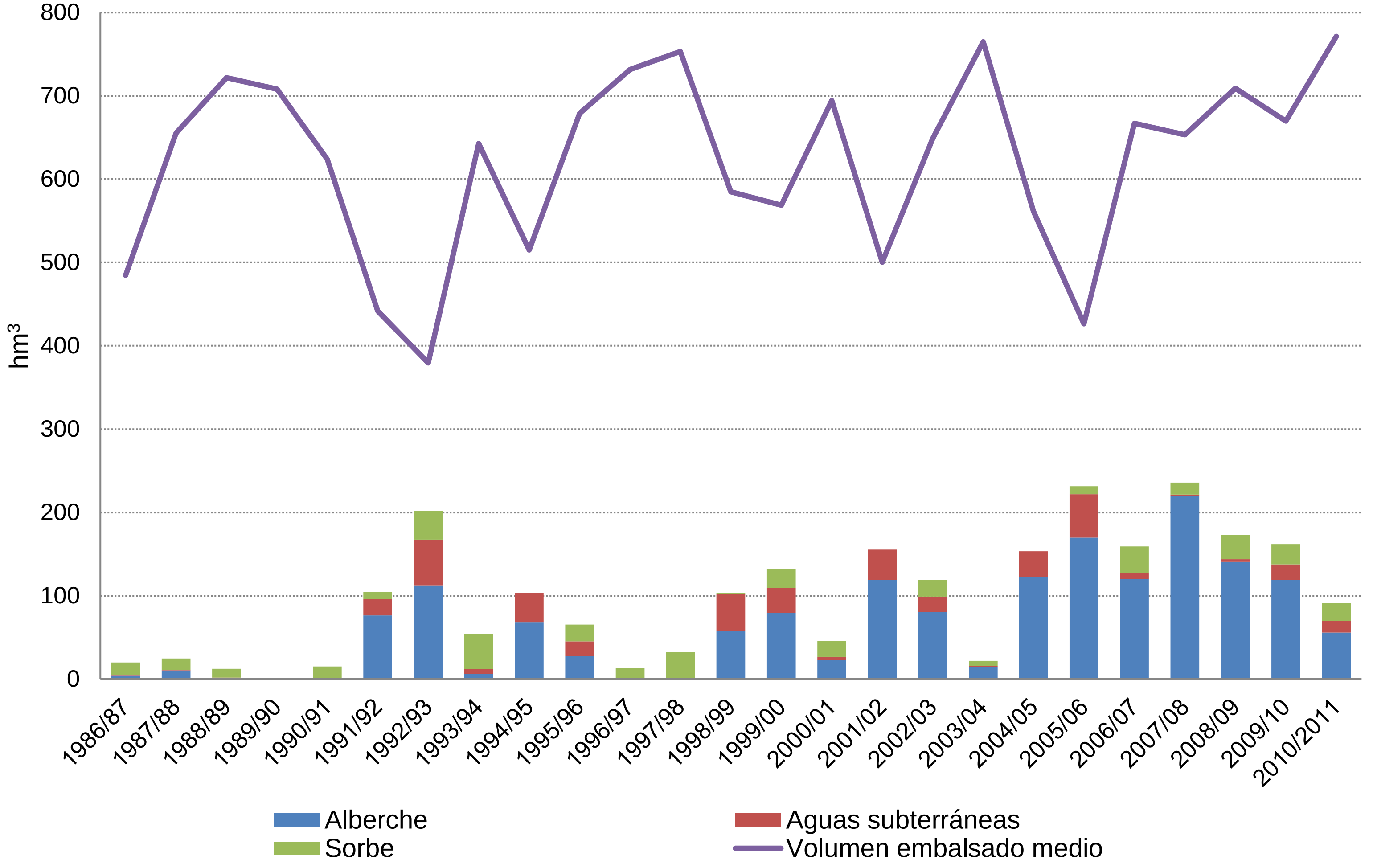


STRATEGIES FOR WATER SUPPLY IN MADRID: **reclaimed water**

- Tertiary treatment
- Tertiary under construction
- Tertiary under project
- Transport network
- Current Municipal network
- Municipal network under construction
- Municipal nectwork under project
- Municipal network (3rd phase)



