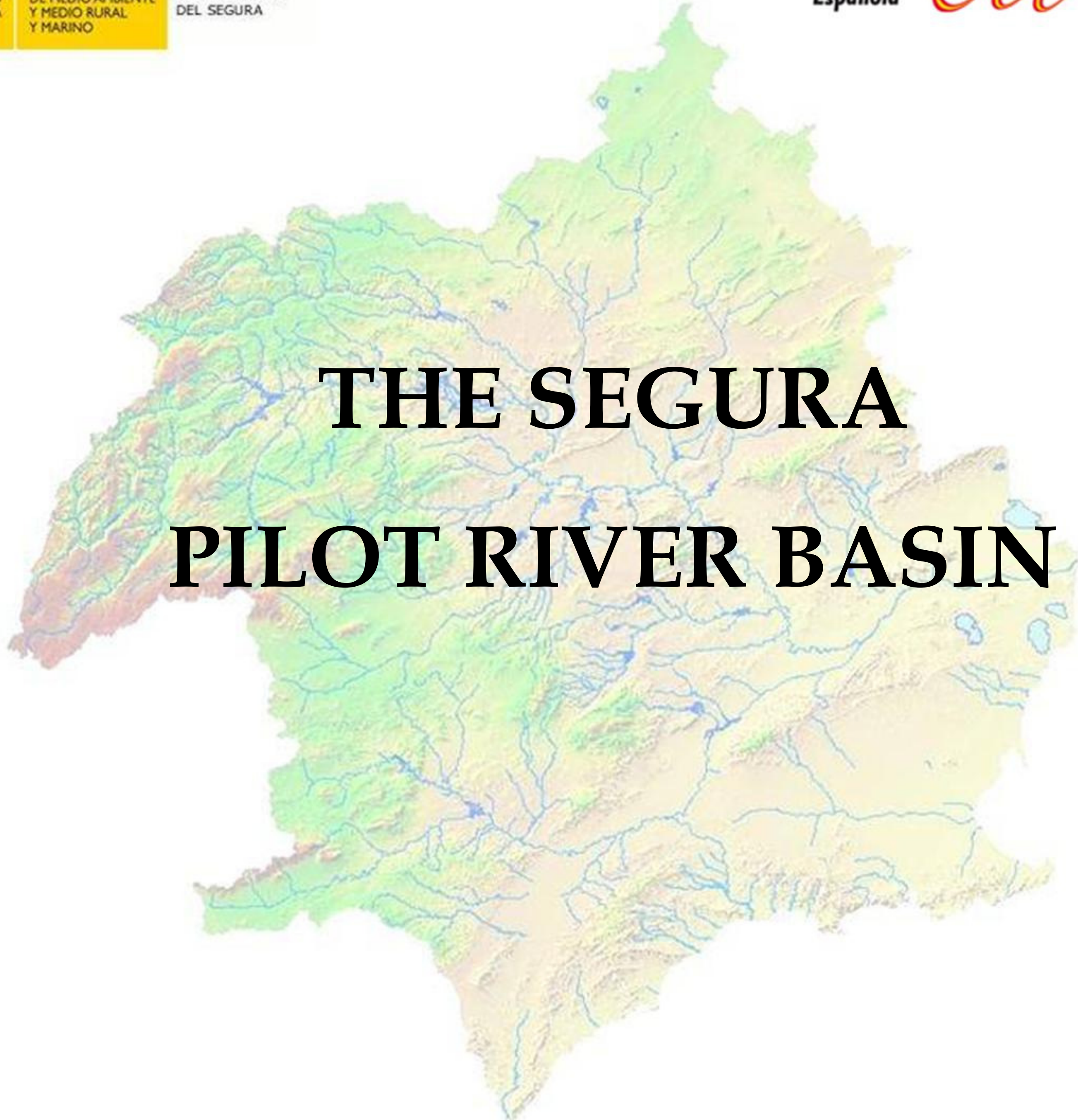
GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
CONFEDERACIÓN HIDROGRÁFICA DEL SEGURA

Presidencia Española eu2010.es

THE SEGURA PILOT RIVER BASIN



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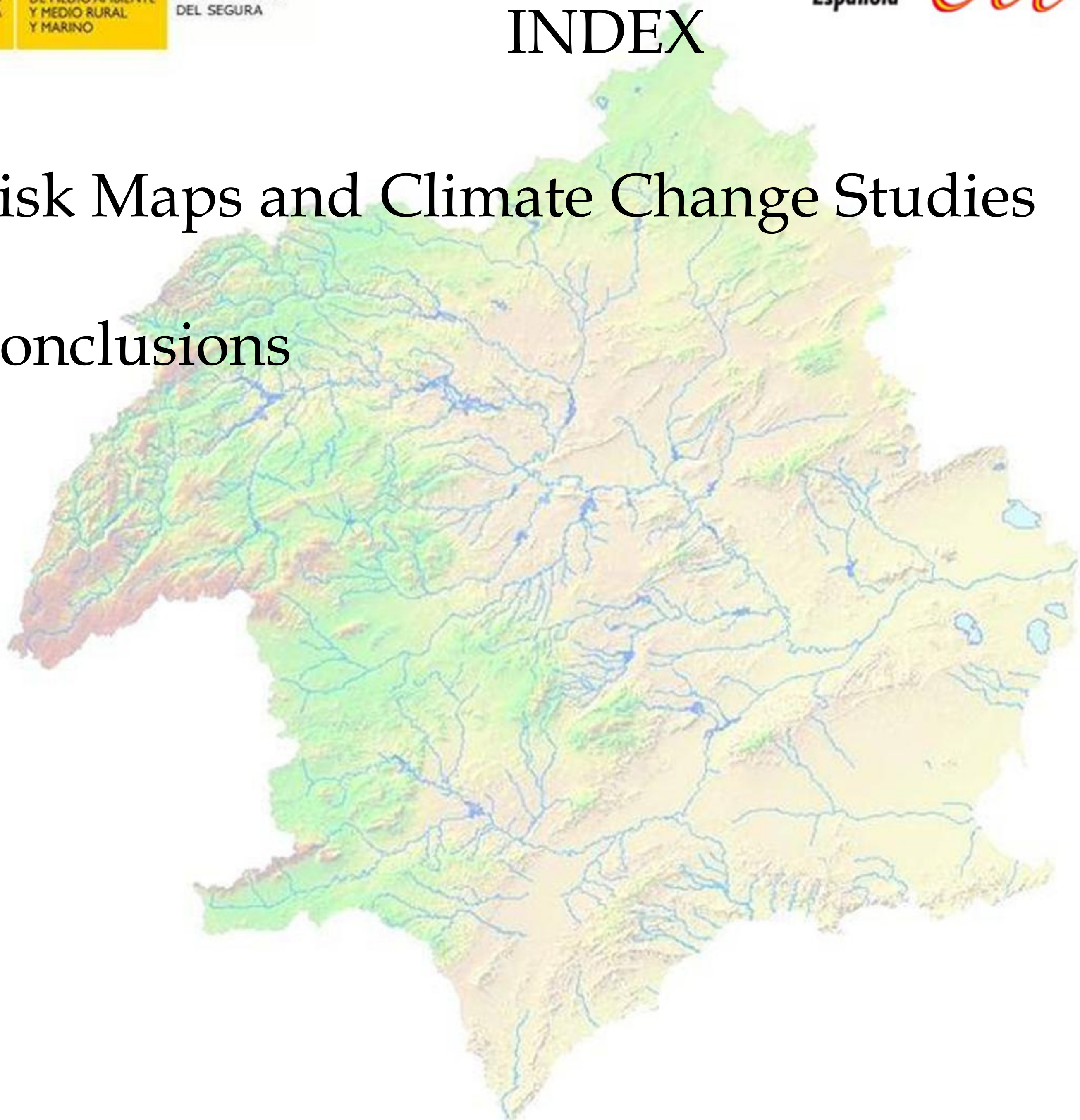
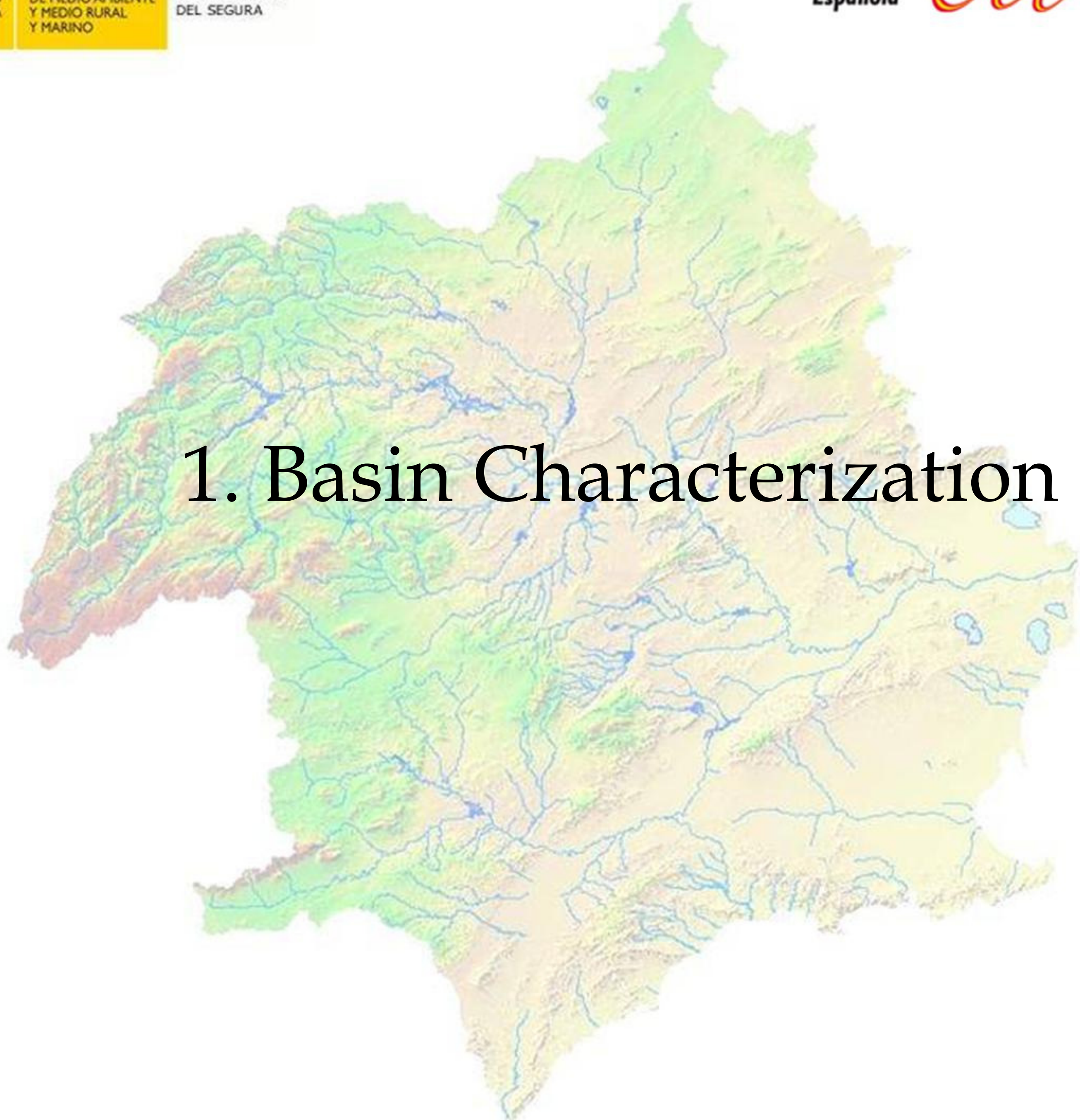




1. Basin Characterization

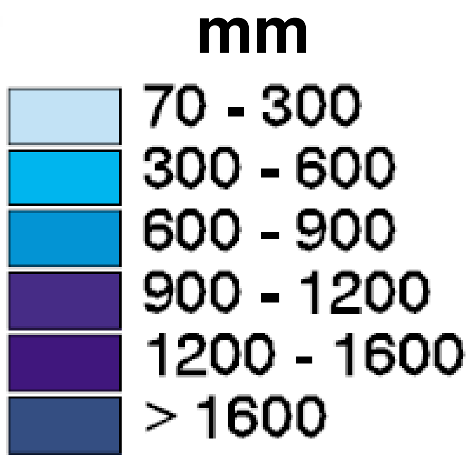
1. Basin Characterization: **1.1 General Characteristics**

