International workshop
Botín Foundation/Rosenberg International Forum on
Managing drought and scarcity in semi-arid lands:
the cases of California and Spain.
January 29, 2015, Botín Foundation, Madrid

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

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Instituto de Ingeniería del Agua y Medio Ambiente

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March, 10th – 13th, 2015 Valencia, Spain

International Conference on

DROUGHT: Research and Science-Policy Interfacing

The DROUGHT-R&SPI project conference

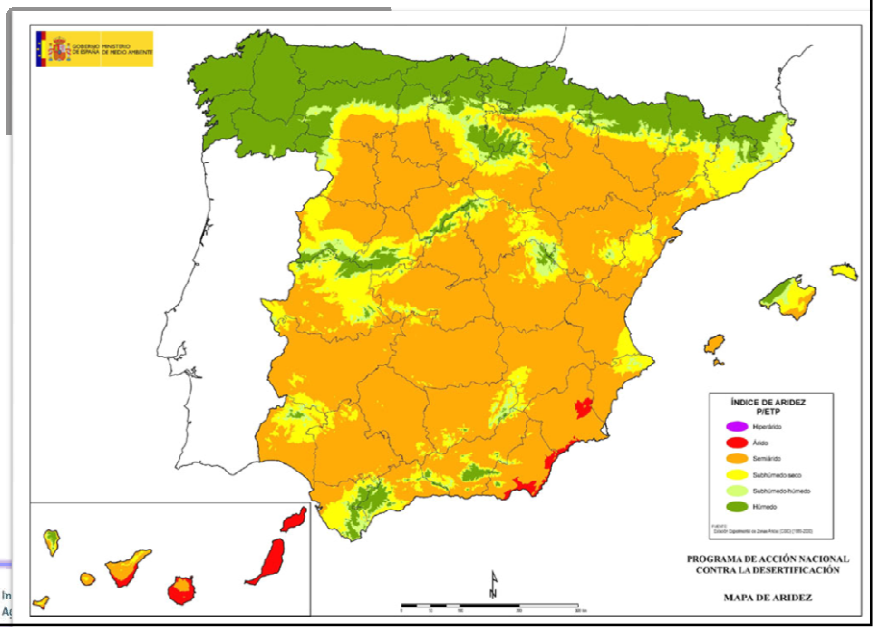
Contact for further information:

Water Resources Engineering Group
Institute of Water and Environmental Engineering
Universitat Politècnica de València

icdrought2015@upv.es
http://www.icdrought2015.upv.es

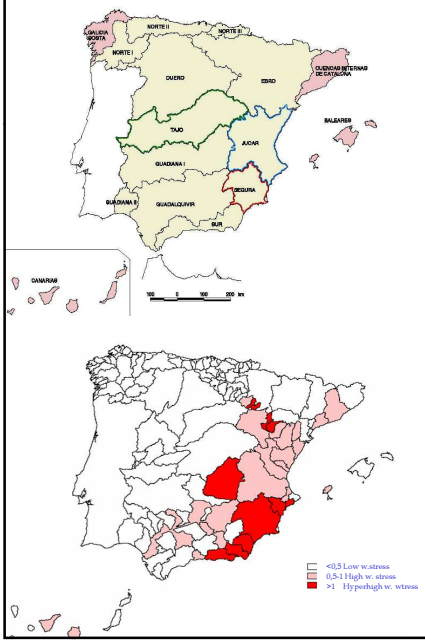
SPANISH RIVER BASINS:

- Aridity (climate)



SPAIN: WATER SCARCITY – W. STRESS

Map of River Basin Districts

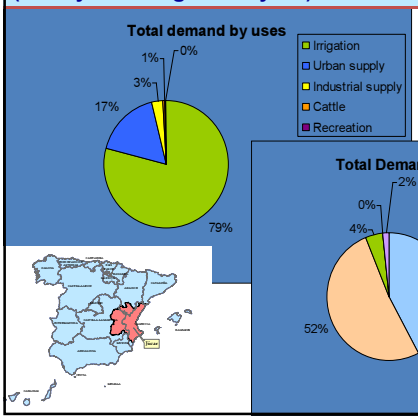


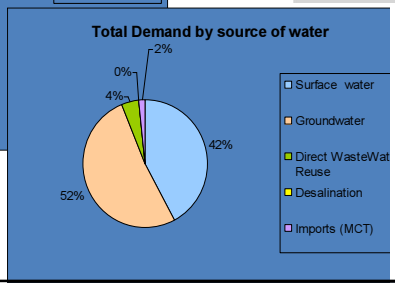
WATER EXPLOITATION INDEX
≈1 (WATER STRESS)

AMBITO	DEMANDA	REC.RENOVABLE	D/RR
Galicia Costa	819	12.250	0,07
Norte I	617	12.689	0,05
Norte II	589	13.881	0,04
Norte III	486	5.337	0,09
Duero	3.860	13.660	0,28
Tajo	4.065	10.883	0,37
Guadiana I	2.312	4.414	0,52
Guadiana II	219	1.061	0,21
Guadalquivir	3.760	8.601	0,44
Sur	1.350	2.351	0,57
Segura	1.834	803	2,28
Júcar	2.962	3.432	0,86
Ebro	10.378	17.967	0,58
C.I. Cataluña	1.357	2.787	0,49
Baleares	288	661	0,44
Canarias	427	409	1,04
Total España	**35.323**	**111.186**	**0,32**

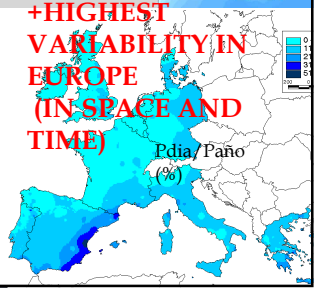
Júcar River Basin District

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) (Hm3/year = Gigaliters/year)	3.172



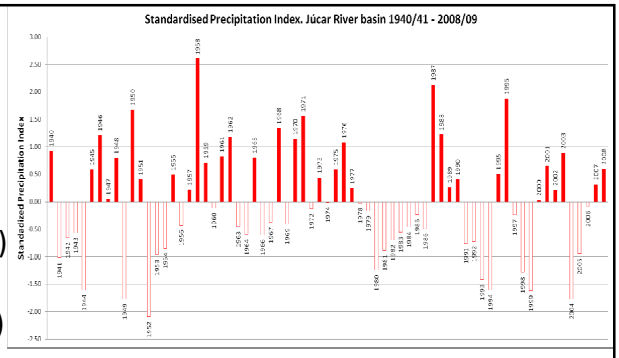


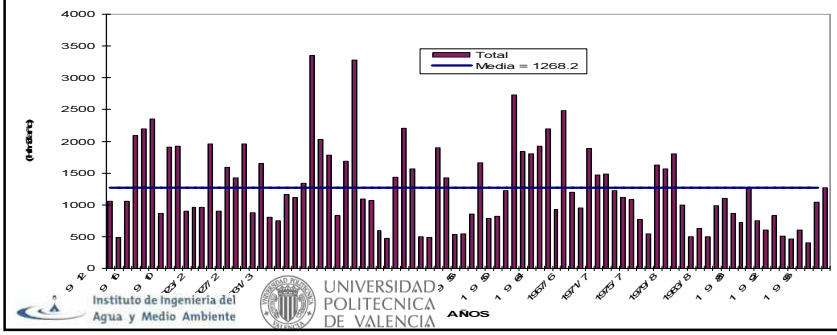
HALF OF THE AREA IS SEMIARID +HIGHEST VARIABILITY IN EUROPE (IN SPACE AND TIME)



SPANISH RIVER BASINS:

- Aridity (climate)
- Scarcity (Human needs)
- Droughts (High hydrological Variability)





Instituto de Ingeniería del Agua y Medio Ambiente

UNIVERSIDAD POLITECNICA DE VALENCIA

Long tradition of

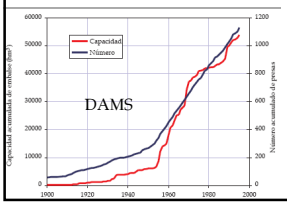
-Adaptation to Water Scarcity and Drought

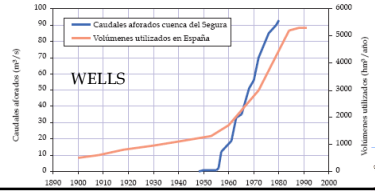
-Infrastructures:

