“Spain's Drought: Characteristics and Highlights. The Júcar River Basin case”

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The DROUGHT-R&SPI project conference

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SPANISH RIVER BASINS:

- Aridity (climate)

**SPAIN: WATER SCARCITY – W. STRESS**

Map of River Basin Districts

**WATER EXPLOITATION INDEX ≥1 (WATER STRESS)**

<table>
<thead>
<tr>
<th>AMBITO</th>
<th>DEMANDA</th>
<th>REC RENOVABLE</th>
<th>GV/H</th>
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Júcar River Basin District

Surface (km²) 43,000
Permanent population 4,792,528
Equivalent population due to tourism 367,322
Irrigation surface (ha) 347,275
Water demand (hm³/year) 3,172

Total demand by uses
- Irrigation: 79%
- Urban supply: 17%
- Industrial supply: 3%
- Cattle: 1%
- Recreation: 0%

Total demand by source of water
- Surface water: 42%
- Groundwater: 52%
- Direct WasteWater Reuse: 2%
- Desalination: 0%
- Imports (MCT): 0%

Half of the area is semi-arid with the highest variability in Europe (in space and time)

Spanish River Basins:
- Aridity (climate)
- Scarcity (Human needs)
- Droughts (High hydrological Variability)
Long tradition of
  - Adaptation to Water Scarcity and Drought
  - Infrastructures:
    - Historical (e.g.: irrigation systems, ditches and reservoirs; from Roman and Arab times, ...)
    - Since 1900’s (large reservoirs, wells, water transfers, ...)
    - Developed Water Resource Systems

Main reservoirs & Urban & Ind. Water Uses

(1 Hm3 = 1 Gl)
Main Environmental Issues

- Risk of drying the Júcar river in Albacete due to losses to aquifer (inverted relationship due to overdrafting).
- Risk of insufficient inflows to Albufera Lake & Wetland.
- Risk of poor water quality and low flows in the lower Júcar river.

BEYOND HIDROLOGICAL DROUGHT:
MANAGED SYSTEMS DROUGHTS

- Meteorological drought (precip.)
- Soil moisture dr.
- Hydrological drought (flows and aquifers)
- Operational dr. (WRS)
Drought analysis:

• Meteorological, soil moisture, hydrological droughts need to be analyzed, ...

• BUT, for the managed system: need to address the (WATER RESOURCES SYSTEM) OPERATIONAL DROUGHT

• Since reservoir & aquifer capacity are bigger than average annual inflows, adequate time scale is one year (nevertheless, models for analysis have monthly and/or daily time steps)

• The adequate space scale is the WRS (usually an entire Basin, but sometimes it includes more than 1 due to interconnections)

• Droughts can last up to 5, 6, 7 … years (Multiyear)

Long tradition of
- Adaptation to Water Scarcity and Drought
- Infrastructures:
  - Historical(e.g.: irrigation systems, ditches and reservoirs;
  - Since 1900’s (large reservoirs, wells, water transfers,...)
- Management:
  - Conjunctive use of surface and groundwater (since 1900’s)
- Institutions & Partnerships:
  - Historical. e.g.: Valencia’s Water Tribunal (Farmers’ Partnership) since year 1000 A.D., to date. STILL WORKING
  - Since 1926 (Multi-sectorial River Basin Partnerships)
Multisectorial Public Private Partnerships (1):  
Jucar River Basin Partnership

1936 (Foundation of CHJ): 
Water Scarcity approach:  
- Mainly Offer Increase (Infrastructures)

Drought approach:  
- Mainly Reactive  
- Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)
CHJ- Jucar River Basin Partnership

1985 (New Spanish Water Law) & 2000 (EU-WFD)

Water Scarcity approach:
- Demand Management & Offer Increase (Infrastructures)
- Long term planning (River Basin Management Plans)
- More water for environment

CHJ- Jucar River Basin Partnership

2000 (EU-WFD) & SWL 2003

Drought approach:
- Mainly Proactive (Special Water Plans (2007), Cities Emergency Plans, Infrastructures to improve reliability - against high variability and droughts, and nonconventional resources)
Multi-sectorial Public Private Partnerships (2): Permanent Drought Commission

1981 (1st PDC): separate partnership

Drought approach:
- Mainly Reactive
- Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)
1983 (2nd PDC)

Drought approach:
- Mainly Reactive
- Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)

1994, after 1985 (New Spanish Water Law)

Drought approach:
- Mainly Reactive
- Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)
2005, and after 2007 Special Drought Plans

Drought approach:
- Mainly Proactive (Special Water Plans, Cities Emergency Plans, Infrastructures to improve reliability - against high variability and droughts, and nonconventional resources)