STRATEGIES FOR WATER SUPPLY IN MADRID: **alternative resources**



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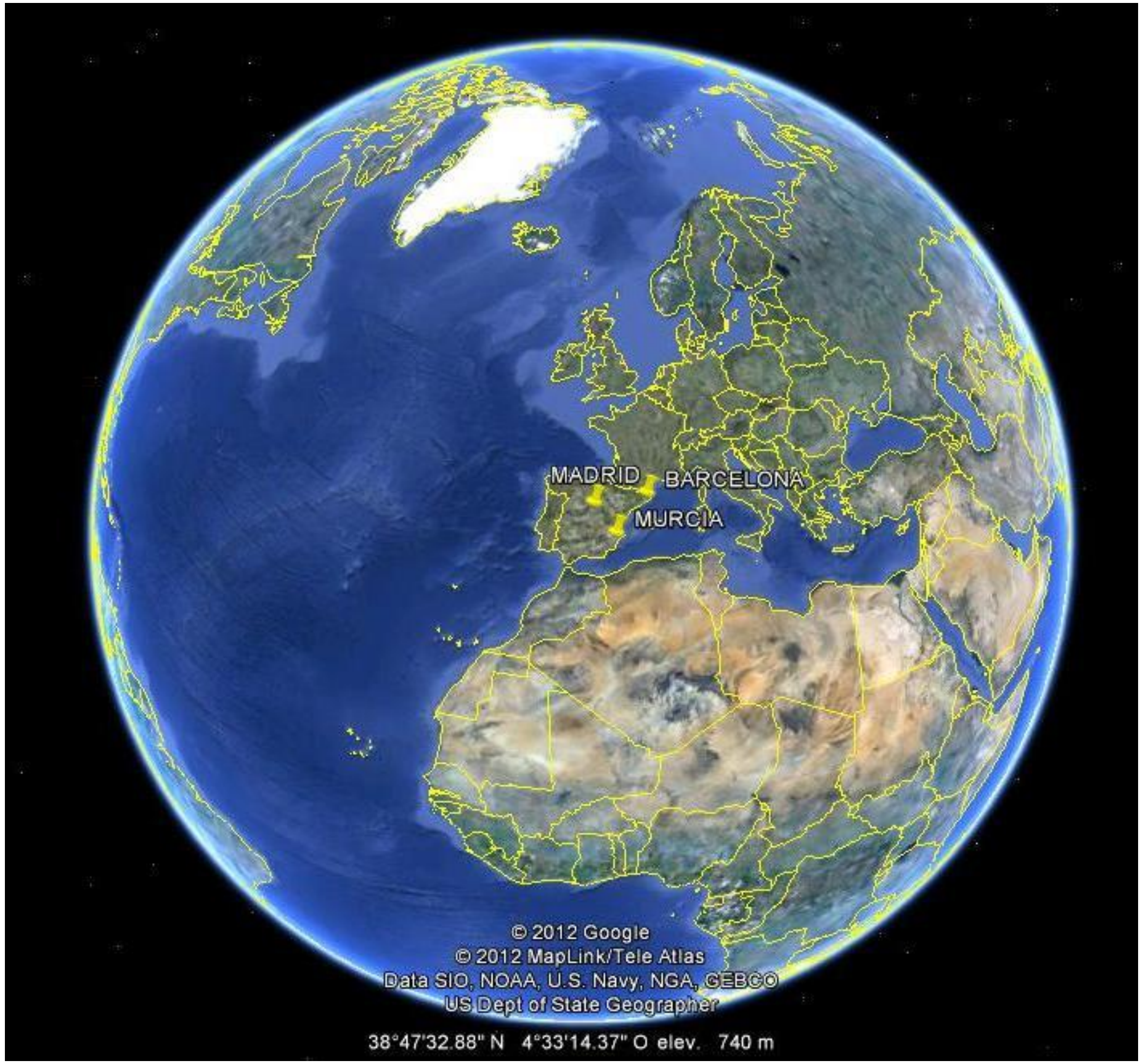
BARCELONA (Spain)