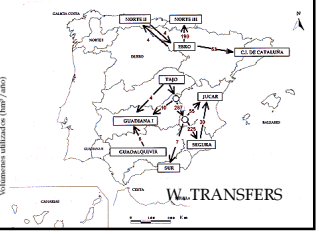
- Historical (e.g.: irrigation systems, ditches and reservoirs; from Roman and Arab times, …)

-Since 1900's (large reservoirs, wells, water transfers,…)

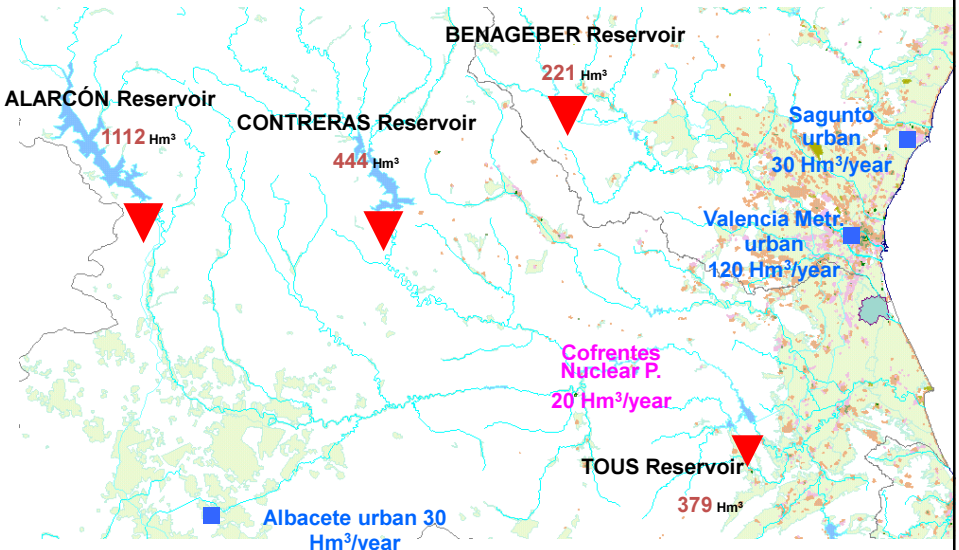
-Developed Water Resource Systems





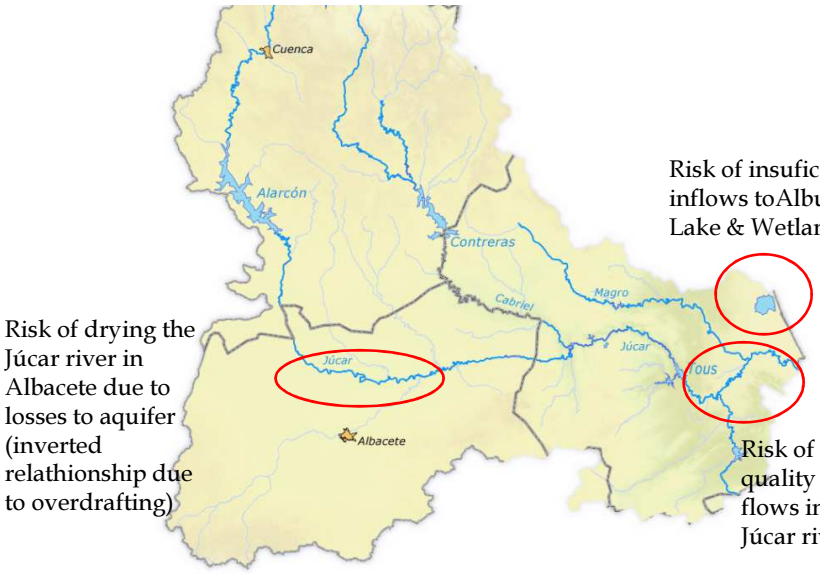


Main reservoirs & Urban & Ind. Water Uses



(1 Hm3 = 1 Gl)

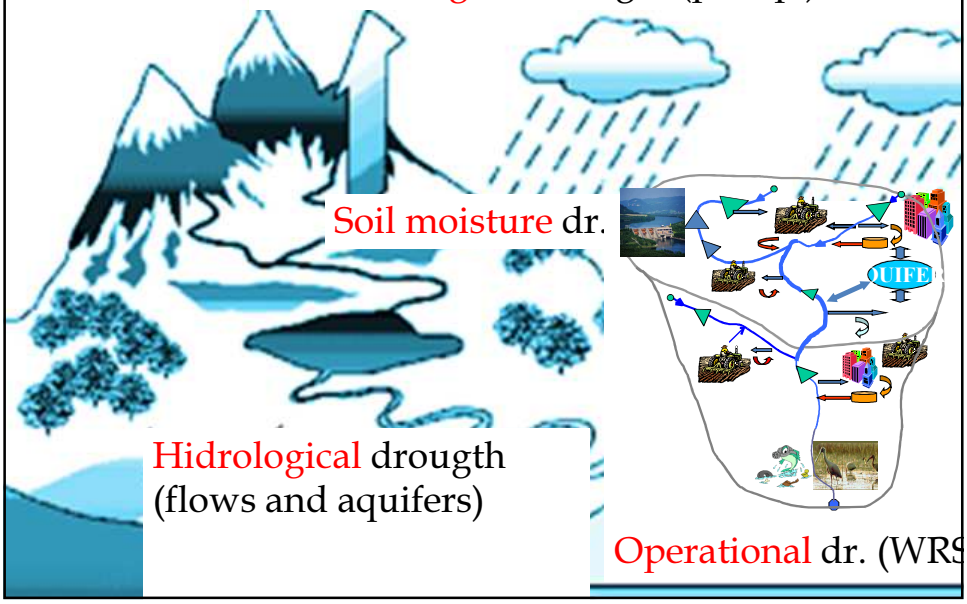
Júcar (& Turia) River Basin Water Resource System. Main Environmental Issues



BEYOND HIDROLOGICAL DROUGHT:

MANAGED SYSTEMS DROUGHTS

metheorological drought (precip.)



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 inter-connections)
- 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)

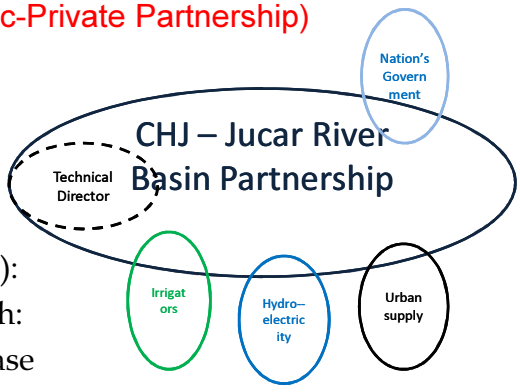
-Institutions & Partnerships:

-Historical. e.g.: Valencia's Water Tribunal (Farmers' Partnership)since year 1000 A.D., to date. STILL WORKING

-Since 1926 (Multisectorial River Basin Partnerships)

Multisectorial Public Private Partnerships (1):
Jucar River Basin Partnership

CHJ- Jucar River Basin Partnership
(Multisectorial Public-Private Partnership)

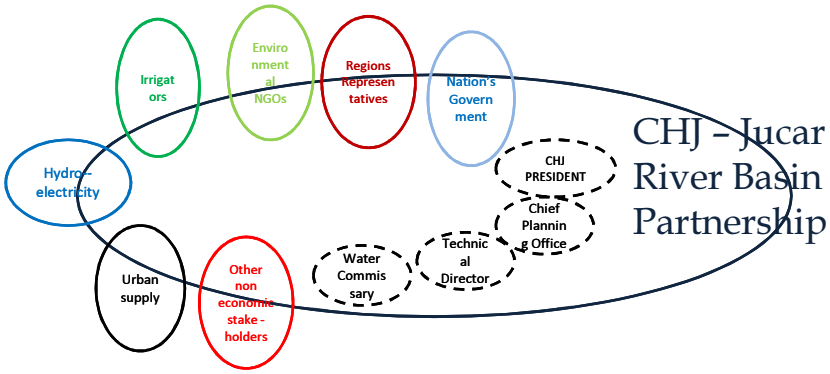


1936 (Foundation of CHJ):
Water Scarcity approach:
-Mainly Offer Increase (Infrastructures)

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:

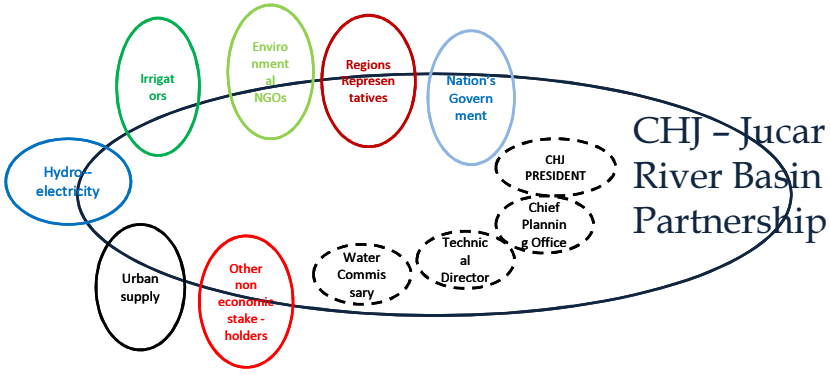
-Demand Management & Offer Increase (Infrastructures)

-Long term planning (River Basin Management Plans

-More water for environment

CHJ- Jucar River Basin Partnership

2000 (EU-WFD) & SWL 2003



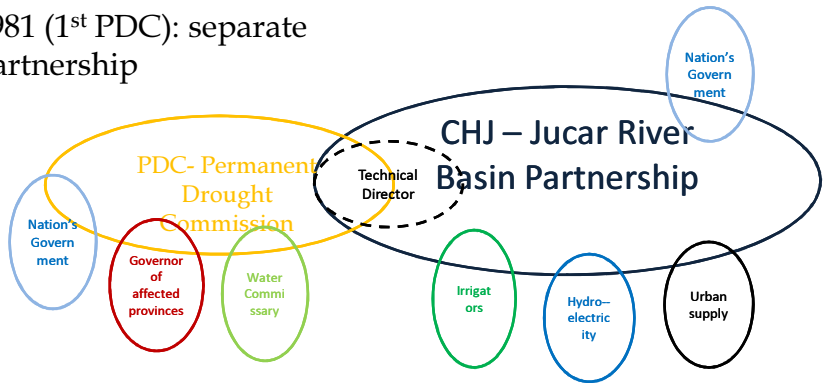
Drought approach:

-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

Permanent Drought Commission

1981 (1st PDC): separate partnership

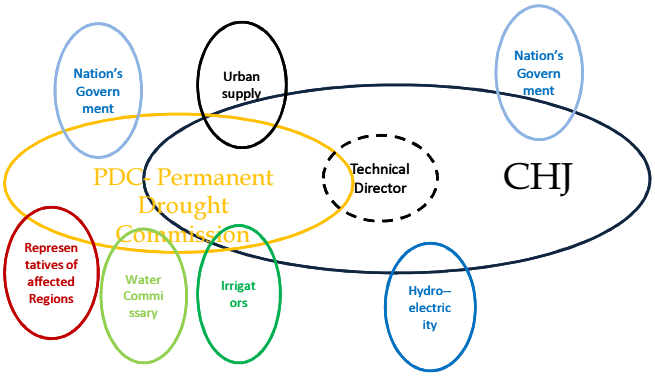


Drought approach:

-Mainly Reactive

-Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)

1983 (2nd PDC)

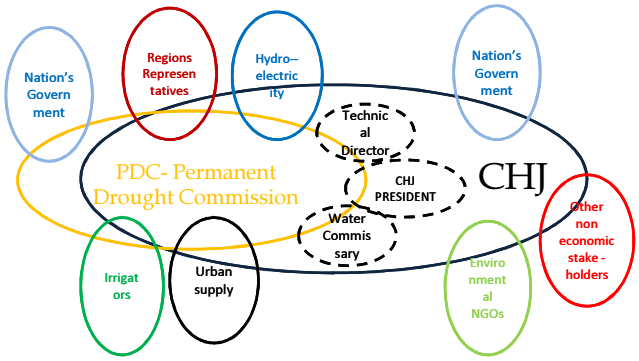


Drought approach:

-Mainly Reactive

-Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)

1994, after 1985 (New Spanish Water Law)

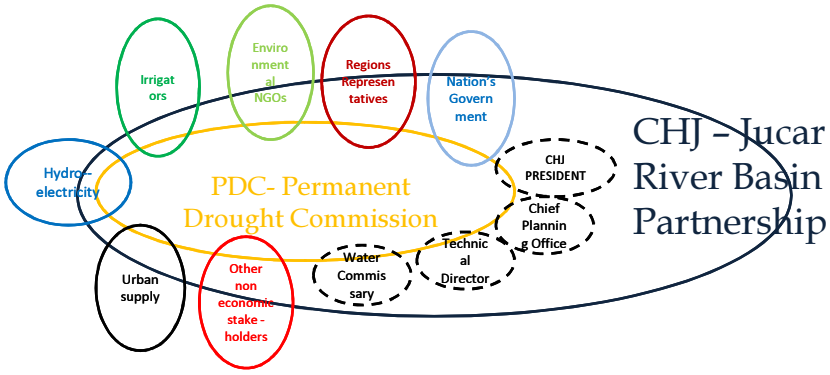


Drought approach:

-Mainly Reactive

-Partly Proactive (infrastructures to improve reliability) (against high variability and droughts)

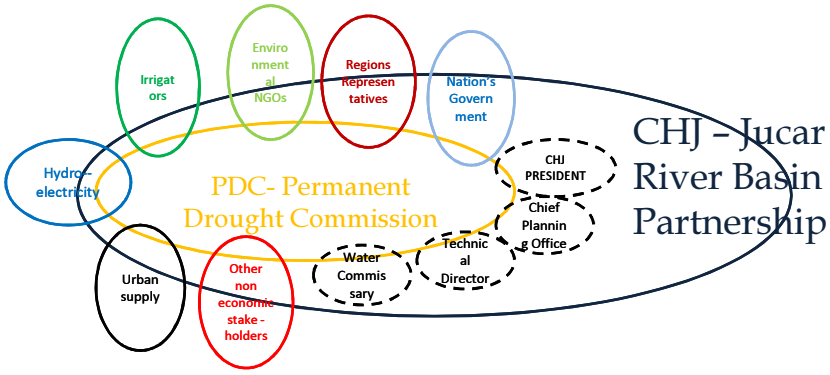
2005, and after 2007 Special Drought Plans



Drought approach:

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

2005, and after 2007 Special Drought Plans



- 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

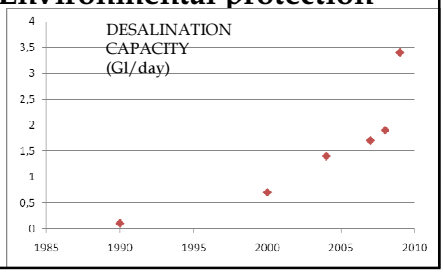
-EFFICIENCY in irrigation and urban supply (Modern distribution systems)

-Waste water treatment and REUSE

-SUSTAINABILITY and Environmental protection

-Desalination

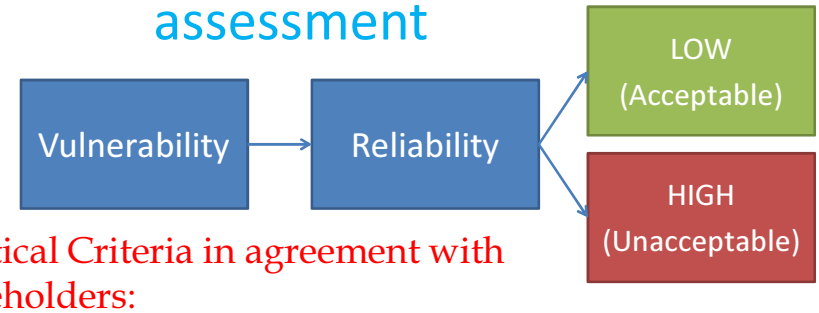
-INTEGRATED & EFFICIENT MANAGEMENT OF WRS



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

- 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 (Risk= ∑ prob(hazard) * 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:

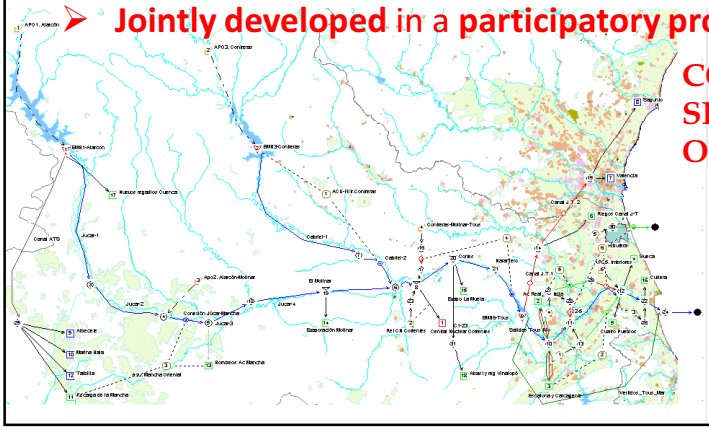
- Max Shortage in 1 month > 10% Monthly Demand
- Max Accumulated shortage in 10 years > 8% Annual Demand