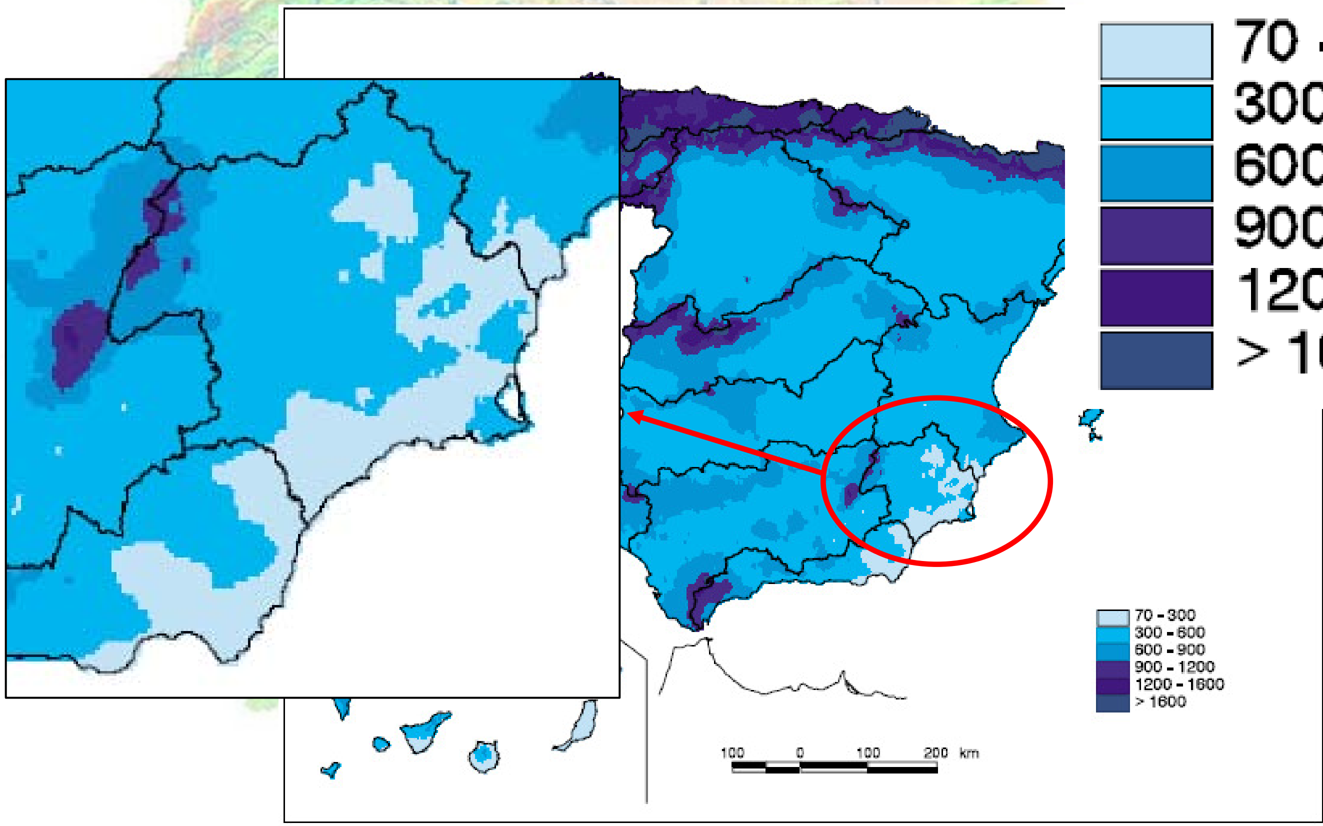
Spain

Europe

SURFACE (Km²)	18.815
POPULATION THAT DEMANDS RESOURCES FROM SEGURA RIVER BASIN (inhabitants). Year 2009	1.969.370
SUMMER POPULATION (inhabitants). Year 2009	> 3.000.000
TOTAL LENGHT OF CHANNEL NETWORK (Km)	1.470
IRRIGATION SURFACE (ha)	269.029
SOURCES OF WATER RESOURCES (Hm³)	Surface waters : 640, Groundwater: 220 Reutilization:110, TAJO-SEGURA WATER TRANSFER: 540

The South East of Spain receives less RAINFALL than the rest of Iberian Peninsula, due to Foëhn effect.





SOURCE: DBW*

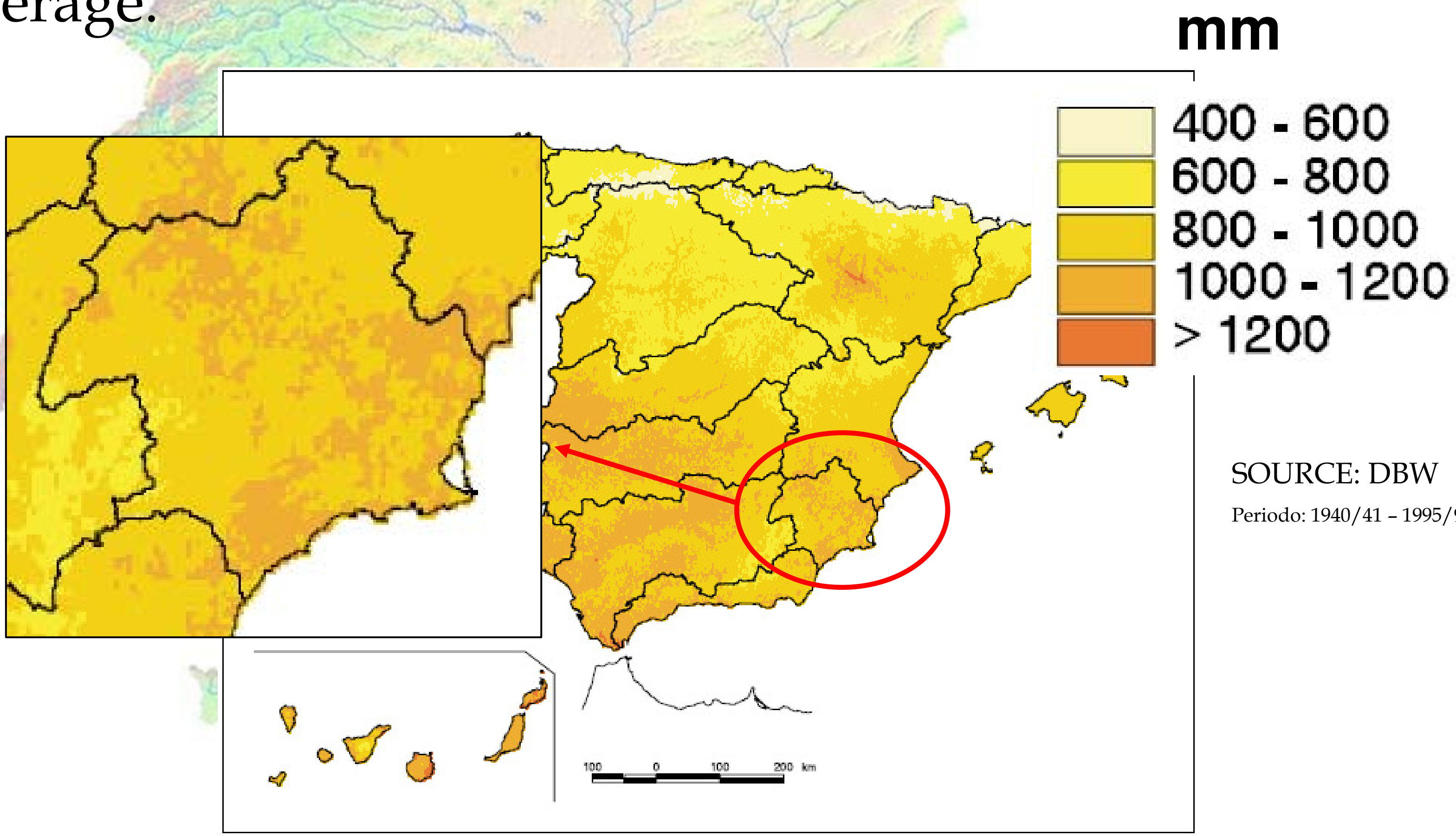
Periodo: 1940/41 – 1995/96

*Digital Book of Water: http://servicios3.mma.es/siagua/visualizacion/lda/index.jsp

Average annual rainfall: 365 mm in the Segura River Basin

1. Basin Characterization: **1.1 General Characteristics**

The high isolation generates a POTENTIAL EVAPOTRANSPIRATION (PET) similar to the Spanish average.



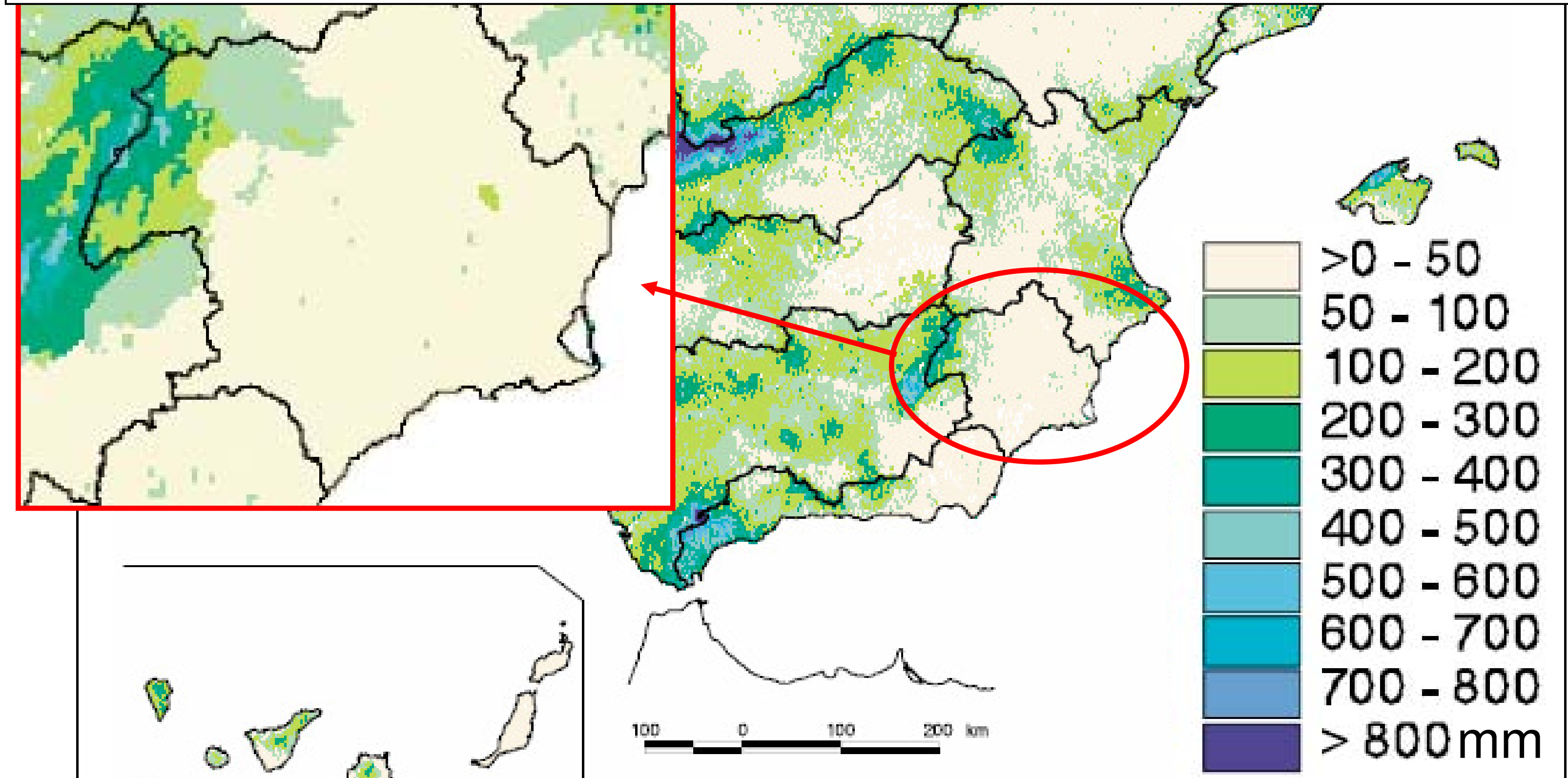
SOURCE: DBW

Periodo: 1940/41 – 1995/96

Average Annual PET: 827 mm in the Segura River Basin

1. Basin Characterization: **1.1 General Characteristics**

Only in the headwaters of the basin , the RUNOFF is significant.



SOURCE: DBW

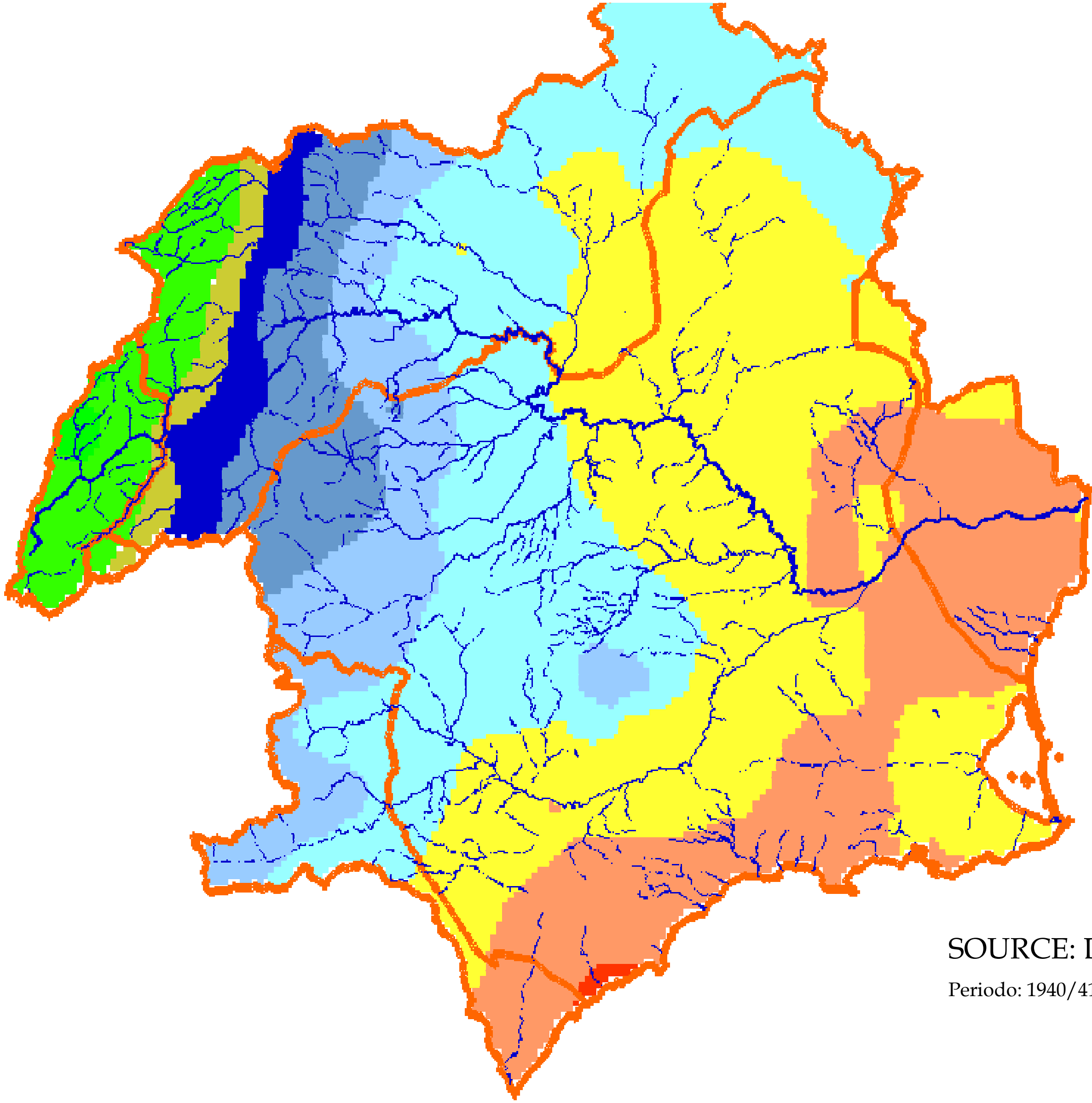
Periodo: 1940/41 – 1995/96

Average total runoff < 100 mm in Segura River Basin

1. Basin Characterization: **1.1 General Characteristics**

Water balance

Rainfall - ETP (mm)



-716 -701	
-700 -601	
-600 -501	
-500 -401	
-400 -301	
-300 -201	
-200 -101	
-100 -1	
0 415	

SOURCE: DBW

Periodo: 1940/41 – 1995/96

❖According to international organisms (UN, WHO, etc…), the water scarcity threshold at national level is set in 1.000 m^3/inhab/year of available water resources.