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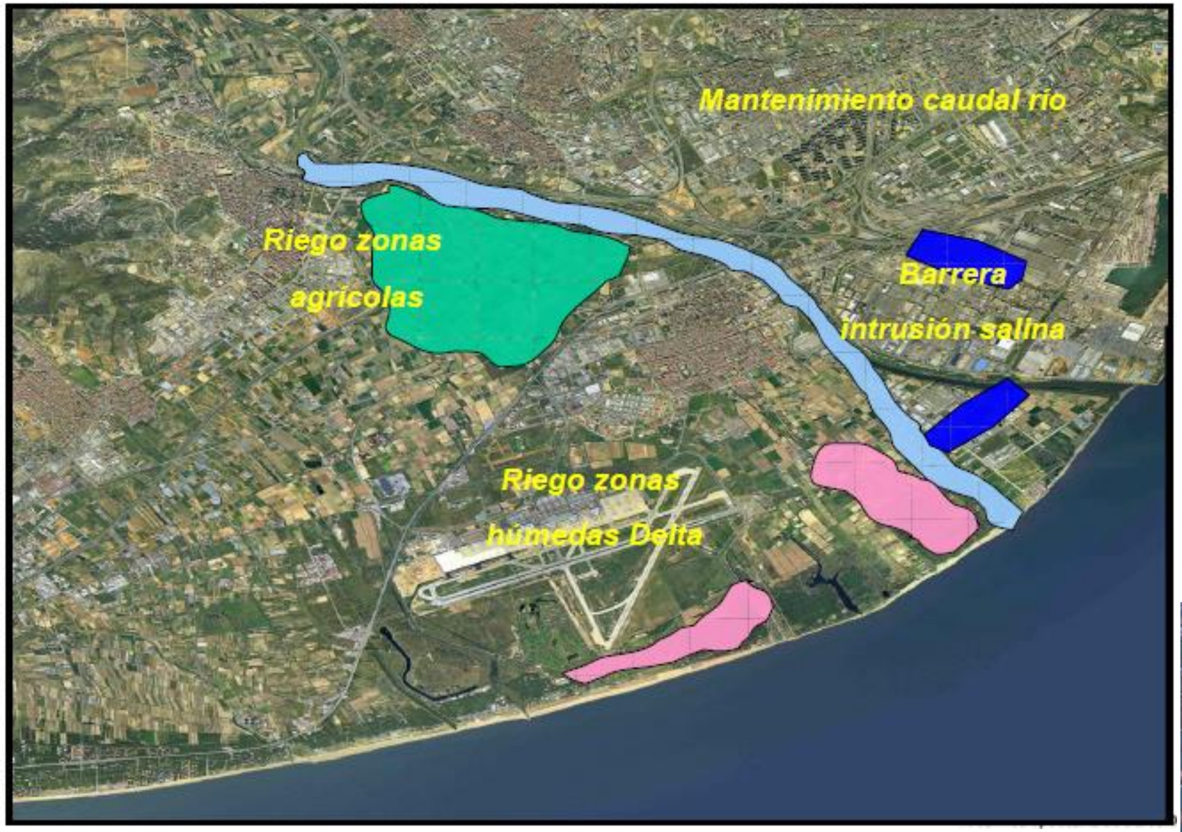
ACTIONS ON DEMAND

- New **rate definitions** according to the service and the efficiency
- Division **of the network in multiple areas** (optimization and leak detections)
- **Installation of meters** (users characterization, better calibration in mathematic model)