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**



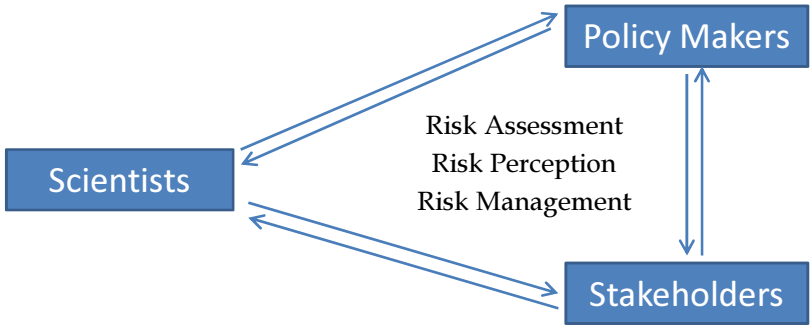
COMMON SHARED VISION OF THE SYSTEM

Engineering News Record, 1993

NEW RISK ASSESSMENT MANAGEMENT APPROACH

- We moved from a Technocratic-Decisionist approach:

- To an Integrated Participative approach:



Drought vulnerability mitigation within the MSPs (2): Continuous vulnerability assessment & management

SPECIAL DROUGHT MANAGEMENT PLANS

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),

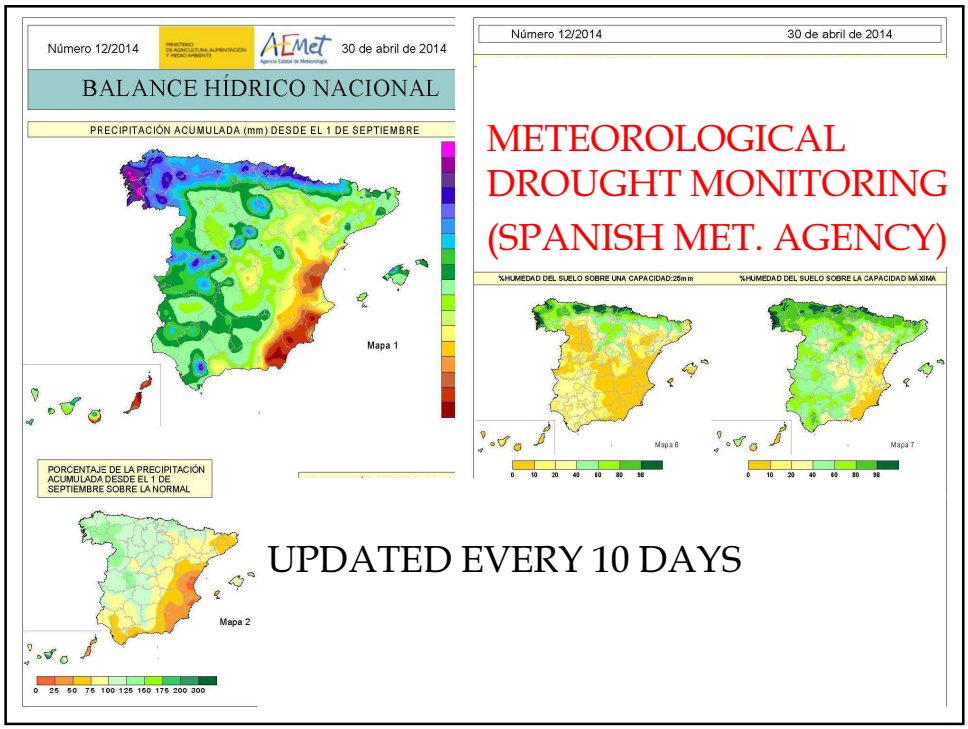
-programme of measures in each drought phase,

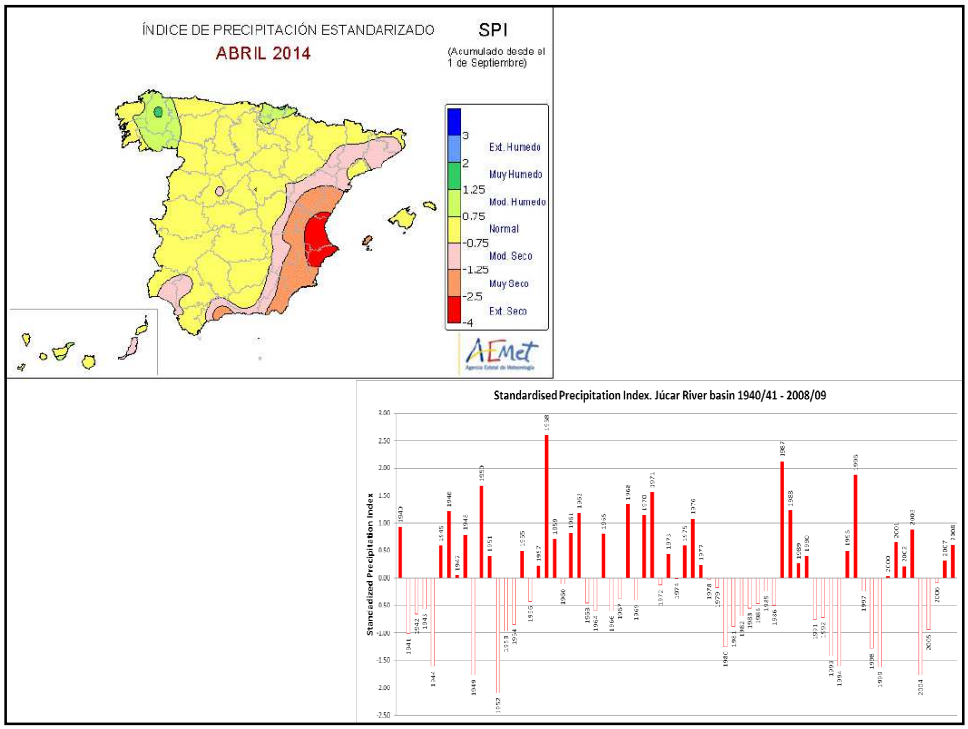
-management and follow-up system.

DROUGHT MONITORING:

Use of different traditional types of indicators:

1) Meteorological drought (deviations and SPI)
2) Agricultural drought
3) Hydrological drought (historical position)
4) ….


Número 12/2014
30 de abril de 2014
BALANCE HÍDRICO NACIONAL
PRECIPITACIÓN ACUMULADA (mm) DESDE EL 1 DE SEPTIEMBRE
Mapa 1
PORCENTAJE DE LA PRECIPITACIÓN ACUMULADA DESDE EL 1 DE SEPTIEMBRE SOBRE LA NORMAL
Mapa 2
0 25 50 75 100 125 150 175 200 300
Número 12/2014
30 de abril de 2014
%HUMEDAD DEL SUELO SOBRE UNA CAPACIDAD:25mm
%HUMEDAD DEL SUELO SOBRE LA CAPACIDAD MÁXIMA
Mapa 6
Mapa 7
0 10 20 40 60 80 90
METEOROLOGICAL DROUGHT MONITORING (SPANISH MET. AGENCY)
UPDATED EVERY 10 DAYS


ÍNDICE DE PRECIPITACIÓN ESTANDARIZADO
ABRIL 2014
SPI
(Acumulado desde el 1 de Septiembre)
3 Ext. Humedo
2 Muy Humedo
1.25 Mod. Humedo
0.75 Normal
-0.75 Mod. Seco
-1.25 Muy Seco
-2.5 Muy Seco
-4 Ext. Seco
Standardised Precipitation Index. Júcar River basin 1940/41 - 2008/09
Standardized Precipitation Index

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

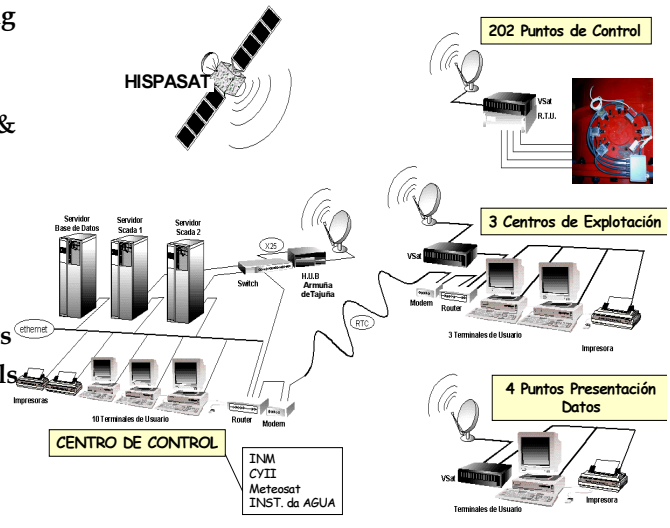
-Volumes in reservoirs

-Flows in rivers

-Flows in canals

-Drought monitoring indexes

-Water quality



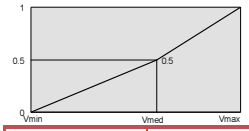
42

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



Status Index	Status
0,75 – 1,00	NORMAL
0,50 – 0,75	
0,30 – 0,50	PRE-ALERT
0,15 – 0,30	ALERT
0,00 – 0,15	EMERG.