❖ This threshold is estimated for food safety or sustainable economic development of the region.

Segura River Basin (S.R.B.)	442 m^3/inhab/year
SPAIN	2.460 m^3/inhab/year

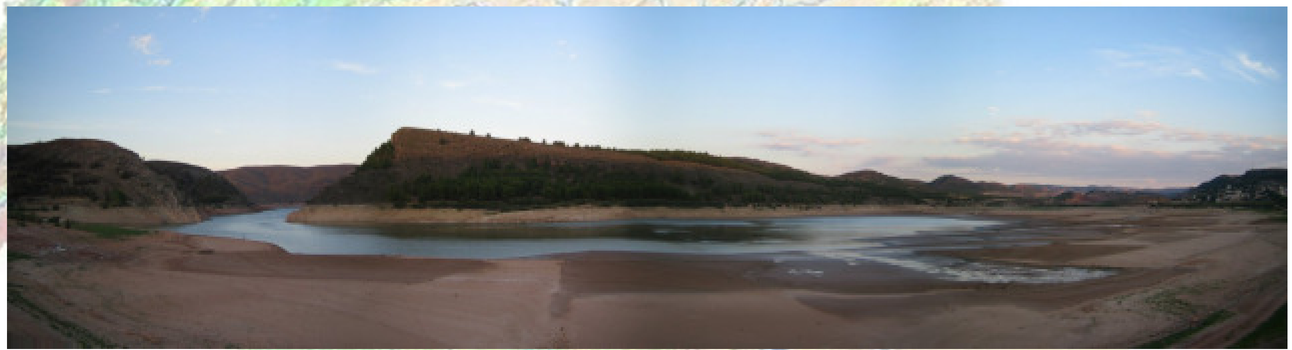
1. Basin Characterization: **1.1 General Characteristics**

	Surface (km^2)	Average rainfall (mm)	PET (mm)	Natural Resources (hm^3/year)	Ratio per inhabitant
S.R.B.	18.870 (3.7%)	365	827	803 (0,7%)	442 m^3/hab/año
Spain	506.474	711	842	111.186	2.460 m^3/hab/año

Source: Digital Book of Water /SRB Report 2008

The Segura River Basin is a semiarid basin that shows the least renewable water resources of the Spanish river basins.

a. Natural Resources: surface water



a. Natural Resources: surface water

- The headwaters of the basin (Segura and Mundo Rivers until their confluence) represent the main source of water resources of the basin.

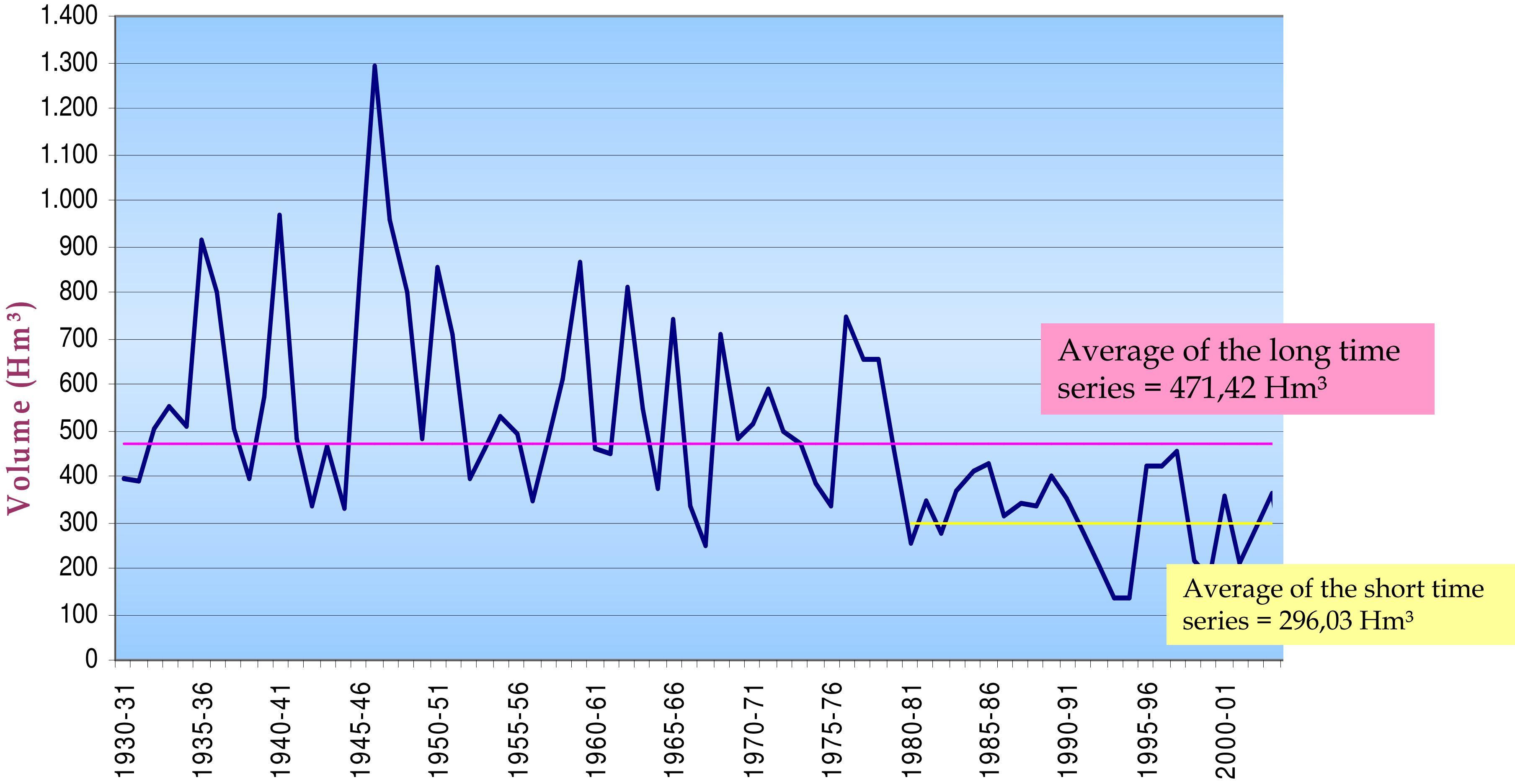
- After headwaters, the second main source of water resources are tributaries of right river bank (Moratalla, Argos, Quipar and Mula Rivers), which have permanent hydrological regime but with scarce water flow (65 hm^3 approximately). They are locally consumed and don't represent significant flow returns to Segura River.

- The torrential tributaries of left river bank correspond to semiarid basins. Therefore, they only are active after storms.

1. Basin Characterization: **1.2 Resources**

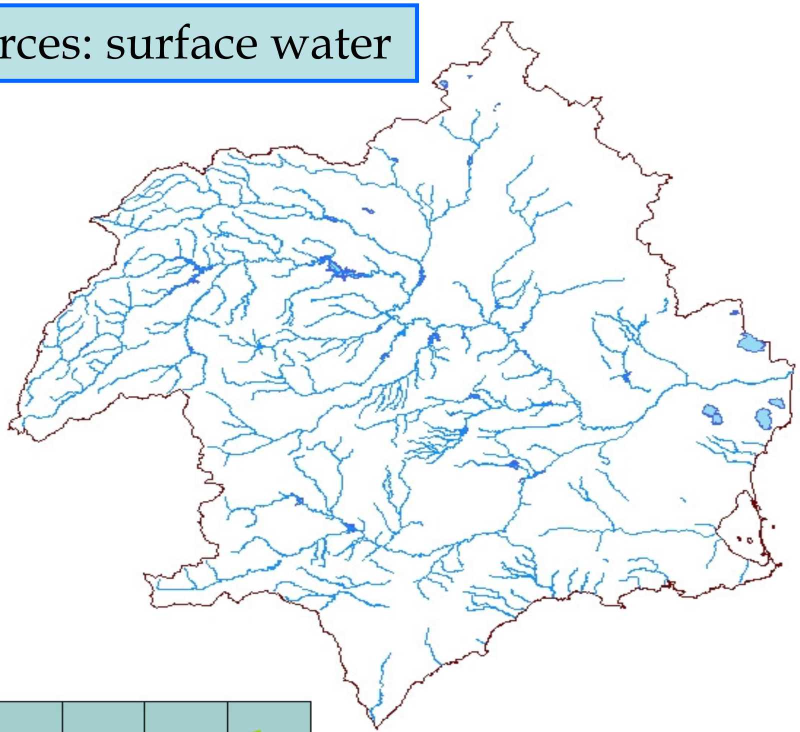
a. Natural Resources: surface water

Interannual acumulated runoff between september 1931 and september 2009



1. Basin Characterization: **1.2 Resources**

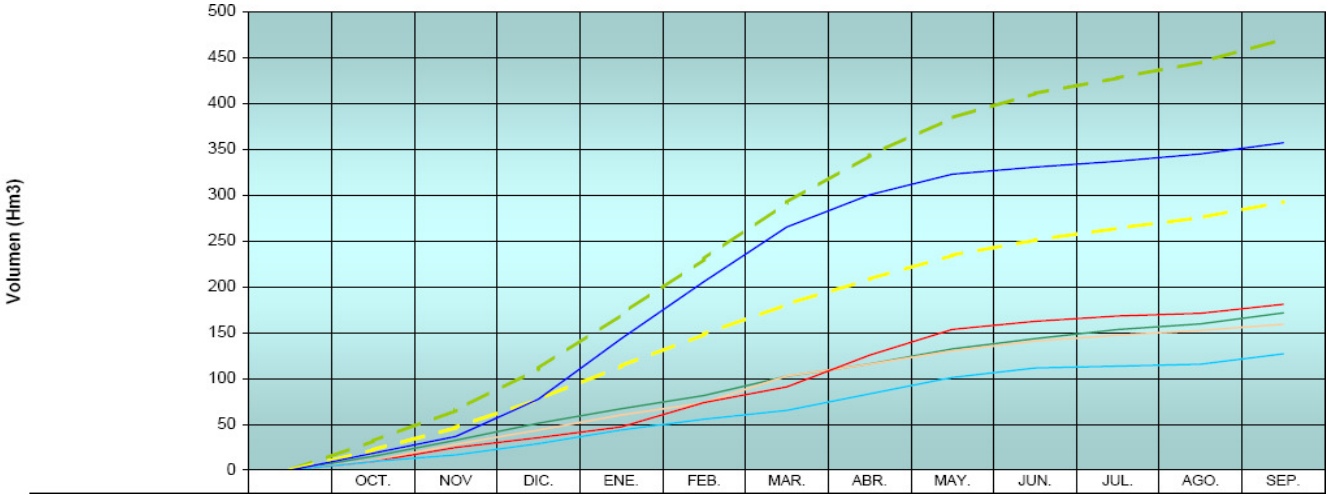
a. Natural Resources: surface water



Surface water of the Basin

Runoff contributions to the Basin in the last 5 hydrological years

Media Histórica	470,232
Media desde 1980-81	290,487
2004-05	171,628
2005-06	159,144
2006-07	181,008
2007-08	126,917
2008-09	357,124



1. Basin Characterization: **1.2 Resources**

a. Natural Resources: groundwater

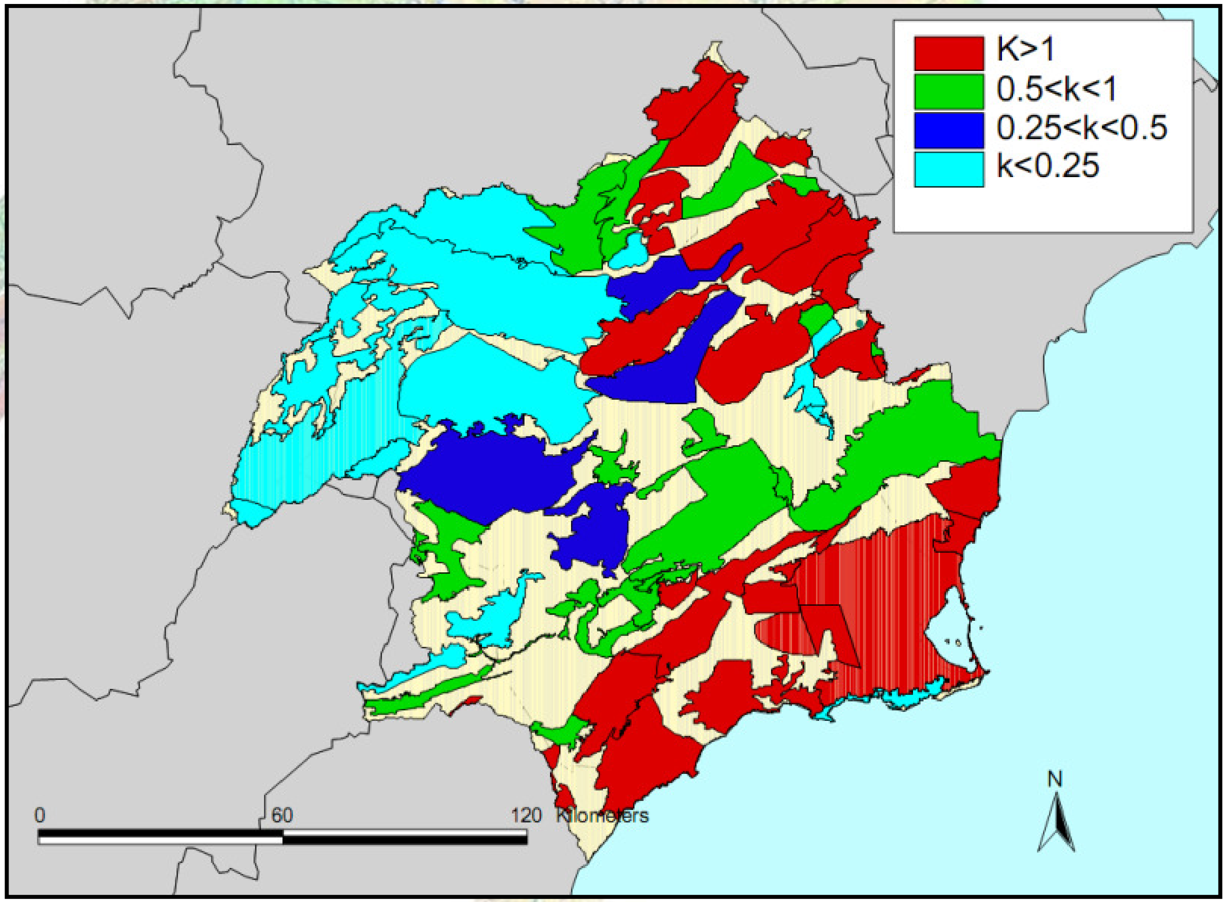
- In the SRB, there are 63 Groundwater bodies

- The groundwater annual available resources are 534 hm^3, but only 334 hm^3 (62 % approximately) correspond to groundwater whose drainage is regulated by dams located in the headwaters of the basin or dams located in tributaries of the right river bank.