- NESTLED PARTNERSHIPS
- Now, almost ALL STAKEHOLDERS are present in the PDC
- PDC is very important. Its decision will influence the management and mitigation of extraordinary drought episodes, when very high potential damages and risk to economy and human safety can happen, this is why it has special powers, given by the Royal Decrees.
Drought vulnerability mitigation within the MSPs (1):

Long term vulnerability assessment & management

Long tradition of

- Adaptation to Water Scarcity and Drought
- Infrastructures:
  - Historical (e.g.: irrigation systems, ditches and reservoirs;)
  - From 1900’s (reservoirs, wells, water transfers, desalination plants, ...)
- Institutions & Partnerships:
  - Historical (e.g.: Valencia’s Water Tribunal since year 1000 A.D., to date)
  - From 1926 (River Basin Partnerships)
- (long term planning) River Basin & Water Resources Systems Planning: 80’s, 90’s, 2000’s
(long term planning) RIVER BASIN & WATER RESOURCES SYSTEMS PLANNING : 80’s, 90’s, 2000’s

-Since the 90’s, the emphasis is on:
- DROUGHT VULNERABILITY mitigation
- EFFICIENCY in irrigation and urban supply (Modern distribution systems)
- Waste water treatment and REUSE
- SUSTAINABILITY and Environmental protection
- Desalination
- INTEGRATED & EFFICIENT MANAGEMENT OF WRS

CONCEPTS and VARIABLES RELATED TO FAILURE IN WATER RESOURCES SYSTEMS (and to OPERATIONAL DROUGHTS)

- **Failure (hazard):** When supply < demand
  - Different Intensity, Duration, Magnitude
- **Reliability:** Probability of satisfactory supply (not in failure).
- **Vulnerability:** The degree to which a systems is susceptible to, and unable to cope with, injury damage or harm (impact).
- **Risk:** Expected damages \( \text{Risk} = \sum \text{prob(hazard)} \times \text{Vulnerability} \)
- **Resiliency:** The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover. (Related to the inverse of time to get back to satisfactory situation after a failure).
- **THESE CONCEPTS ARE NOT EASY TO QUANTIFY WITH MEANINGFUL INDEXES FOR DROUGHTS**
**Future drought vulnerability assessment**

Practical Criteria in agreement with stakeholders:

**Urban demand, HIGH if:**
- Max Shortage in 1 month > 10% Monthly Demand
- Max Accumulated shortage in 10 years > 8% Annual Demand

**Irrigation demands, HIGH if:**
- Max Shortage in 1 year > 50% Annual Demand
- Max Accumulated Shortage in 2 years > 75% Annual Demand
- Max Accumulated Shortage in 10 years > 100% Annual Demand

**Use of INTEGRATED BASIN MODELLING & DECISION SUPPORT SYSTEMS**

- Considering conjunctive use of surface, groundwater, reclaimed wastewater, desalinated, ...
- Considering water rights and priorities.
- Taking into account environmental requirements.
- Jointly developed in a participatory process in 2005

**COMMON SHARED VISION OF THE SYSTEM**

*Engineering News Record, 1993*
NEW RISK ASSESSMENT MANAGEMENT APPROACH

- We moved from a Technocratic-Decisionist approach:

  Scientists ➔ Policy Makers ➔ Stakeholders

  Risk assessment ➔ Risk Management

- To an Integrated Participative approach:

  Scientists ➔ Policy Makers ➔ Stakeholders

  Risk Assessment
  Risk Perception
  Risk Management

Drought vulnerability mitigation within the MSPs (2):
Continuous vulnerability assessment & management
All Spanish River Basins have Drought Man. Plans since 2007

Objective: minimize environmental, social and economic impacts of drought situations (decreasing vulnerability and risk, and increasing resilience)

Contents:

- diagnosis of vulnerability to droughts (historical droughts, vulnerability of basin),
- monitoring and indicators system (precipitation, river inflows in natural regime, stored volume in surface reservoirs, water levels in aquifers),
- programme of measures in each drought phase,
- management and follow-up system.

DROUGHT MONITORING:
Use of different traditional types of indicators:

1) Meteorological drought (deviations and SPI)
2) Agricultural drought
3) Hydrological drought (historical position)
4) ....
METEOROLOGICAL DROUGHT MONITORING
(SPANISH MET. AGENCY)

UPDATED EVERY 10 DAYS
DROUGHT MONITORING:

Use of different traditional types of indicators:
1) Meteorological drought
2) Agricultural drought
3) Hydrological drought
4) ….