	SISTEMA EXPLOTACIÓN	Ind Estado 31/03/2008		ÍNDICE SIST. EXPLOTACIÓN
1	Cenia-Maestrazgo	**0,99**		**0,66**
2		**0,52**		
3		**0,74**		
4	Mijares-Plana de Castellón	**0,39**		**0,67**
5		**0,82**		
6		**0,66**		
7	Palancia-Los Valles	**0,35**		**0,57**
8		**0,70**		
9		**0,61**		
10	Turia	**0,32**		**0,33**
11		**0,10**		
12		**0,04**		
13		**0,19**		
14		**0,39**		
15		**0,45**		
16		**0,53**		
17	Júcar	**0,00**		**0,14**
18		**0,00**		
19		**0,35**		
20		**0,14**		
21		**0,20**		
22		**0,58**		
23		**0,16**		
24		**0,18**		
25		**0,73**		
26		**0,14**		
27		**0,58**		
28		**0,82**		
29	Serpis	**0,53**		**0,72**
30		**0,80**		
31	Marina Alta	**0,82**		**0,82**
32	Marina Baja	**0,88**		**0,88**
33	Vinalopó-Alacantí	**0,79**		**0,73**
34		**0,70**		

Drought indicators JRBA (31 March 2008).

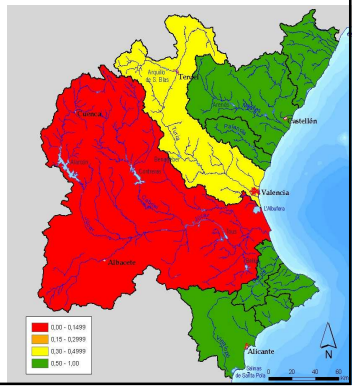
Continuous monitoring (Published monthly in web page)

Sistema	*Jun*	*Jul*	*Ago*	*Sep*	*Oct*	*Nov*	*Dic*	*Ene*	*Feb*	*Mar*
Cenia-Maestrazgo	0,67	0,63	0,61	0,64	0,7	0,59	0,74	0,69	0,66	0,66
Mijares-Plana de Castellón	0,66	0,66	0,65	0,72	0,73	0,66	0,68	0,67	0,66	0,67
Palancia-Los Valles	0,66	0,61	0,55	0,64	0,67	0,59	0,68	0,61	0,58	0,57
Turia	0,44	0,39	0,38	0,4	0,44	0,45	0,43	0,39	0,37	0,34
Júcar	0,29	0,26	0,23	0,23	0,22	0,19	0,16	0,14	0,14	0,14
Serpis	0,41	0,43	0,45	0,5	0,69	0,63	0,78	0,70	0,67	0,72
Marina Alta	0,51	0,51	0,55	0,69	1,00	0,92	0,96	0,89	0,90	0,82
Marina Baja	0,80	0,80	0,80	0,85	1,00	1,00	1,00	0,92	0,92	0,88
Vinalopó-Alacantí	0,74	0,73	0,83	0,95	1,00	0,86	0,87	0,80	0,82	0,73

SCENARIOS

System	*Risk Valuation*	*Scenario*
Cenia-Maestrazgo	LOW	NORMAL
Mijares-Plana de Castellón	LOW	NORMAL
Palancia-Los Valles	LOW	NORMAL
~~Turia~~	~~MEDIUM~~	PRE-ALERT
~~Júcar~~	~~VERY HIGH~~	EMERGENCY
Serpis	LOW	NORMAL
Marina Alta	VERY LOW	NORMAL
Marina Baja	VERY LOW	NORMAL
Vinalopó-Alacantí	VERY LOW	NORMAL

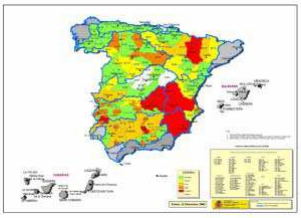
Status Index Values	Scenario Inputs		Scenario outputs	
	During	Condition	Condition	Output Scenario
Normal	-	≥ 0,50	-	
Pre-alert	3 months in a row	]0,5 - 0,30]	3 consecutive months Ie ≥ 0,50	Normal
Alert	2 months in a row	]0,3 - 0,15]	2 consecutive months Ie ≥ 0,50 6 consecutive months Ie]0,5 - 0,30]	Pre-alert
Emergency	2 months in a row	< 0,15	2 consecutive months Ie]0,5 - 0,30] 6 consecutive months Ie]0,3 - 0,15]	Alert



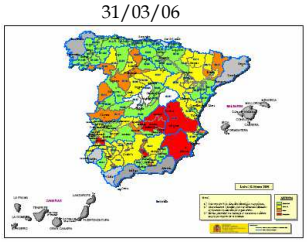
Drought status indicator per exploitation system

PROTOCOL FOR DROUGHT STARTING AND DROUGHT TERMINATION

31/12/05



31/03/06



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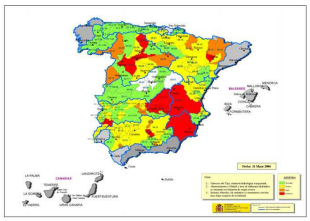

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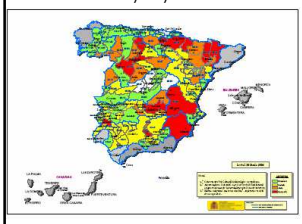

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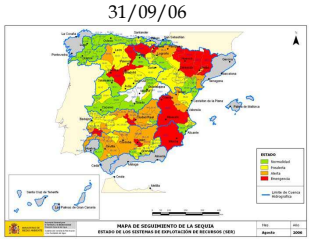

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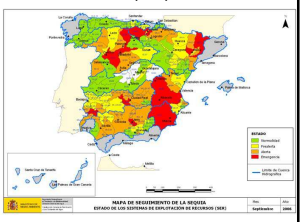

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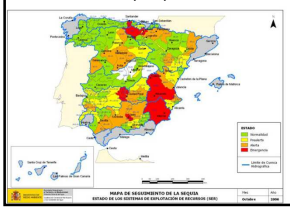

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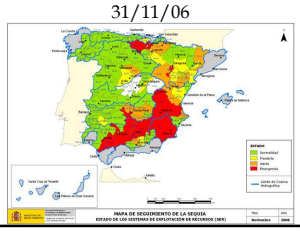

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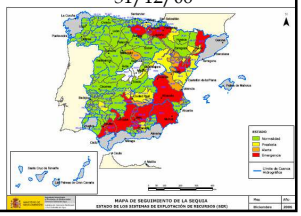

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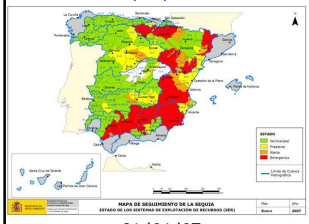
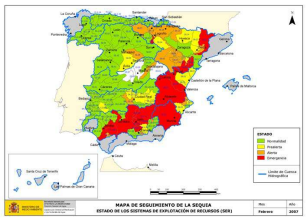


31/02/07



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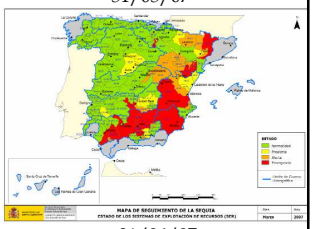

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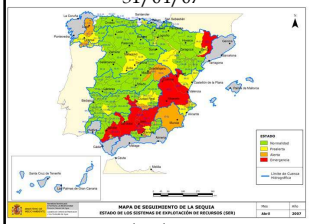
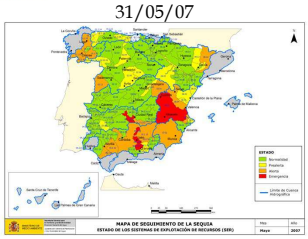