1. Basin Characterization: **1.2 Resources**

a. Natural Resources: groundwater

Preliminary Index of water abstraction in the Segura River Basin District



Ratio k=abstraction/recharge
Source: General River Basin District Study. 2007

1. Basin Characterization: **1.2 Resources**

a. Natural Resources: groundwater

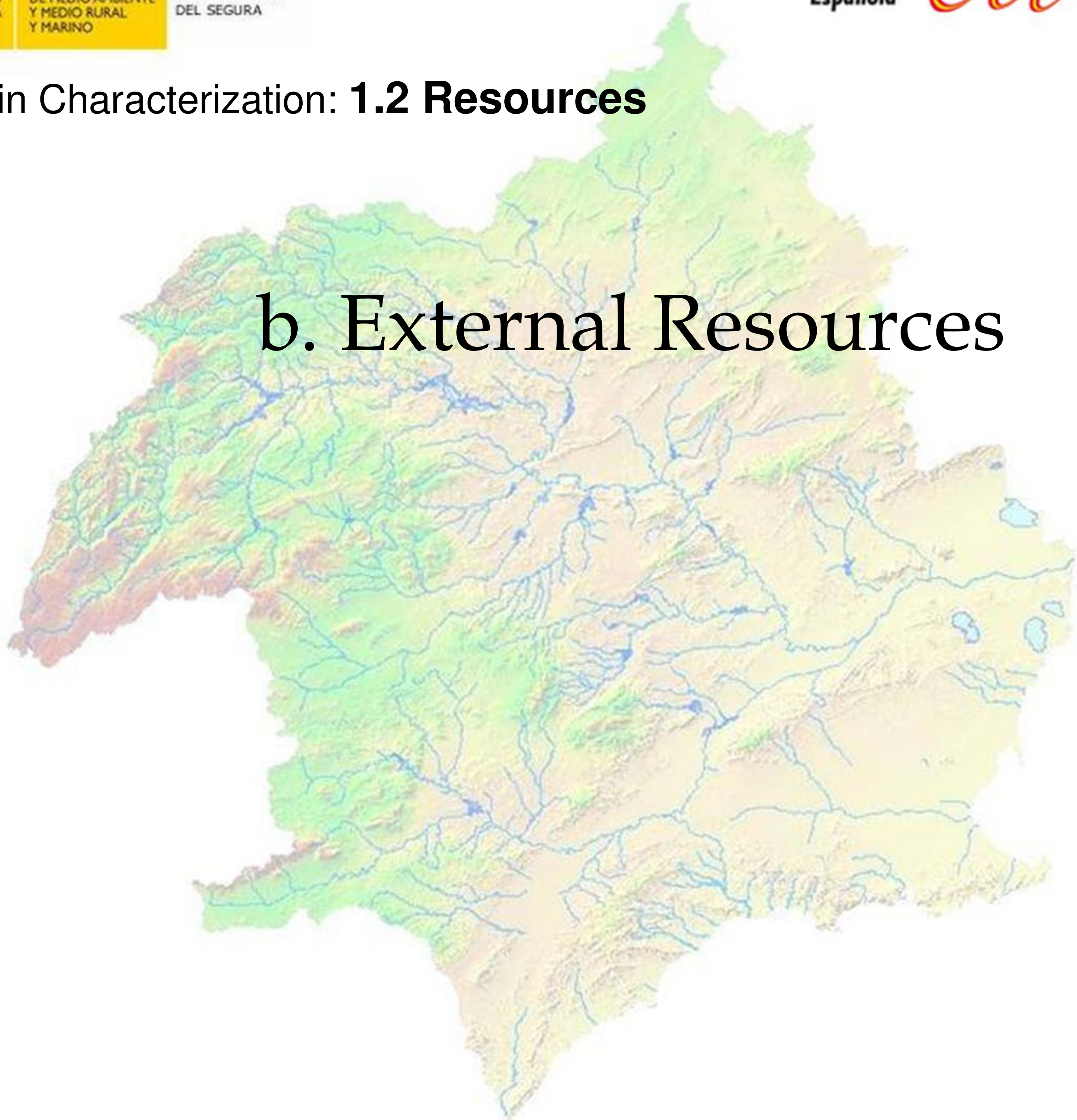
OVEREXPLOITATION *STATEMENTS*

Acuífero	Fecla de la declaración de sobreexplotación
Alto Guadalentín	10-marzo-1987 y 4-octubre-1988 (*)
Bajo Guadalentín	10-marzo-1987 y 4-octubre-1988 (*)
Ascoy-Sopalmo	17-diciembre-1988 (*)
Cresta del Gallo	4-octubre-1988 (*)
Jumilla-Villena	31-julio-1987 (**)
Sierra de Crevillente	31-julio-1987 (**)
Acuíferos de la Unidad Hidrogeológica de Aguilas	6-abril-2004 (*)
Acuíferos de la Unidad Hidrogeológica de Mazarrón	6-abril-2004 (*)
Acuífero de Cabo Roig	6-abril-2004 (*)
Sector Triásico de las Victorias (Acuífero Campo de Cartagena)	6-abril-2004 (*)
Terciario de Torrevieja	6-abril-2004 (*)
Carrascoy	6-abril-2004 (*)
Santa- Yéchar	6-abril-2004 (*)
Aledo	6-abril-2004 (*)

(*) Junta de Gobierno dela CH del Segura
(**) DG Obras Hidráulicas y Calidad de las Aguas

SOURCE: SRB REPORT 2008

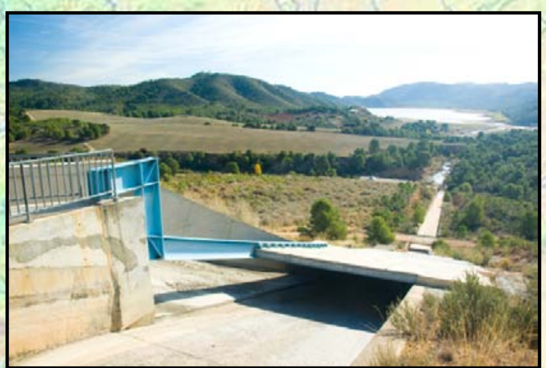
b. External Resources



1. Basin Characterization: **1.2 Resources**

b. External Resources

- Water resources from Entrepeñas and Buendía reservoirs, in Tajo River Basin.

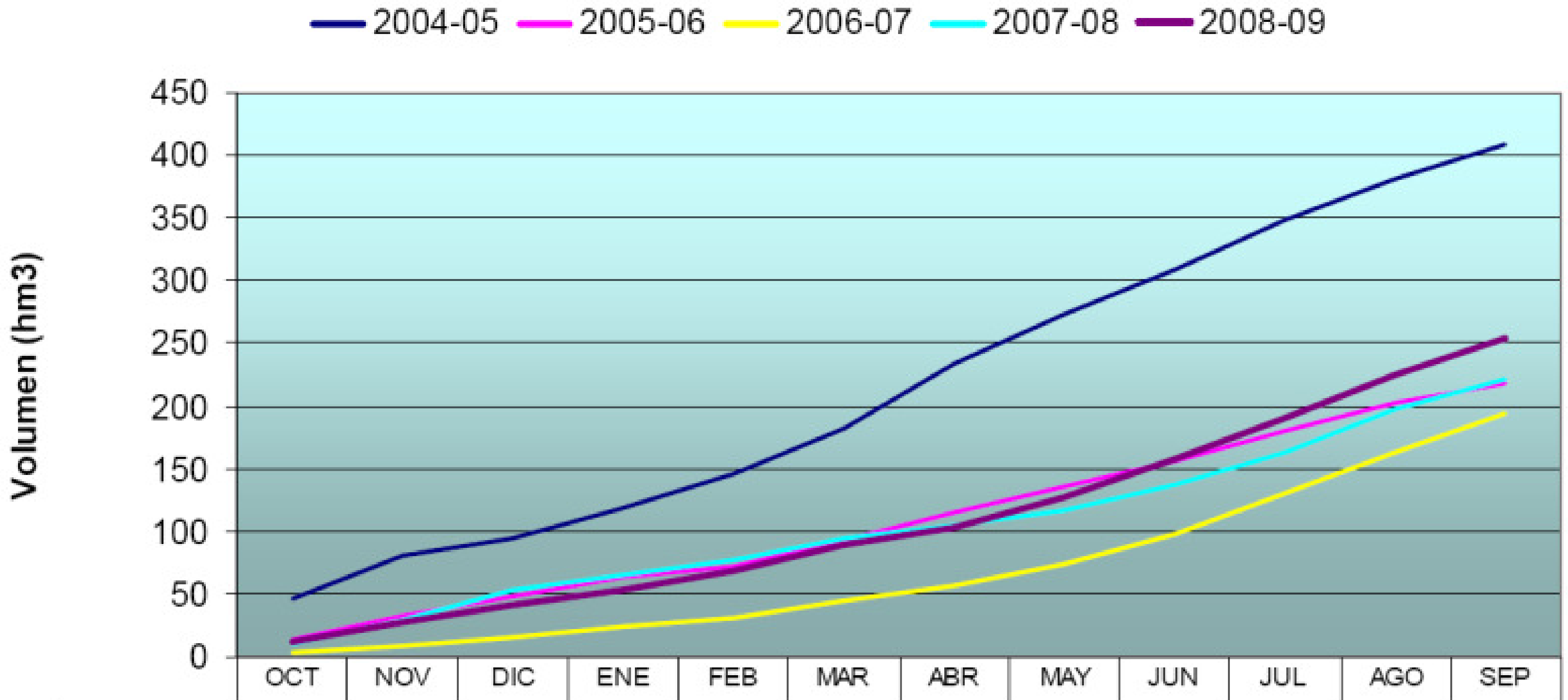


- The Tajo-Segura water transfer, with a maximum amount of 600 hm^3/year, is oriented to:
  - **Urban Water Supply: 140 hm^3**
    - Taibilla River Channels Community (SRB) 131 hm^3.
    - Mediterranean basins from Andalucía 9 hm^3.
  - **Irrigation: 400 hm^3**
    - Segura River Basin District: 335 hm^3.
    - Jucar River Basin District: 50 hm^3.
    - Mediterranean basins from Andalucía: 15 hm^3.
  - Water losses: 60 hm^3.