Better planning and management

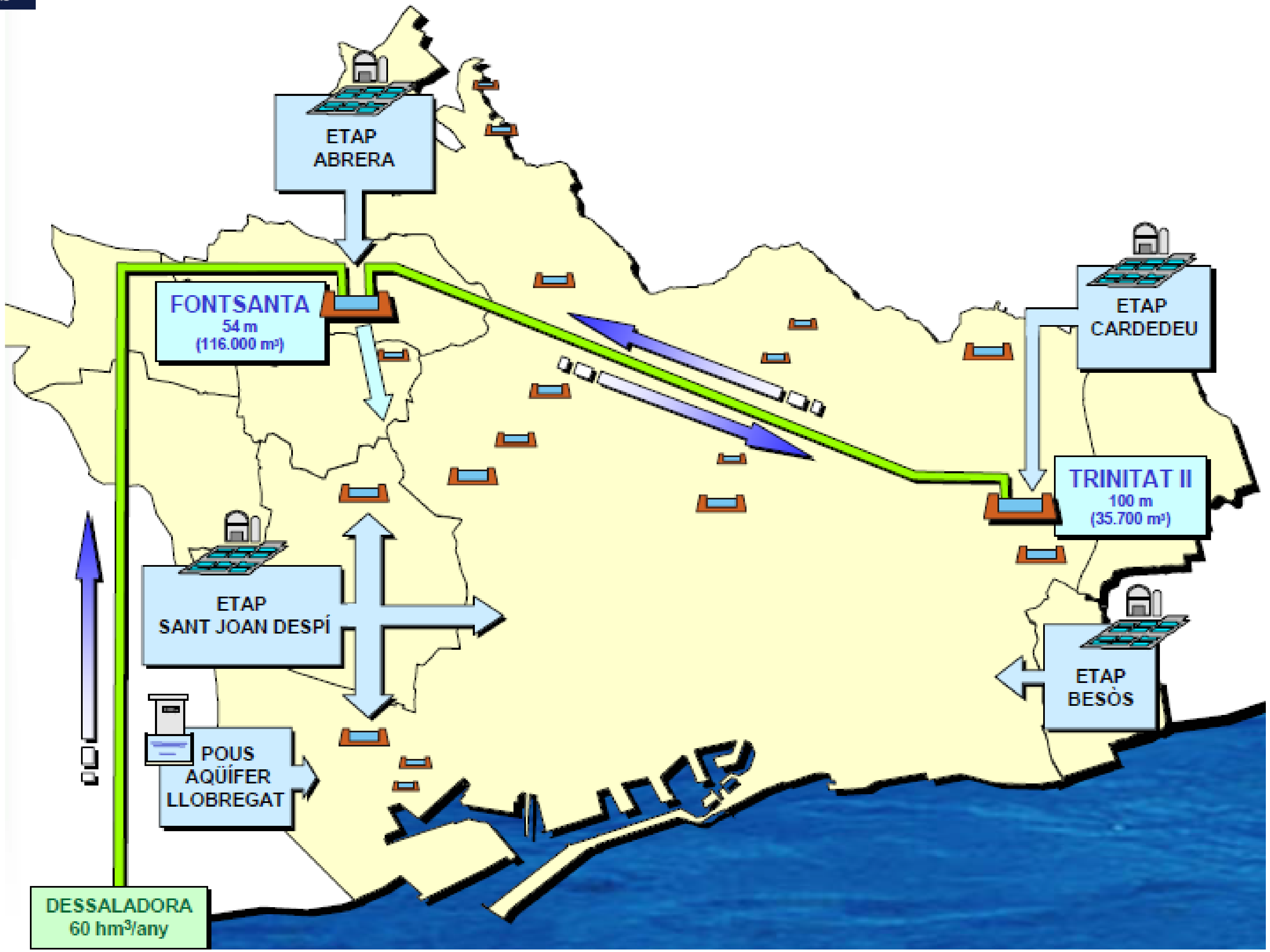
ACTIONS ON RESOURCES: **RECLAIMED WATER**