31/05/07



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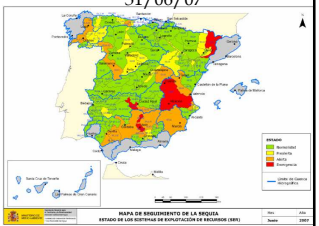

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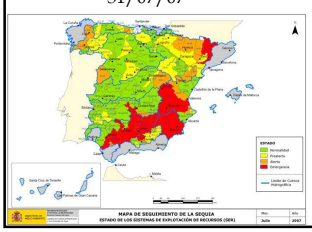
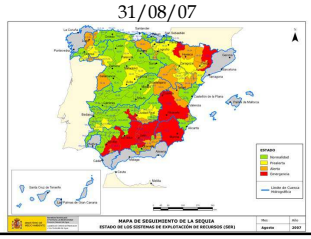


31/08/07



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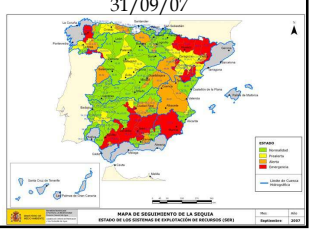


LINK BETWEEN MONITORING AND ACTIONS

TYPE OF MITIGATION MEASURES							
Indicator	1-0.5	0.5-0.4	0.4-0.3	0.3-0.2	0.2-0.15	0.15-0.1	**0.1-0**
Status	Normal	Pre-alert		Alert		Emergency	
Objective	Planning	Information-control		Conservation		Restriction	
Type of measure	Strategic			Tactics		Emergency	

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

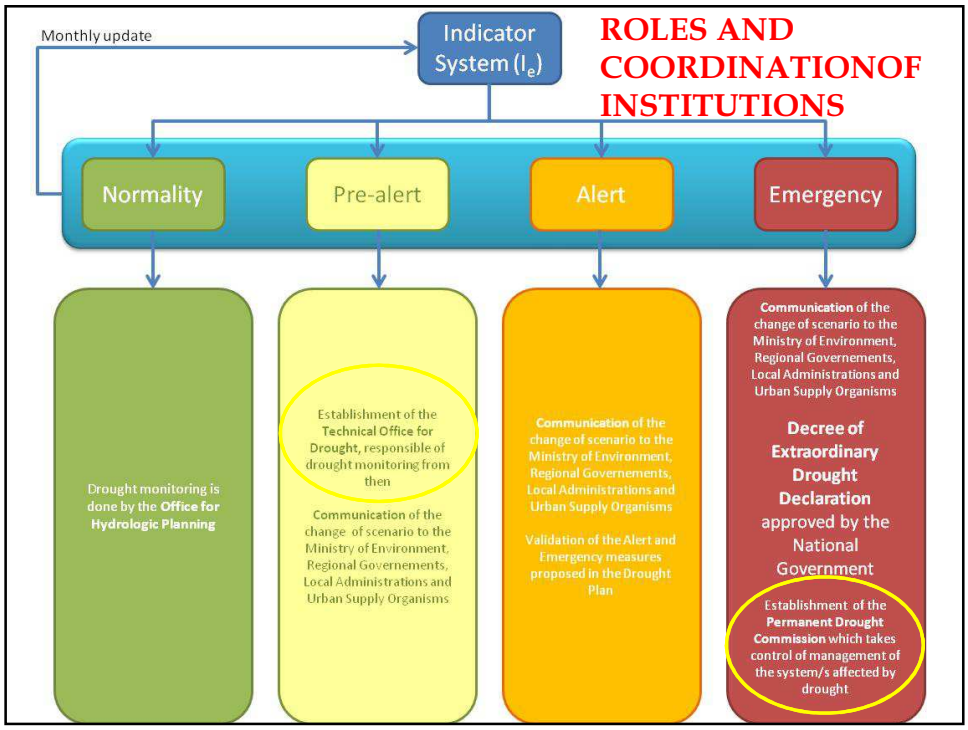
- Promover campañas de ahorro voluntarias de agua en el abastecimiento
- Promover campañas de ahorro voluntarias de agua entre los regantes
- Agilizar el desarrollo de nuevas infraestructuras de sequía ya planificadas

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
- Restricción del volumen de agua superficial suministrada para el regadío
- Restricción 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

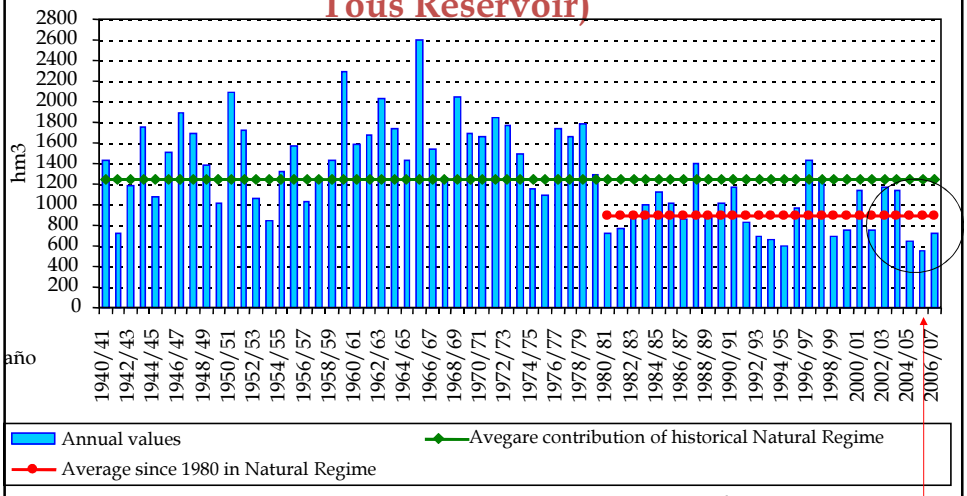
The Drought Plan provides

- **-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. hystory

2006/07: third lower

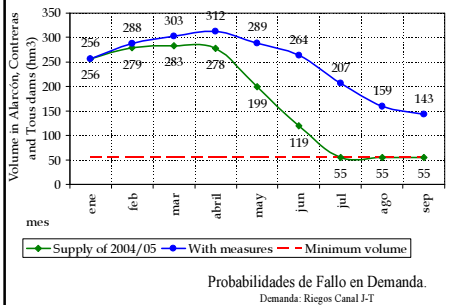
PDC Meeting Calendar

1) 1st December 2005
2) 21st December 2005
3) 21st January 2006
4) 13th February 2006
5) 15th March 2006
6) 18th April 2006
7) 22nd May 2006
8) 27th June 2006
9) 19th July 2006
10) 24th August 2006
11) 12th September 2006
12) 28th September 2006
13) 15th November 2006
14) 15th December 2006
15) 15th February 2007
16) 20th April 2007
17) 18th July 2007
18) 17th September 2007
19) 31st October 2007
20) 12th December 2007
21) 15th February 2008
22) 14th March 2008
23) 18th April 2008
24) 12th June 2008
25) 16th September 2008
26) 17th October 2008
27) 22nd December 2008
28) 12th March 2009

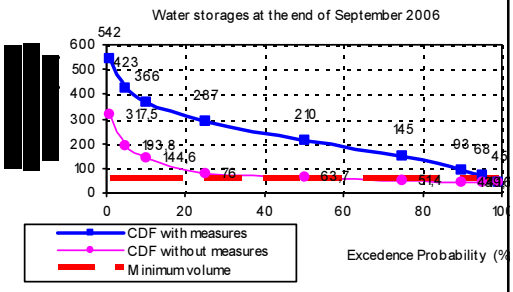
Specific Risk Assesment & Effectiveness of the measures

February forecasts (if measures are applied)

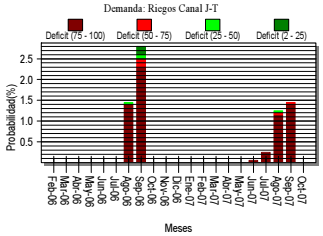
Deterministic forecast: Future volume reservoir evolution
Using same Inflows as last year (2004/05)



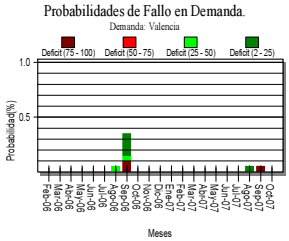
Probabilistic forecast:



Probabilidades de Fallo en Demanda.
Demanda: Riegos Canal J-T



Probabilidades de Fallo en Demanda.
Demanda: Valencia



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 trough media (Newspapers, …) in order to reduce urban consumption
- Intensive monitoring and surveillance of critical points
- Other …

CONJUNCTIVE USE OF SURFACE AND GROUND WATER

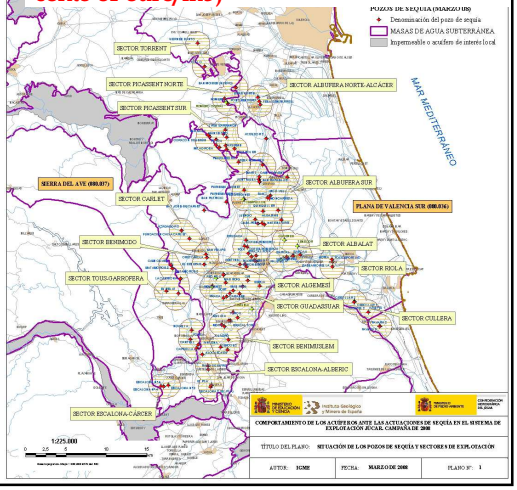
(Alarcon's agreement + Drought wells)

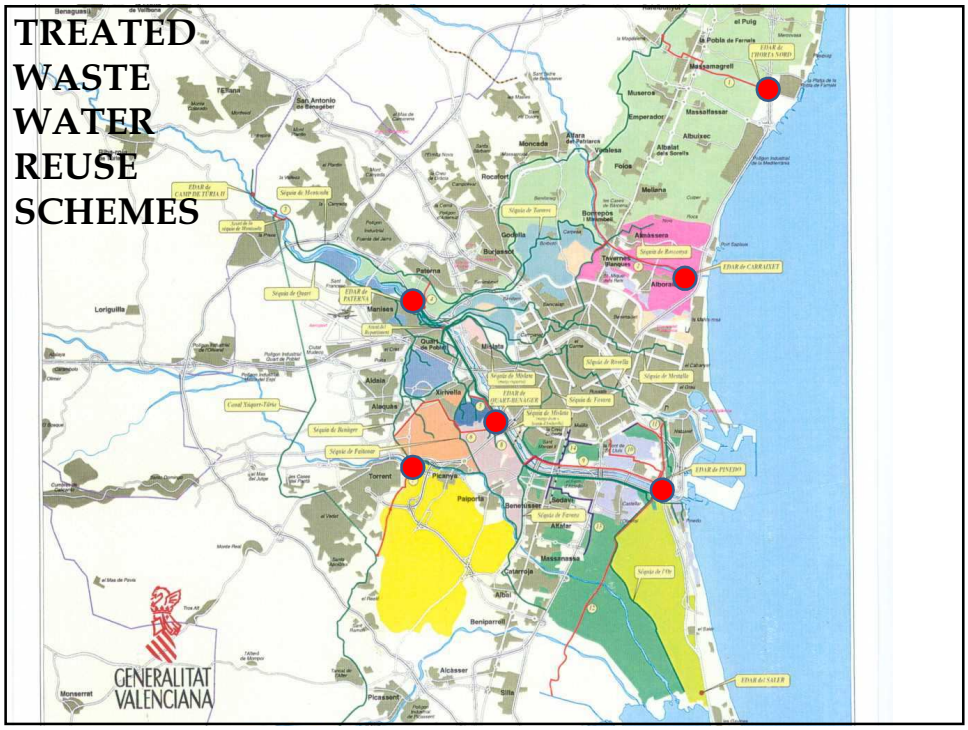
and RECYCLING in the irrigation system

2008	Wells	Recycl. pumps
Real del Júcar Ditch	66	2
Real de Escalona Ditch	7	
Real de Carcaixent Ditch	3	
Sueca irrigation union		8
Cullera irrigation union	6	8
Mayor de la Villa and Honor de Corbera Ditch	4	1
General Community from Canal Júcar-Turia	40	
Total	126	19

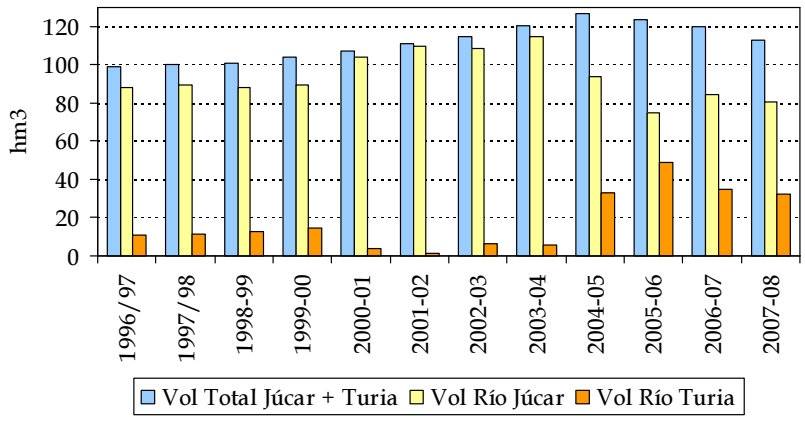
Farmers in the coastal plane, who are entitled to surface water, pumped from the aquifer and recycled sluice water, giving up an equal amount from their surface water allocation to be used by the upstream farmers and urban suppliers.

The later paid for the costs of pumping (5 cents of euro/m3)





Management measures



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

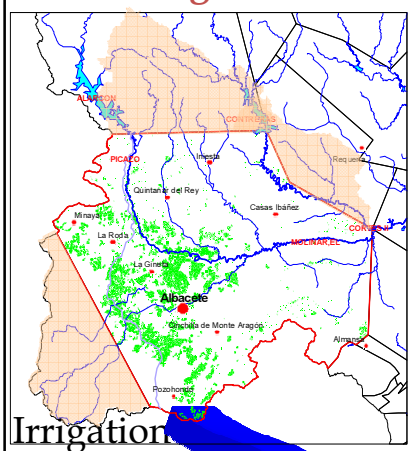
Environmental measures

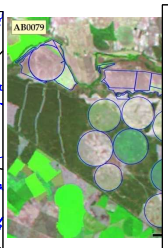
Albufera Lake
Ramsar Wetland

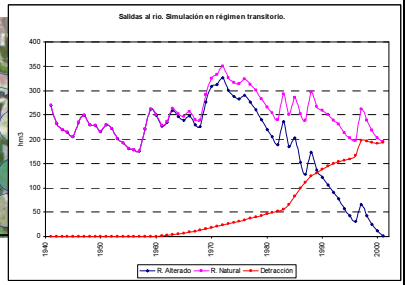
Monitoring network:

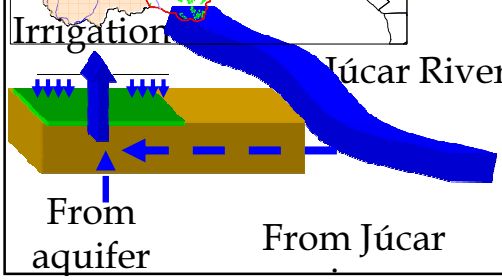
- Lake level
- Outflow in the 5 canals
- Inflow in some ditches

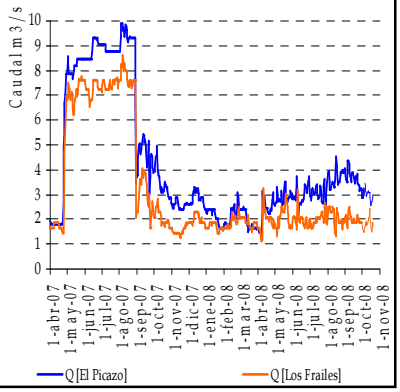
Monitoring and maintenance of minimum flows











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):

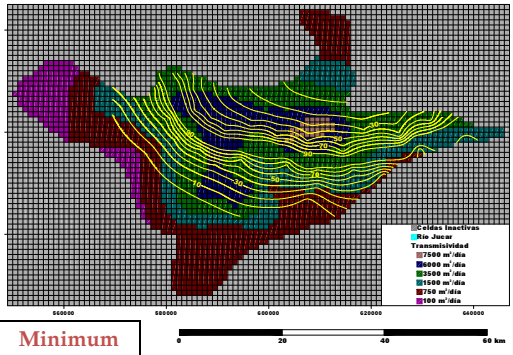
1. Effects on river (0-20 points)
2. Offered price (0-20 points)