1. Basin Characterization: **1.2 Resources**

b. External Resources

TAJO-SEGURA WATER TRANSFERS IN THE LAST 5 YEARS



	OCT	NOV	DIC	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP
2004-05	46,394	80,073	94,006	118,586	146,202	181,805	233,155	273,918	309,513	348,865	381,657	409,238
2005-06	13,557	32,246	48,868	62,801	72,958	92,104	114,864	135,298	155,699	179,649	203,301	217,788
2006-07	2,622	8,63	15,713	23,83	30,634	44,86	56,934	74,034	98,278	130,142	162,731	194,252
2007-08	9,929	28,363	52,808	65,207	77,736	94,825	105,575	117,187	137,226	163,503	196,853	220,929
2008-09	11,541	26,641	41,336	52,898	68,618	88,652	102,272	127,005	157,607	190,579	225,296	254,134

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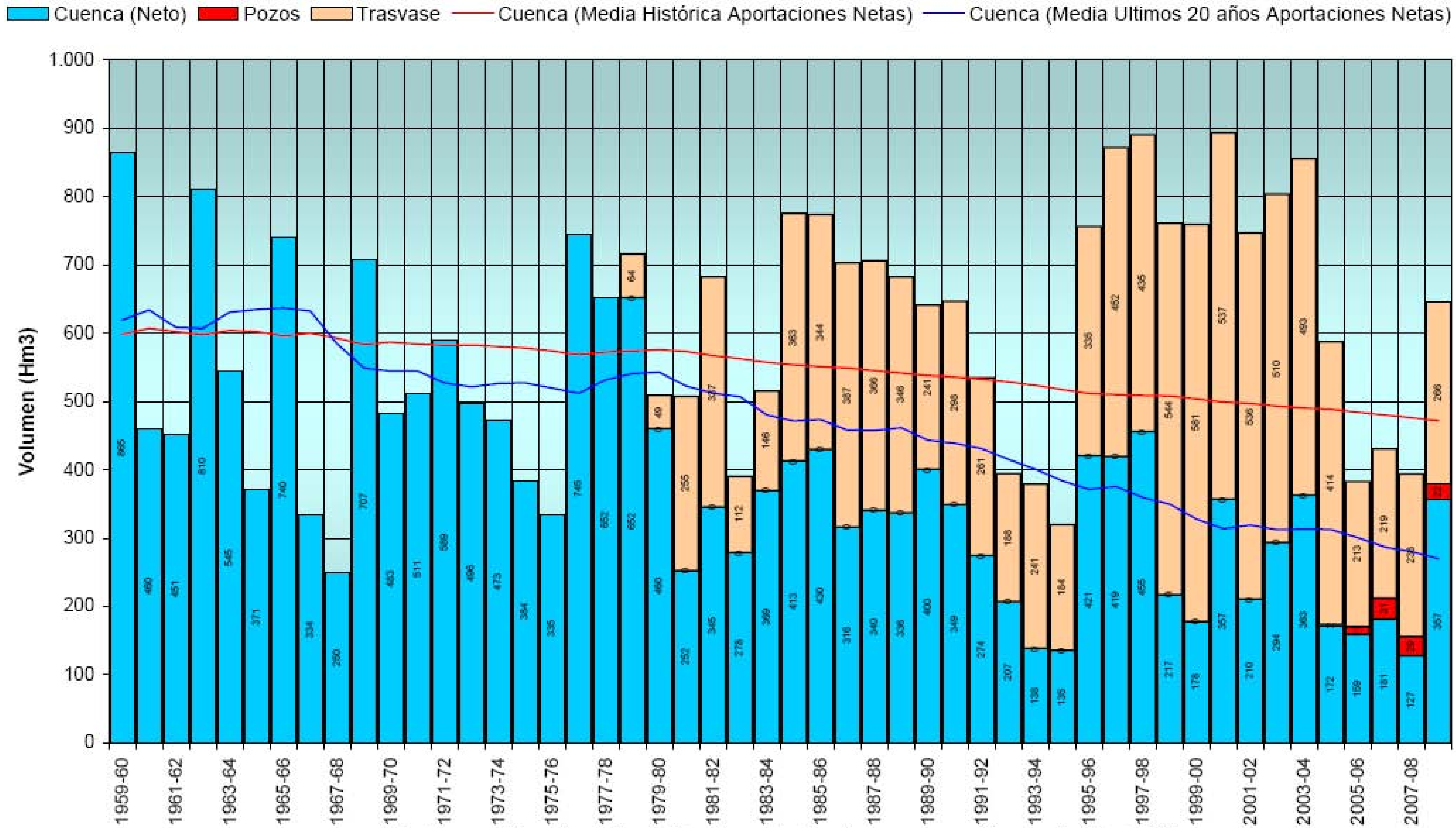
1. Basin Characterization: **1.2 Resources**

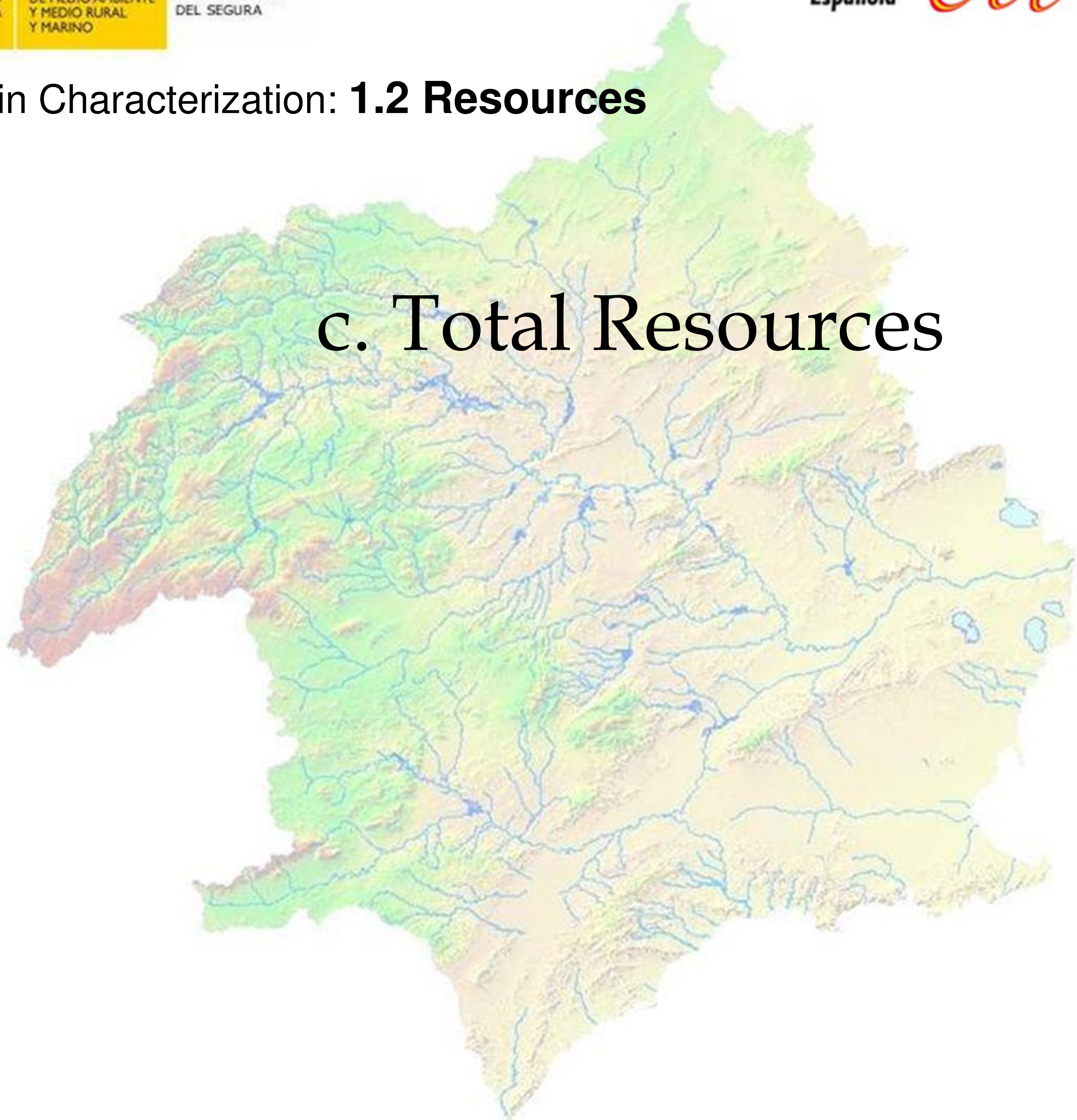
b. External Resources

EXTERNAL AND NATURAL WATER RESOURCES. LAST 50 YEARS



(*) Aportaciones reguladas por los embalses del sistema de uso conjunto (aquellos que aparecen en el bloque superior del Parte Oficial)

c. Total Resources



1. Basin Characterization: **1.2 Resources**

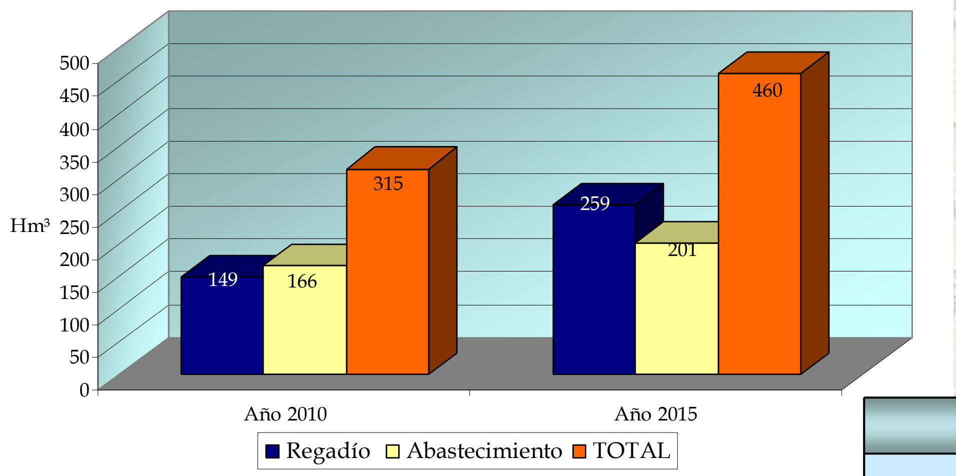
c. Total Resources

1. NATURAL RENEWABLE WATER RESOURCES		
Natural regime of Segura River and Torrential coastal channel rivers	1.000 Hm^3	
Drainage to sea. Segura River	-50 Hm^3	
Drainage to sea. Torrential rivers and coastal aquifers	-30 Hm^3	
Evapotranspiration of reservoirs and direct recharge of aquifers	-60 Hm^3	
TOTAL NATURAL RESOURCES WITH POTENCIAL USE		**860 Hm^3**
2. EXTERNAL RESOURCES		
First phase of A.T.S	600 Hm^3	
Losses	-60 Hm^3	
EXTERNAL TOTAL		**540 Hm^3**
AVAILABLE RENEWABLE TOTAL RESOURCES		**1.400 Hm^3**
3.ABSTRACTED GROUNDWATER		**210 Hm^3**
4.TOTAL REUSE OF RESOURCES		**100 Hm^3**
5.OTHER NON RENEWABLE RESOURCES		**35 Hm^3**
TOTAL RESOURCES		**1.745 Hm^3**

SOURCE: WATER MANAGEMENT PLAN OF THE SEGURA RIVER BASIN

1. Basin Characterization: **1.2 Resources**

d. Other Resources: Desalination



	2010 Year		2015 Year	
	Irrigation	Urban Water Supply	Irrigation	Urban Water Supply
Valdelentisco	37	20	37	33
San Pedro Pinatar I		24		24
San Pedro Pinatar II		24		24
Águilas	48	10	58	12
Ampliación Águilas- C.R.	8		8	
Torrevieja	40	40	80	40
Desalinizadora Alicante I		18		18
Ampliación Alicante I		6		6
Alicante II		24		24
El Mojón	6		6	
Guardamar			60	
Desaladora C.R. Mazarrón	10		10	
Desaladora de Escombreras. CARM				20
TOTAL	**149**	**166**	**259**	**201**

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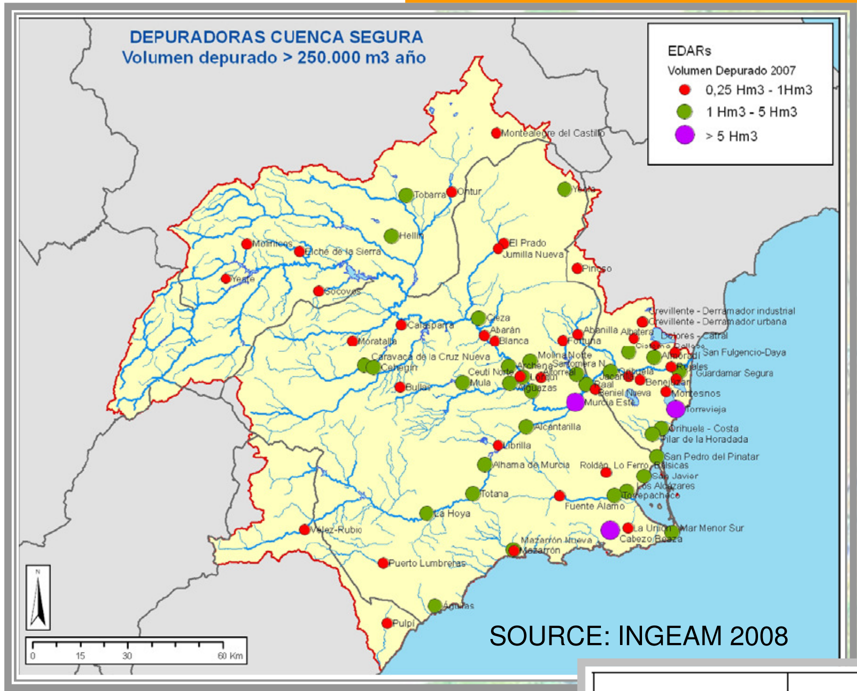
1. Basin Characterization: **1.2 Resources**

d. Other Resources: Reuse of wastewaters



Comunidad Autónoma	*Provincia*	*Todas las Instalaciones C.H. Segura*		*Instalaciones >0,25 hm³/año*	
		EDAR	*Volumen hm3*	*EDAR*	*Volumen hm3*
Castilla La Mancha	Albacete	14	6,8	8	5,9
Valencia	Alicante	38	26,7	18	24,8
Andalucía	Almería	2	0,6	2	0,6
	Jaén	5	0,1	-	-
Murcia	Murcia	80	102,4	43	100,2
TOTAL		***139***	***136,7***	***71***	***131,5***

Summary of demands

Demand \ Time Horizon	2007	2015	2027
Urban supply and Industrial demand	263,2	318,9	360
Irrigation	1.662	1.549	1.549
Environmental consuming demand	30	30	30
TOTAL (Hm3)	**1.955,2**	**1.897,9**	**1.939**

1. Basin Characterization: **1.3 Demands**

AGRICULTURAL DEMAND

- Gross demand. Region SRB District: 1.662 hm^3
- Source of Water Resources:

	WATER RESOURCE			
	SURFACE	PUMPINGS	W. TRANSFER	OTHERS
SRB DISTRICT	34.56%	28.75%	27.91%	8.78%

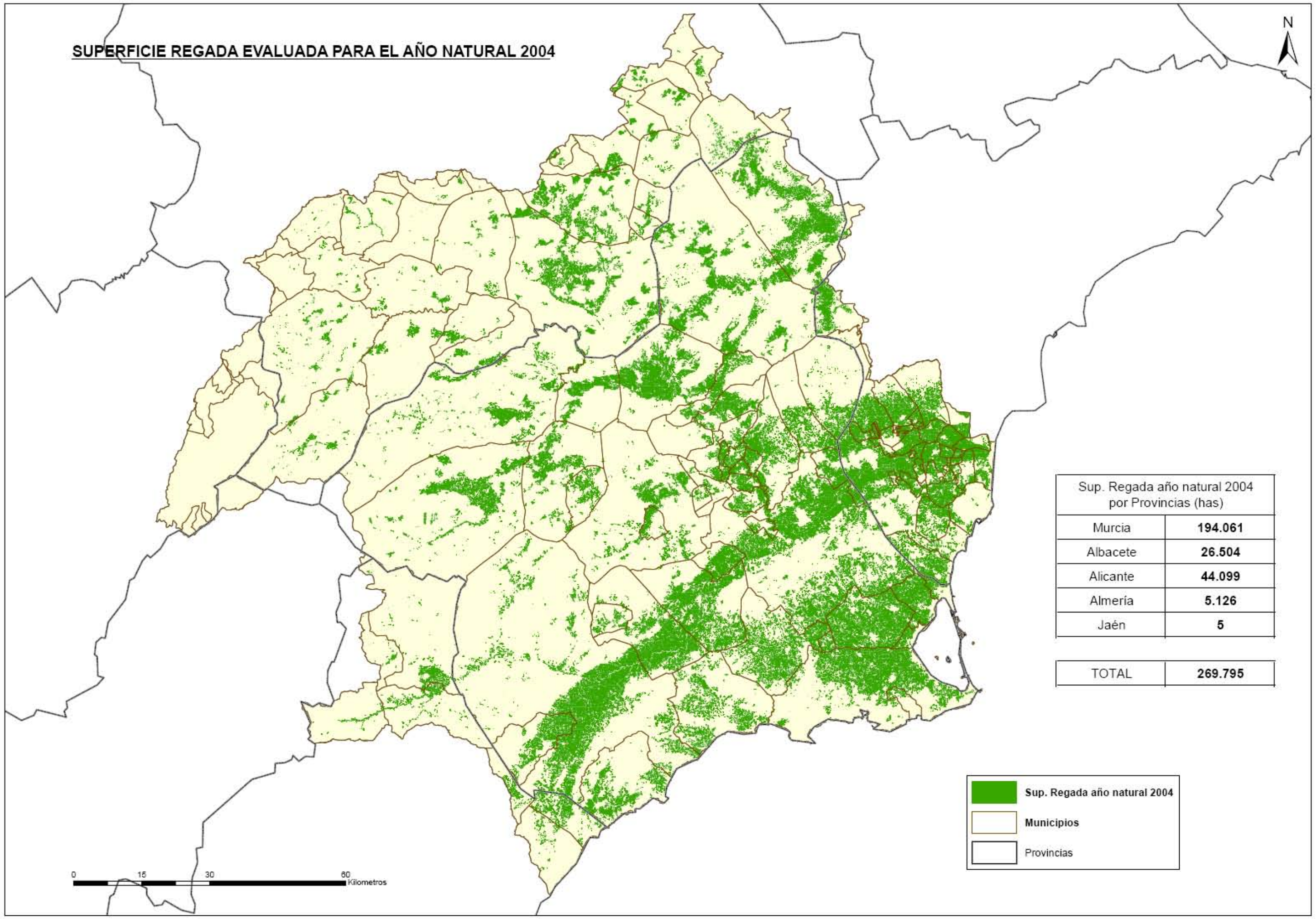
AGRICULTURAL DEMAND

	PHCS Area
Net area	**269.000 has**
Gross demand Volume	**1.662 hm^3/año**
Production value	**3.202 M€**
Net margin	**1.202 M€**

High profitability, with an average value production of 1,93 €/m^3 and a net margin of 0,72 €/m^3.

1. Basin Characterization: **1.3 Demands**

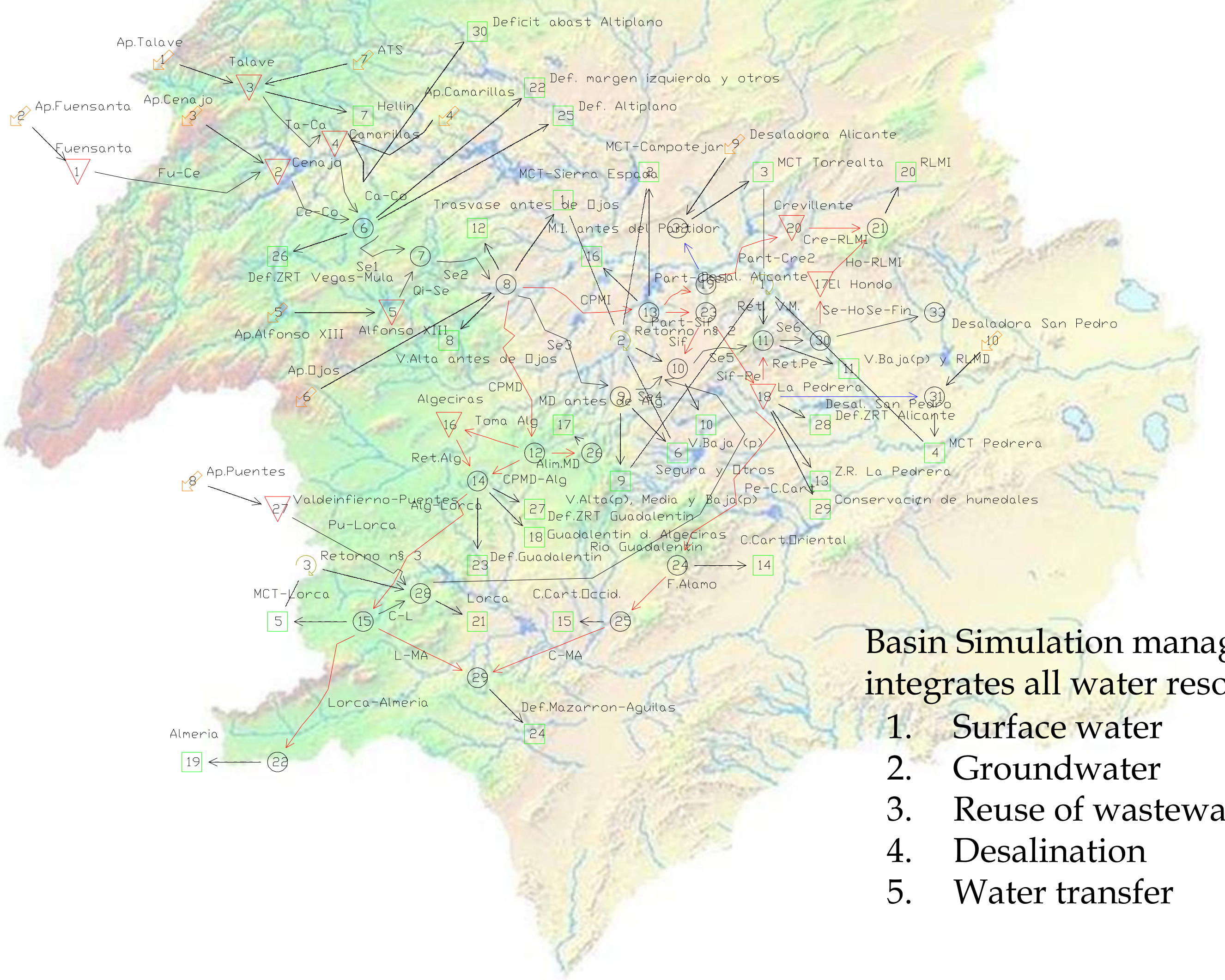
AGRICULTURAL DEMAND



Sup. Regada año natural 2004 por Provincias (has)	
Murcia	194.061
Albacete	26.504
Alicante	44.099
Almería	5.126
Jaén	5
TOTAL	269.795

IRRIGATION SURFACE 269.000 ha

Integrated water resources management

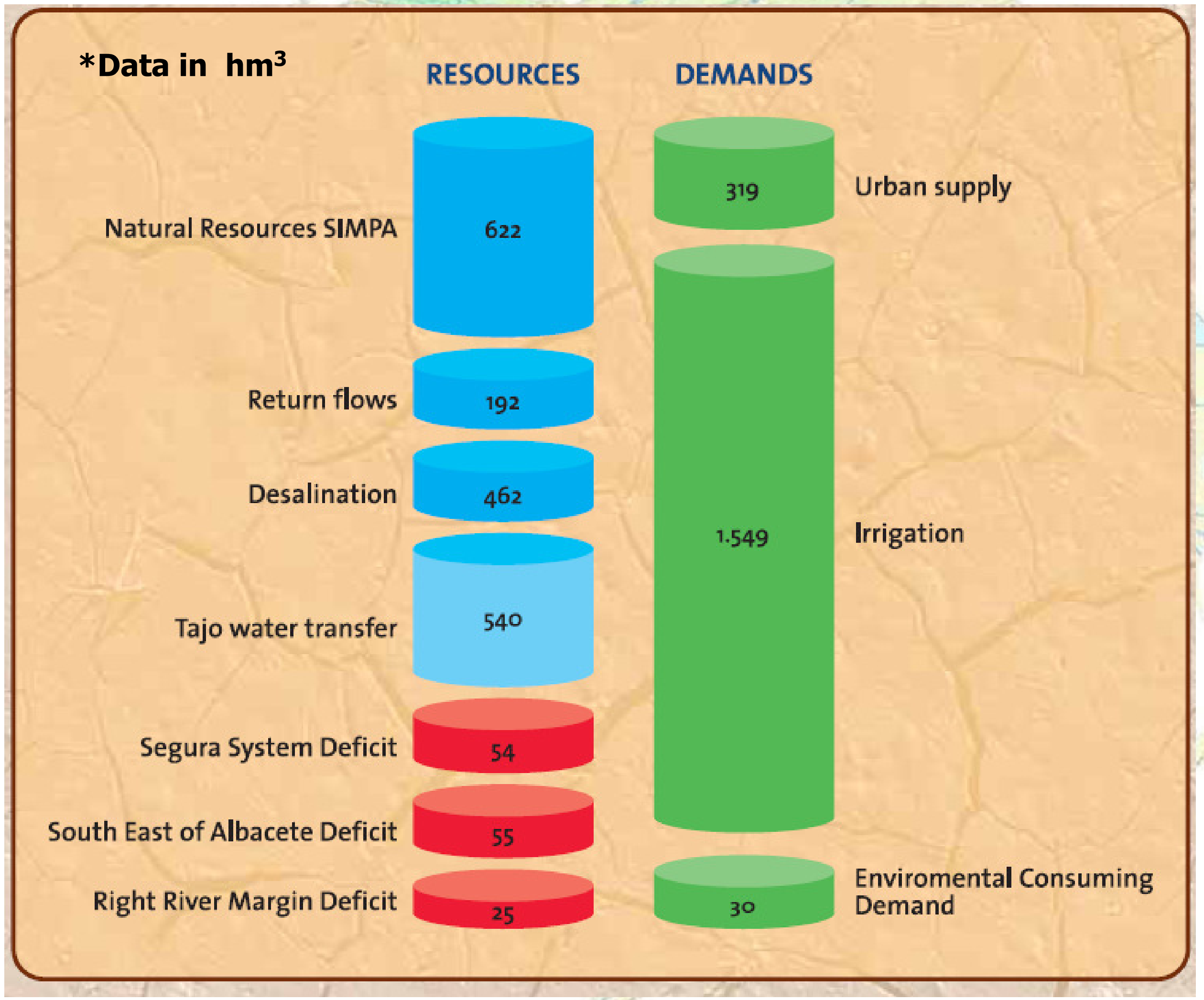


Basin Simulation management model integrates all water resources:

1. Surface water
2. Groundwater
3. Reuse of wastewater
4. Desalination
5. Water transfer

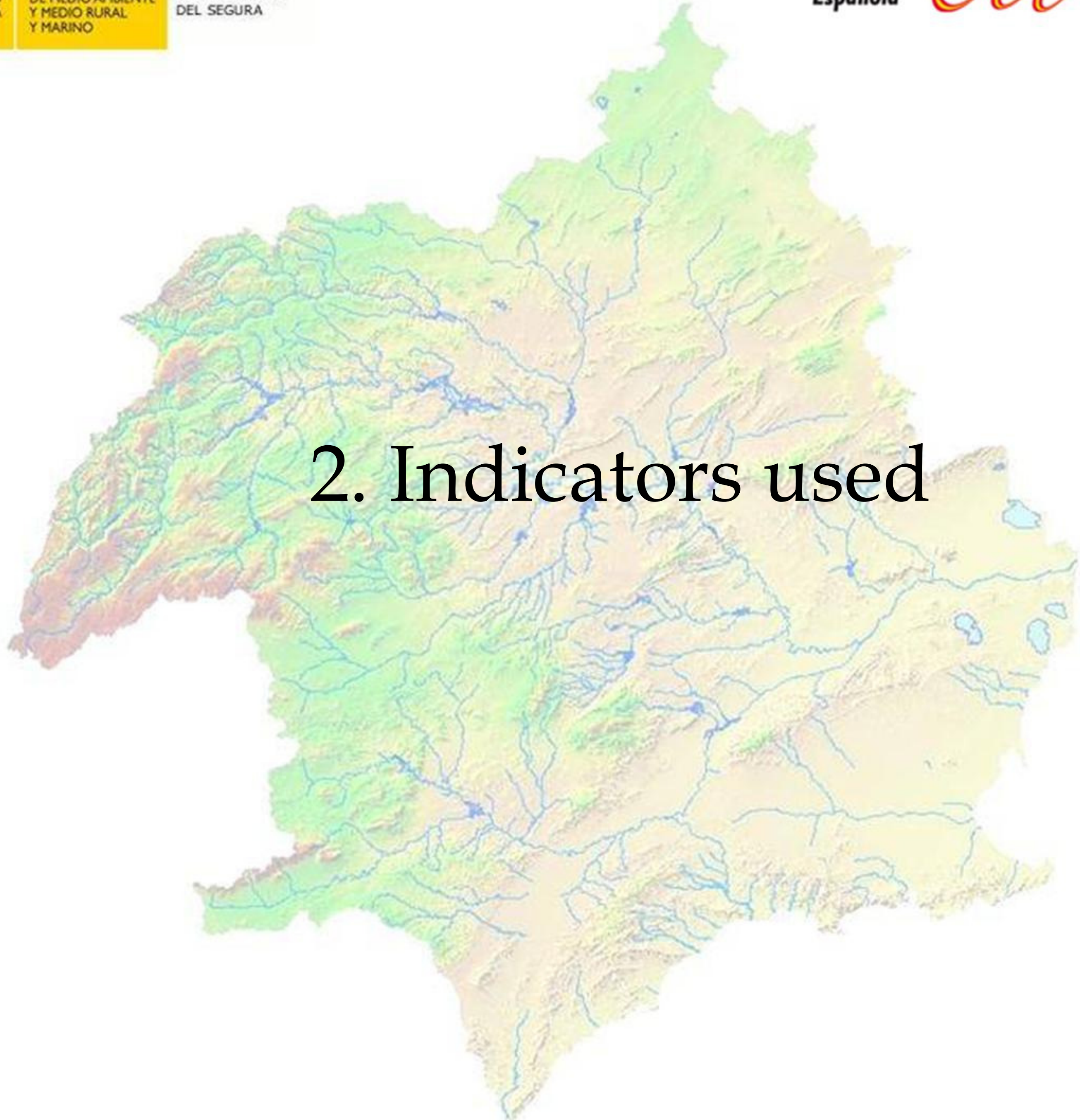
1. Basin Characterization:

1.4 Balance between Water resources and Demands



Expected in 2015

Source: Overview of the significant issues



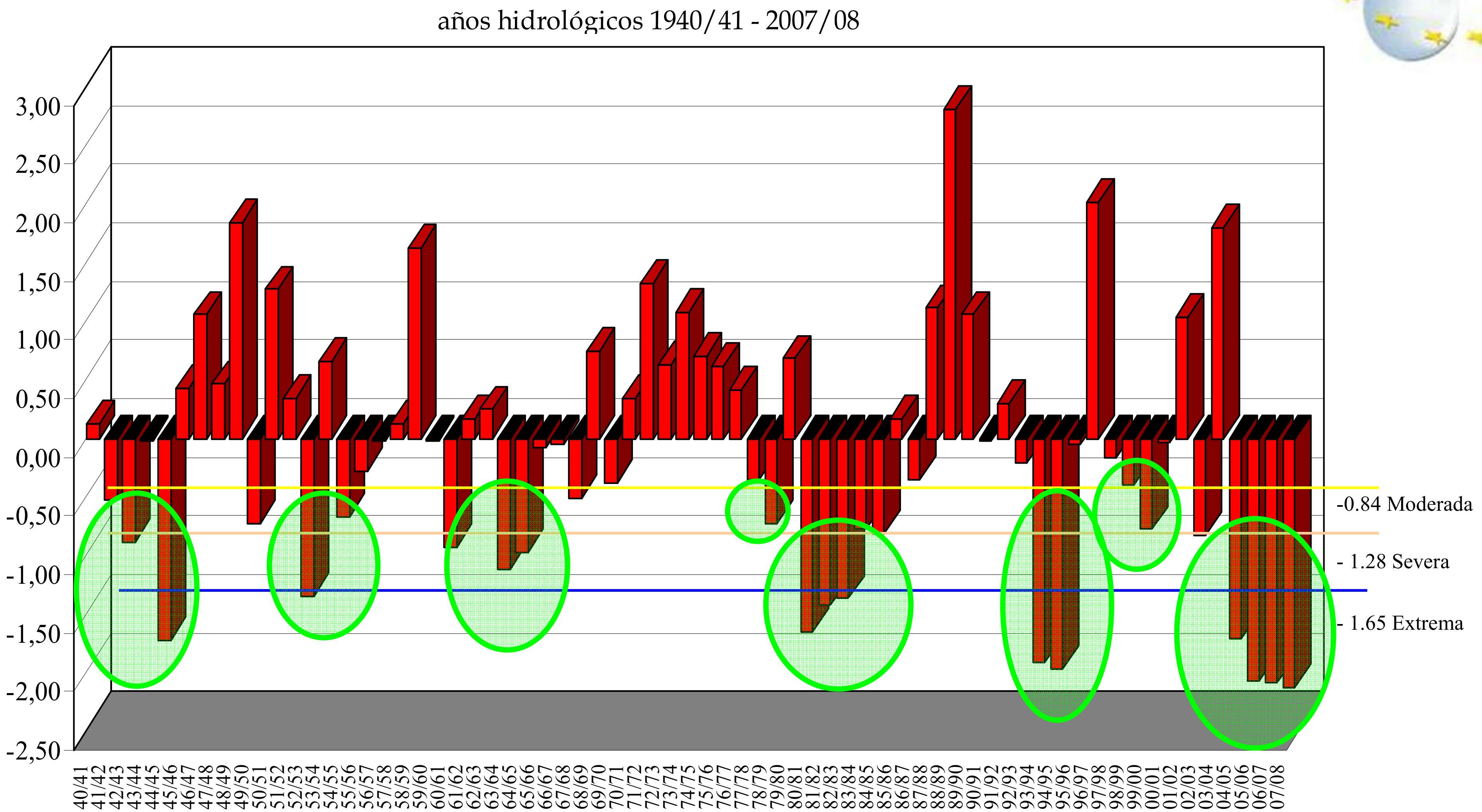
2. Indicators used

2. Indicators Used: **2.1 SPI Indicator**

- SPI indicator only takes into account rainfall values for its evaluation.
- It’s based on the probability of registering a certain precipitation, and it allows to quantify a precipitation deficit in several time scales.
- Considered probabilities are normalized, consequently SPI indicator values similar to zero involve the average precipitation, whilst positive or negative SPI values imply a wet year or a dry year respectively.

CONFEDERACIÓN HIDROGRÁFICA

2. Indicators Used: **2.1 SPI Indicator**



The most important long drought events (having an intensity higher than moderate, and lasting than a year) can be clearly identify in the upper graph, in the period of time from 1940 to 2008:

1940-1945, 1952-1957, 1977-1986, 1992-1996, 2004-2008

- It is a cyclical and repetitive phenomenon, difficult to predict and sometimes can suddenly appear.
- In the beginning the drought is characterized by a decrease of precipitation values (meteorological drought), causing consequently a reduction of natural water resources (hydrological drought).
- This hydrological drought may cause supply failures and therefore, is the one that has to be tackle by the natural water resource managers.
- **Drought (temporary situation) shouldn’t be confused with water scarcity (permanent deficit situation).**

DROUGHT MANAGEMENT IN SPAIN: LEGAL BACKGROUND

The National Hydrological Plan Law, released in 2001, provides the following measures dealing with droughts (Art. 27):

- The Establishment of a global hydrological indicator system, at national level, which will have to be used when formally stating a drought.
- Development of DROUGHT ACTION PLANS.
- Development of Emergency Plans for Urban supply in cities with more than 20.000 inhabitants.

DROUGHT MANAGEMENT IN SPAIN: LEGAL BACKGROUND

DROUGHT ACTION PLANS
MAIN OBJECTIVES

1. *¿When?*: It is very important because taking measures in advance is much more efficient than facing the drought effects.
2. *¿How?*: A sequence of measures activation should be established according to state of indicators, natural resources and expected drought evolution.
3. *¿Who are the ones responsible for drought management?:* Responsibility for the establishment, execution and monitoring of defined measures, as well as the coordination with stakeholders, should be assigned.

DROUGHT MANAGEMENT IN SPAIN: LEGAL BACKGROUND

DROUGHT ACTION PLANS

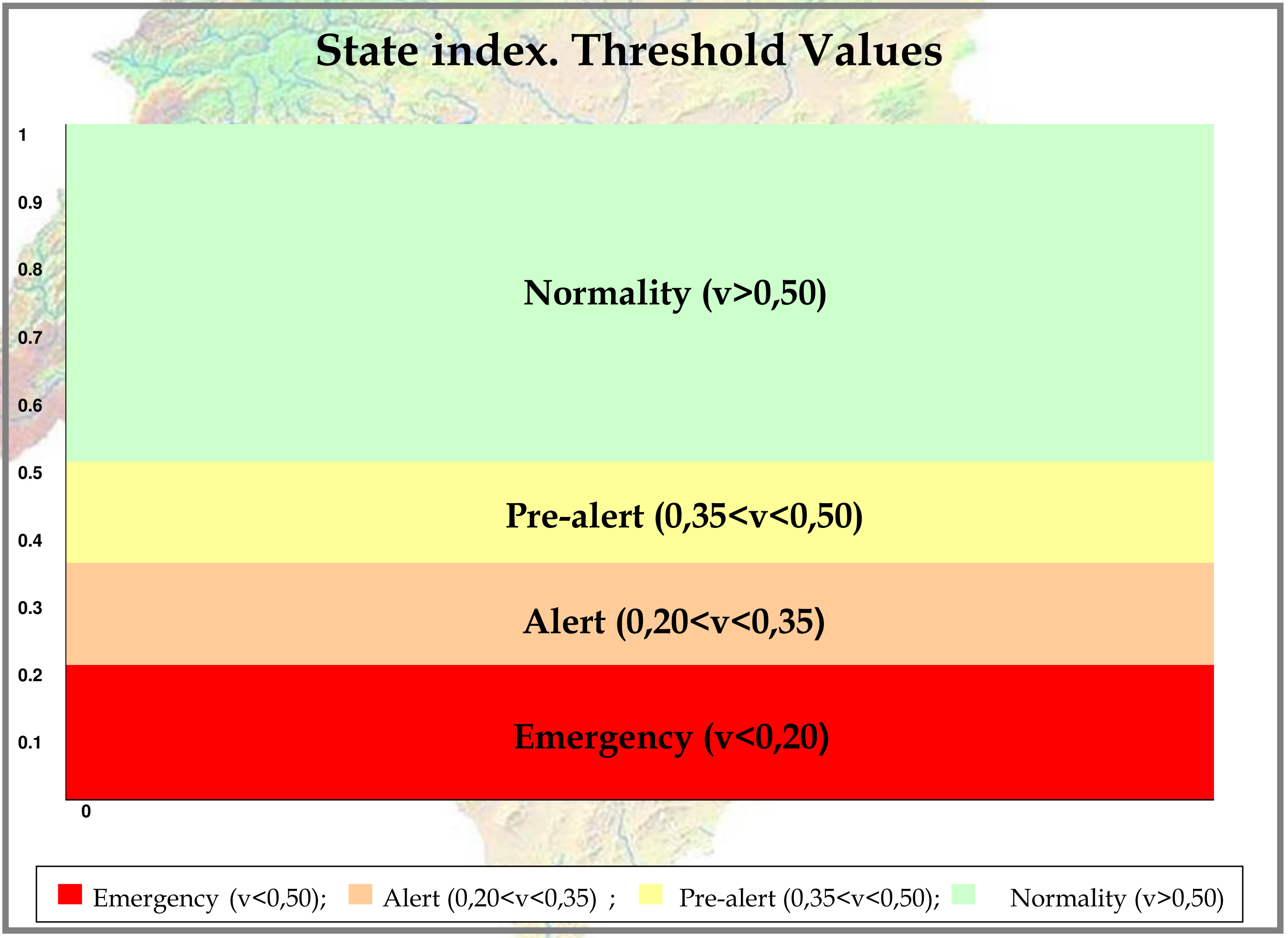
DROUGHT INDICATORS

- **Drought indicators of the Segura River Basin Action Plan are hydrological indicators instead meteorological indicators.**
- **A set of representative indicators are defined according to the evolution of natural water resources and demands.**
- **These indicators are composed of several factors, including water in reservoirs and natural water resources in the basin.**
- **The adoption of final indicators is checked with real situation in order to confirm its suitability.**

2. Indicators Used: **2.2 Drought definition**

DROUGHT MANAGEMENT IN SPAIN: LEGAL BACKGROUND

DROUGHT ACTION PLANS-DROUGHT INDICATORS



2. Indicators Used: **2.2 Drought definition**

DROUGHT MANAGEMENT IN SPAIN: LEGAL BACKGROUND

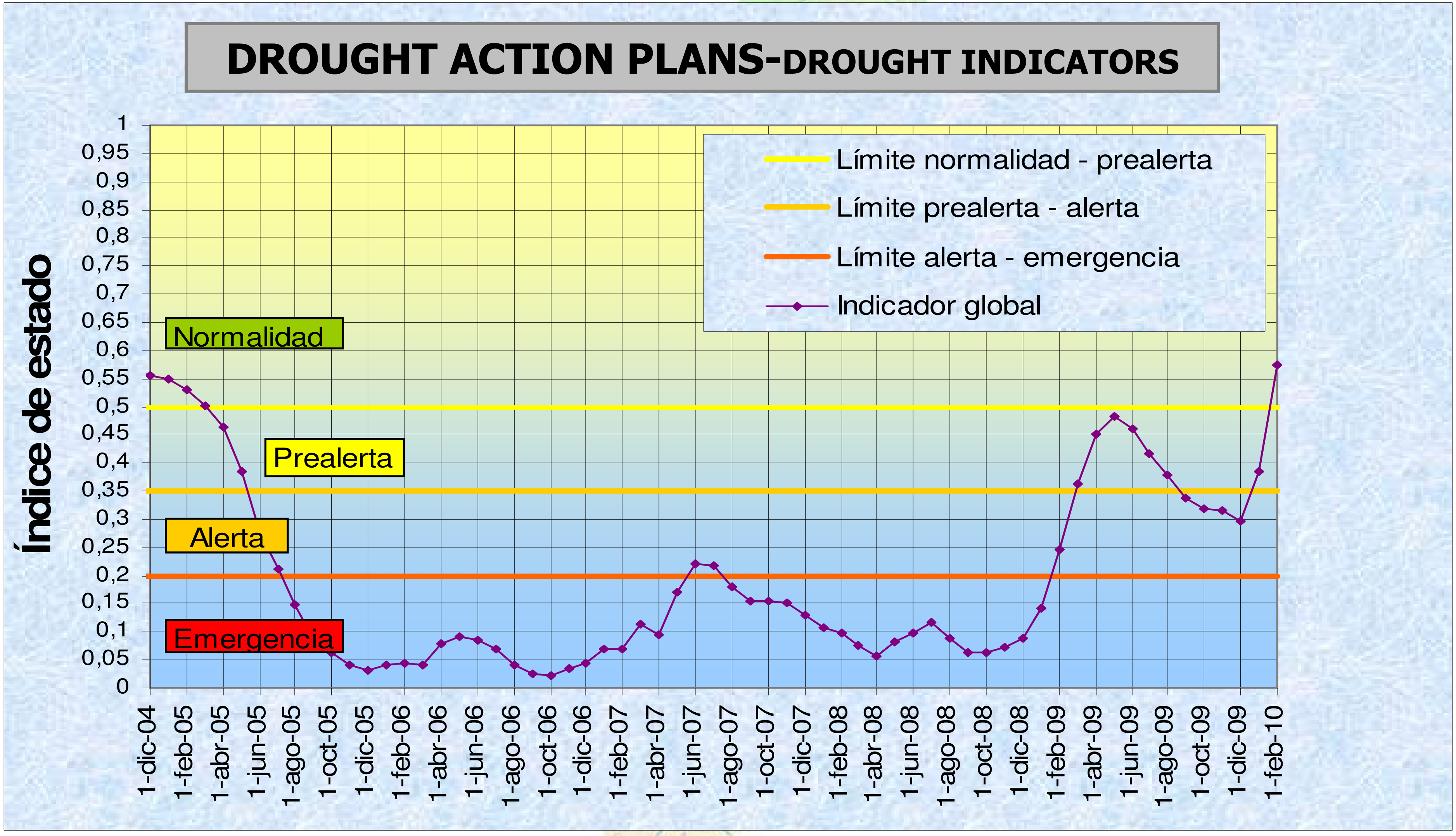
DROUGHT ACTION PLANS-DROUGHT INDICATORS

- Drought severity is classified in three levels, according to the Drought Action Plan. These are Pre-alert, Alert and Emergency.
- The definition of the threshold values is established in order to define which measures and action have to be taken in each drought severity level.
- Threshold values will correspond to State index values after the calibration had been carried out.