Very little use for risk assessment and perception from stakeholders, nor for decision making

Need for
- Operative Drought Indicators that serve as early warning system.
- Tailored to each basin and Water Resource System
- To improve risk assessment and perception by stakeholders
- To define drought scenarios and link them with actions

Automatic Data Gathering System

- Initial objective:
  early flood warning system
- Most of the time:
  Basin monitoring & real time management:
  - Meteorology
  - Volumes in reservoirs
  - Flows in rivers
  - Flows in canals
  - Drought monitoring indexes
  - Water quality
Operative Drought Indicator and Threshold Definition

Weighted combinations of standardized values of key variables related to water availability:

34 individual indicators:
- 9 reservoir volumes
- 9 piezometric level
- 9 fluvial networks
- 7 pluviometers

Drought indicators JRBA (31 March 2008).
Continuous monitoring (Published monthly in web page)

SCENARIOS

Drought status indicator per exploitation system

PROTOCOL FOR
DROUGHT STARTING AND DROUGHT TERMINATION
## LINK BETWEEN MONITORING AND ACTIONS

### TYPE OF MITIGATION MEASURES

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<tr>
<th>Indicator</th>
<th>1-0.5</th>
<th>0.5-0.4</th>
<th>0.4-0.3</th>
<th>0.3-0.2</th>
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<td>Objective</td>
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<td>Information-control</td>
<td>Conservation</td>
<td>Restriction</td>
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<td>Tactics</td>
<td>Emergency</td>
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</table>

### Escenario de normalidad (medidas no incluidas como objetivo en el PES)
- Medidas estratégicas a largo plazo de carácter, principalmente, infraestructural
  - Actuaciones previstas en las normativas estatales o autonómicas
  - Estudio del marco operacional del Centro de Intercambio de Derechos Concesionales
  - Estudios de mejora conocimiento de masas de agua subterráneas y acuíferos
  - Estudios de mejora del conocimiento del comportamiento hidrogeológico de zonas húmedas
  - Estudios sobre el hábitat óptimo y en situación de sequía de diferentes especies fluviales
  - Estudios en EDARs con problemas de alta conductividad

### Escenario de prealerta
- Promover campañas de ahorro voluntarias de agua en el abastecimiento
- Promover campañas de ahorro voluntarias de agua entre los regantes
- Agilizar el desarrollo de nuevas infraestructuras de sequía ya planificadas

### Escenario de Alerta
- Incremento de las extracciones de aguas subterráneas
- Recursos no convencionales: Reutilización potencial sostenible
- Recursos no convencionales: Máxima desalación estival
- Reducción del volumen de agua superficial suministrada para el regadío
- Reducción del volumen de agua superficial suministrada para el abastecimiento
- Medidas de carácter ambiental: Plan de Vigilancia

### Escenario de Emergencia
- Extracciones de aguas subterráneas: Intensificar las extracciones
- Recursos no convencionales: Reutilización potencial máxima
- Recursos no convencionales: Máxima desalación potencial
- Suministros alternativos en abastecimiento
- Reducción del volumen de agua superficial suministrada para el regadío
- Reducción del volumen de agua superficial suministrada para el abastecimiento
- Activación del Centro de Intercambio de derechos para asegurar el abastecimiento
- Medidas de carácter ambiental: Plan de policía y control del dominio público hidráulico
Drought vulnerability mitigation within the MSPs (3):

Short term risk assessment & management
SETS OF MEASURES FOR EACH SCENARIO

The Drought Plan provides
- Guidelines for drought management
- Measures with ranges of degree of application depending on the situation (Normal, pre-alert, alert, or emergency) to reduce vulnerability and risk.

BUT: ALL DROUGHTS ARE DIFFERENT
- The measures to be applied in real situation MUST BE REFINED IN REAL TIME in Pre-alert, Alert and Emergency situation by the Water Allocation Committee, or the Permanent Drought Committee

JRB Natural System streamflows (discharge up to Tous Reservoir)

2004/05 to 2007/2008:
Four consecutive years of intense hydrological drought

2005/06: Worse in rec. history
2006/07: third lower
Specific Risk Assessment & Effectiveness of the measures

February forecasts (if measures are applied)

Deterministic forecast: Future volume reservoir evolution
Using same inflows as last year (2004/05)

Probabilistic forecast:
Water storages at the end of September 2006

Exceedance Probability (%)
Main Measures adopted (after negotiation and consensus)

- Use of drought wells (Conjunctive use)
- Recycling of sluice water in irrigation
- Direct Reuse of waste water
- Water rights purchase to increment environmental flows
- Application of measures to save water: increasing irrigation efficiency, irrigation reduction, and alternative urban supply
- Conjunctive management of Turia and Jucar Basins
- Public education through media (Newspapers, …) in order to reduce urban consumption
- Intensive monitoring and surveillance of critical points
- Other …