Extension: 28.000 has

W. Rights volume: 148 hm3

Time frame: seasons 2007-08

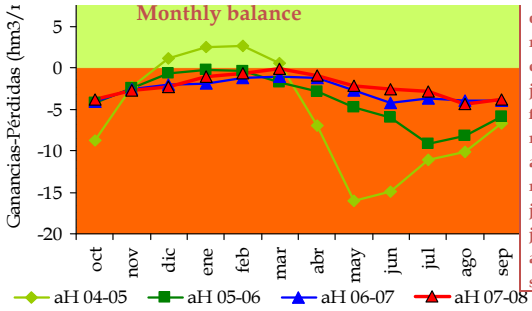
Uses reduction 2007&2008



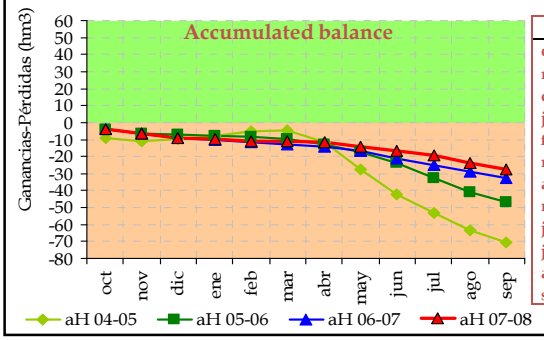
Maximum amount 07	Minimum amount 07	Maximum amount 08	Minimum amount 08
0,1957 €/m³	0,13 (€/m³)	0.25 €/m³	0.20 (€/m³)

	2007 Total	2008 Total
HGU Presented requests:	119	234
Right volume (hm³)	**56,8**	**109,6**
Renounced volume (no economic compensation) (hm³)	22,9	12,5
Offered volume (hm³)	27,3	50,6
Materialised budget (million€)	**5,5**	**12,7**
Reserved volume (hm³)	6,6	46,5

Monitoring the effectiveness of the measure: Balance for the Picazo-Los Frailes reach of Júcar River



	aH 04-05	aH 05-06	aH 06-07	aH 07-08
oct	-8,78	-4,19	-4,09	-3,87
nov	-2,36	-2,47	-2,62	-2,70
dec	1,15	-0,69	-2,08	-2,31
jan	2,44	-0,34	-1,85	-1,04
feb	2,59	-0,47	-1,18	-0,72
mar	0,56	-1,83	-1,12	-0,18
apr	-6,93	-2,89	-1,24	-0,98
may	-16,06	-4,73	-2,78	-2,15
jun	-14,95	-6,01	-4,21	-2,55
jul	-11,13	-9,22	-3,74	-2,86
aug	-10,14	-8,18	-3,93	-4,34
sep	-6,75	-5,83	-4,02	-3,87



	aH 04-05	aH 05-06	aH 06-07	aH 07-08
oct	-8,78	-4,19	-4,09	-3,87
nov	-11,13	-6,66	-6,71	-6,57
dec	-9,98	-7,36	-8,78	-8,88
jan	-7,54	-7,69	-10,63	-9,92
feb	-4,95	-8,16	-11,81	-10,64
mar	-4,39	-9,99	-12,93	-10,82
apr	-11,33	-12,88	-14,17	-11,81
may	-27,39	-17,61	-16,96	-13,96
jun	-42,34	-23,62	-21,16	-16,51
jul	-53,47	-32,84	-24,90	-19,37
aug	-63,61	-41,02	-28,84	-23,72
sep	-70,35	-46,85	-32,86	-27,58

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

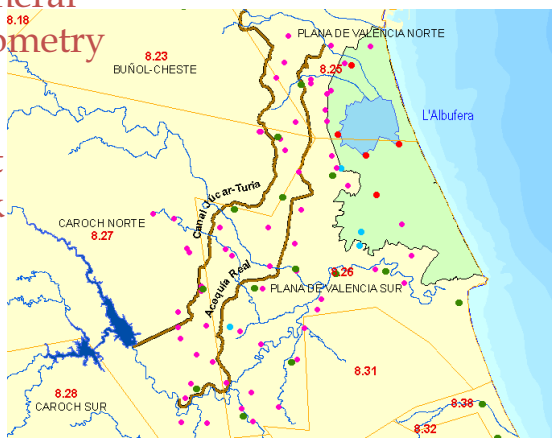
Groundwater Basic Monitoring Network

General Piezometry

Albufera

Hydrometry

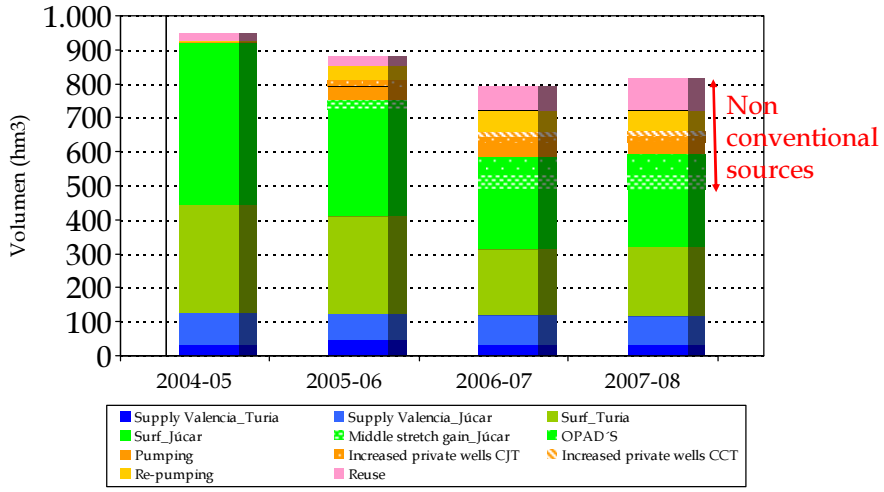
Specific drought network



Piezometry	46	Piezometry = 72	
Piezometry and Quality	26		Quality = 33
Quality	7		
Hydrometry	4		Hidrometry =4

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

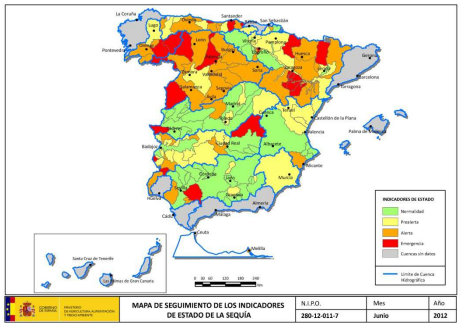
Conclusions:

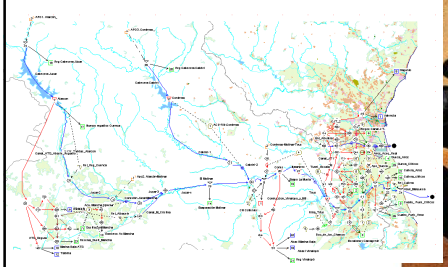
- Adaptation Capacity
- Proactive Drought policy approach:
  - Plans, Monitoring for decision, Measures, Recovery plans
- Customized Operational Drought Indicators, and
- Specific real time risk assessment & efficiency of measures evaluation by means of DSS

have been very useful for decision making in drought risk assessment, perception, management & mitigation

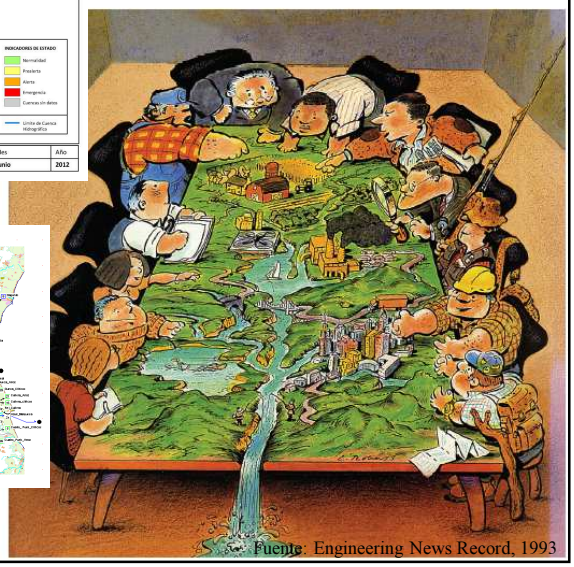
Conclusions (2):

- In Jucar River Basin MSP have been essential for drought vulnerability mitigation and management.
- Transparency, Well informed debate, Co-responsibility in Policy & Decision Making → 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) → Influencing Science & technological developments
- Knowledge brokering has also been essential





Thank you very much!!!



Fuente: Engineering News Record, 1993