ACTIONS ON RESORUCES: RECLAIMED WATER

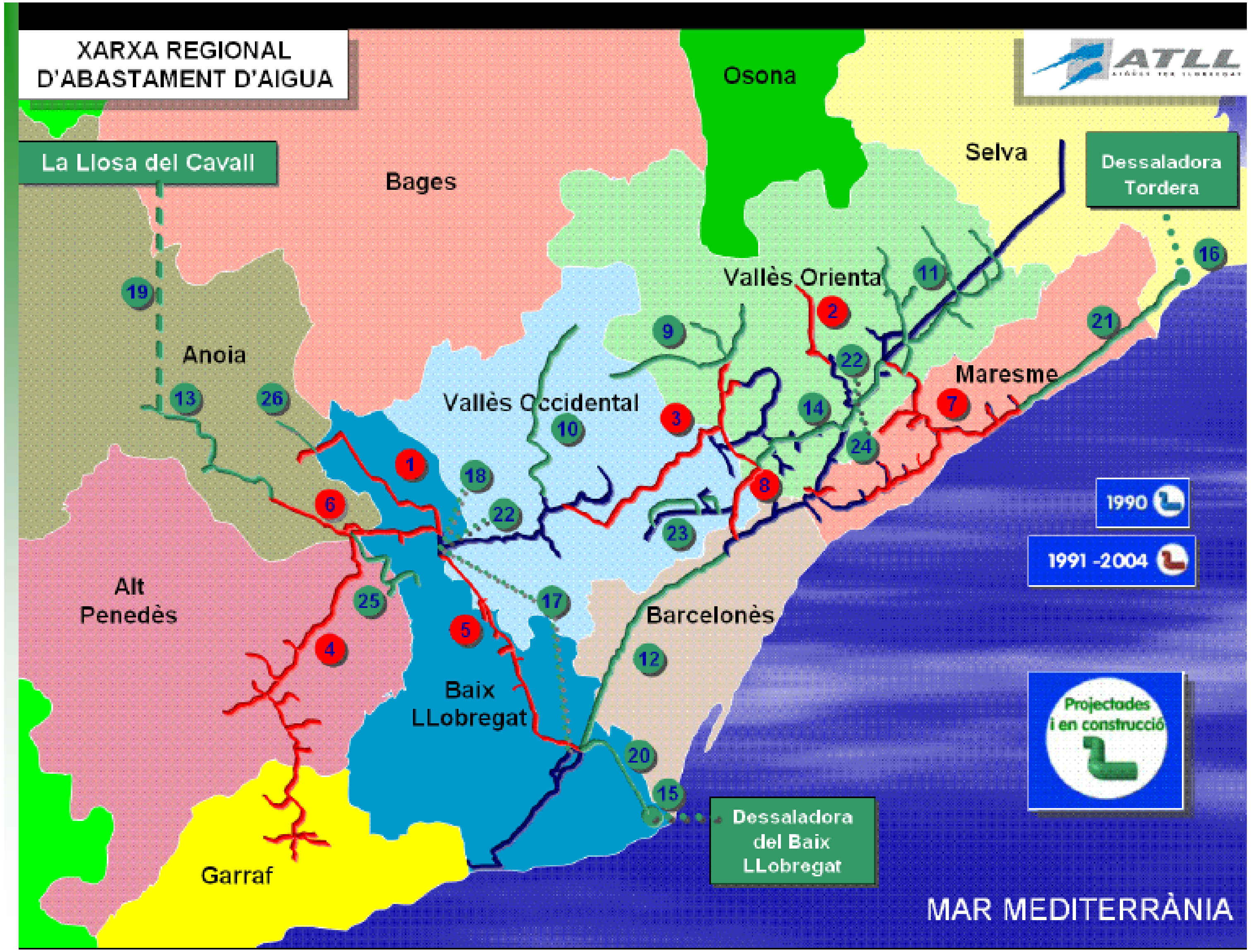


Q= 3.5 m3/s
V= 50 hm3/year
Thanks to tertiary treatment

ACTIONS ON RESOURCES: **DESALINATION**



REGIONAL NETWORK FOR WATER SUPPLY IN BARCELONA



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NEW BALANCE AFTER THE MEASURES

DEMAND

525 hm3/year (5% saving)

WATER RESOURCES

770 hm3/year (140 hm3 increase):

+ 80 Hm3/año desalinitation
+ 35 hm3/año reclaimed water
+ 30 hm3/año increased groundwater

60	hm3/año	desaladora AMB
20	hm3/año	desaladora Tordera
30-35	hm3/año	reutilización
30	hm3/año	incremento acuífero

BALANCE 770 / 525 = 1,47

47 % < 50% mínimo recomendable


Thank you
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