CONJUNCTIVE USE OF SURFACE AND GROUND WATER (Alarcon’s agreement + Drought wells) and RECYCLING in the irrigation system

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<td>Real de Escalona Ditch</td>
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<td>Sueca irrigation union</td>
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<td>Cullera irrigation union</td>
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<td>Mayor de la Villa and Honor de Corbera Ditch</td>
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<td>1</td>
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<tr>
<td>General Community from Canal Júcar-Turia</td>
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<tr>
<td>Total</td>
<td>326</td>
<td>19</td>
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</table>

Farmers in the coastal plane, who are entitled to surface water, pumped from the aquifer and recycled sluice water, giving up an equal amount from their surface water allocation to be used by the upstream farmers and urban suppliers. The later paid for the costs of pumping (5 cents of euro/m3)
TREATED WASTE WATER REUSE SCHEMES

BALANCING the supply for the metropolitan area of Valencia with surface water from rivers Júcar and Turia
Environmental measures

Albufera Lake
Ramsar Wetland

Monitoring network:
- Lake level
- Outflow in the 5 canals
- Inflow in some ditches

Monitoring and maintenance of minimum flows

Irrigation aquifer

Lake level

Environmental measures

Júcar River

Ramsar Wetland canals

Salidas al río. Simulación en régimen transitorio.

Monitoring network:
- Inflow in some Júcar River Casas Ibáñez Molinar, El Picazo
- Outflow in the 5 Almansa Pozohondo Iniesta Contreras

Detracción

6

Caudal m3/s

1 2 3 4 5 6 7 8 9 10

1 2 3 4 5 6 7 8 9 10

Caudal m3/s

From aquifer From Júcar

1 -abr -07 1 -may -07 1 -jun -07 1 -jul -07 1 -ago -07 1 -sep -07 1 -oct -07 1 -nov -07 1 -dic -07

1 -abr -08 1 -may -08 1 -jun -08 1 -jul -08 1 -ago -08 1 -sep -08 1 -oct -08 1 -nov -08 1 -dic -08


Requena Contreras

La Roda

Albufera Lake ditches

Minaya
La Mancha Aquifer Use Reduction
2007-08

Public offer agreement for water rights acquisition in the middle section of the Júcar basin due to environmental reasons

Objective: Reducing extractions in the middle section of the Júcar river, both in surface water and in the area of the aquifer with a greater effect on the river flow.

2007 Rights acquisition and adaptation through reduction of irrigated surface.

2008 Rights acquisition and adaptation by using less water-consuming crops (spring crops) (Changes in crop patterns)

Selection criteria (model based):
1. Effects on river (0-20 points)
2. Offered price (0-20 points)

Extension: 28,000 has
W. Rights volume: 148 hm3
Time frame: seasons 2007-08

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<td>Total HGU Presented requests:</td>
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<td>Renounced volume (no economic compensation) (hm³)</td>
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<td>Offered volume (hm³)</td>
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<td>Materialised budget (million€)</td>
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<td>Reserved volume (hm³)</td>
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Monitoring the effectiveness of the measure: Balance for the Picazo-Los Frailes reach of Júcar River

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Surveillance middle section of Júcar river

Objective: flow maintenance downstream from Alarcón reservoir

Júcar river in summer 1995

Júcar river in summers 2006 and 2007
Groundwater Basic Monitoring Network

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Low flows and water quality monitoring in the lower Jucar River
Total annual supplies by origins and destinations

Urban: Supply Valencia Júcar and Supply Valencia Turia
Agricultural: Surface Júcar, Surface Turia, Pumping, Re-Pumping, Reuse
Management: OPAD’S, Middle stretch gain Júcar, Increased private wells

Conclusions:

- Adaptation Capacity
- Proactive Drought policy approach:
  - Plans, Monitoring for decision, Measures, Recovery plans
- Customized Operational Drought Indicators, and
- Specific real time risk assessment & efficiency of measures evaluation by means of DSS

have been very useful for decision making in drought risk assessment, perception, management & mitigation
Conclusions (2):

• In Jucar River Basin MSP have been essential for drought vulnerability mitigation and management.

• Transparency, Well informed debate, Co-responsibility in Policy & Decision Making \(\rightarrow\) Reduce Vulnerability & Improve Resiliency

• Many measures were applied for first time in 2005-2008 drought, and will be consolidated through the Drought Emergency Plan and Operating Rules.

• Integrated strategic risk assessment and management (interaction between Science-P. Making and Stakeholders & Public) \(\rightarrow\) Influencing Science & technological developments

• Knowledge brokering has also been essential

Thank you very much!!!