Indicators are needed in order to:

- Drought prevention.
- Gradual analysis of first drought stages.
- Activation of measures according to the drought severity level.
- Create an uniform background dealing with drought management with the aim of having a rational management, in particular with help instruments.

2. Indicators Used: **2.2 Drought definition**



El valor del índice de estado en el Sistema Global para el 01 de Febrero de 2010 es **0,573**, situación de **Normalidad**

(Calculado según la metodología descrita en el "Plan Especial Ante Situaciones de Sequía" aprobado el día 21 de marzo de 2007 BOE 23/03/07)

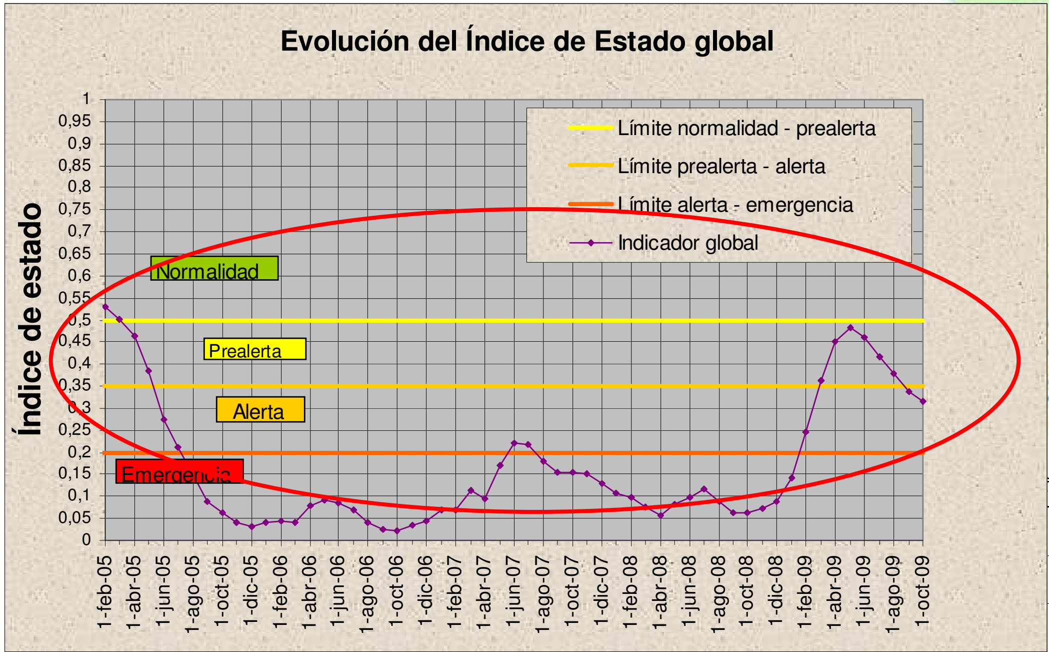
DROUGHT MANAGEMENT IN SPAIN: LEGAL BACKGROUND

DROUGHT ACTION PLANS-MEASURES

Several types of measures have been defined:

- **Forecast, administrative and management measures.**
- **Operative measures, such as:**
  - **Measures to provide additional water resources (*measures to increase resources*).**
  - **Measures to reduce demands significantly (*measures aimed to manage the demands*).**
- **Monitoring and recovery measures**

2. Indicators Used: **2.3 Last Drought (2005-2010)- Characterization**



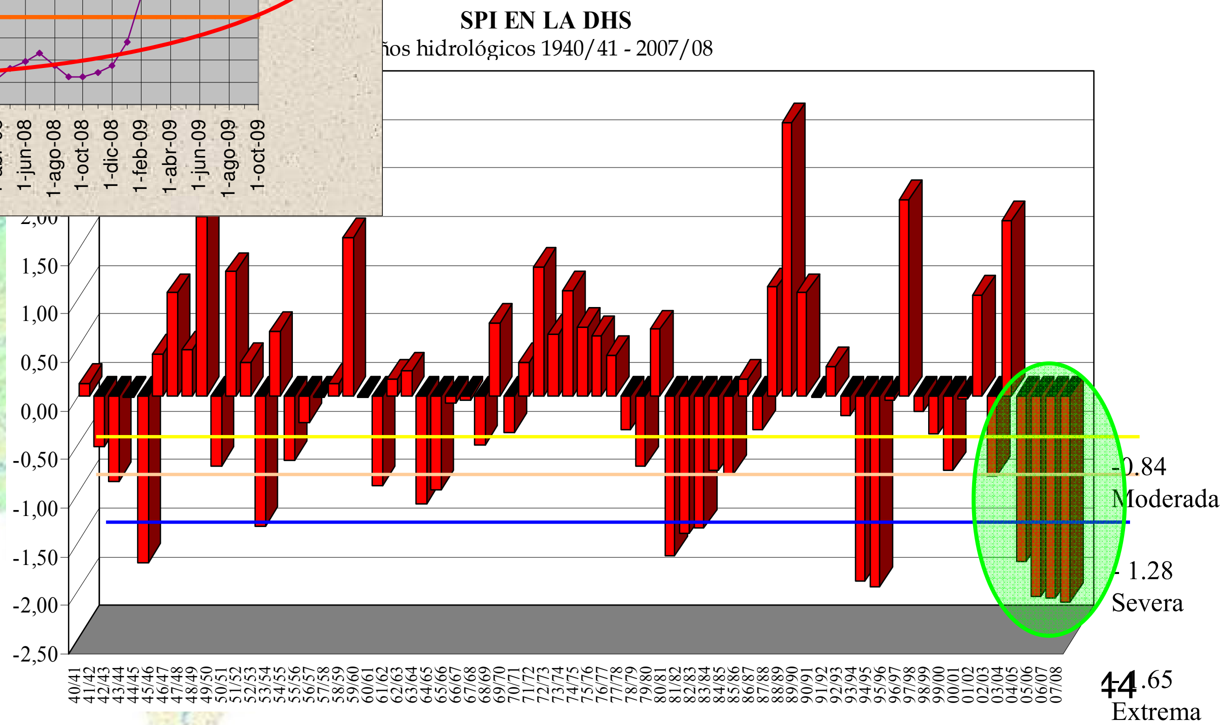
Drought 2005-2010

Severe hydrological and meteorological drought. It is clearly shown by indicators.

Year 2007-2008

Water resources: 127,44 hm^3

(It is the minimum value of the water resources time series, in 78 years. Water resources were only the 57.25% of the water resources short time series average,).



2. Indicators Used: **2.3 Last Drought (2005-2010)- Measures**

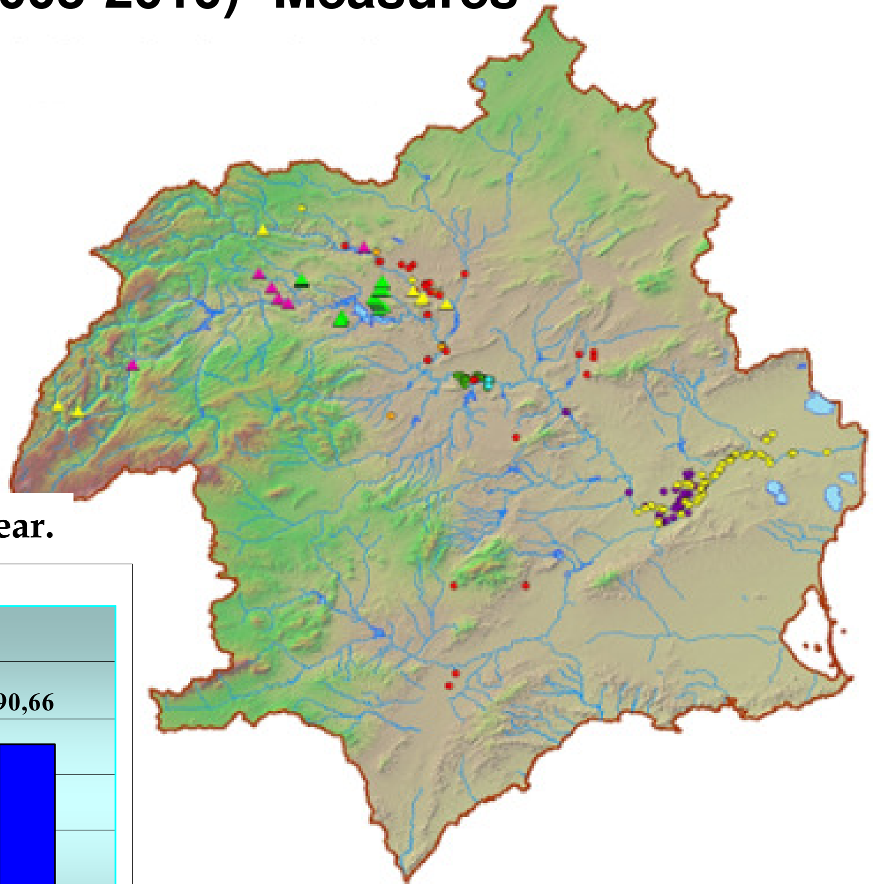
Several measures, according to Drought Action Plan, were taken:

- Weekly monitoring System
- New desalination plants were constructed
- Operation of the Well Strategic Network
- Restrictions to irrigation supply, up to 50%
- Use of the deeper water of reservoirs (increasing controls over water intended for human consumption)
- Improving installations and networks to reduce water losses.
- Emergency investments in new infrastructures to increase water resources or to improve demand management.
- Economic measures to compensate farmers for water supply restrictions.
- Modernization of irrigation systems
- Administrative measures, including a drought decree to improve water resource management

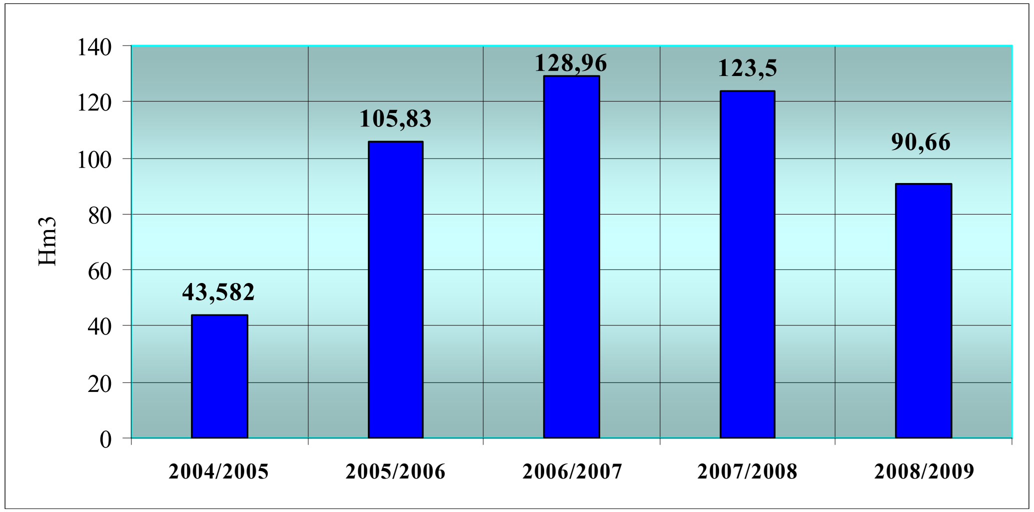
Aimed at minimizing the drought effects, existing in the Segura River Basin from 2005, one of the main measures adopted for increasing the basin resources is the execution of emergency public works such as **Well Strategic Network** (BES). The BES is managed by CHS.

2. Indicators Used: **2.3 Last Drought (2005-2010)- Measures**

Well Strategic Network



Abstracted volume at the end of the Hydrological year.



Total Volume (2004/09) = 492,44 Hm^3

2. Indicators Used: **2.3 Last Drought (2005-2010)- Measures**

In addition to the well Strategic Network, other measures to increase water resources have been taken, such as emergency investments in desalination plants and investment in sewage treatment plants.

DESALINATION PLANTS and SEWAGE TREATMENT PLANTS are measures which not only have increased water resources during the last drought period, but also will help tackle water scarcity as a general purpose.

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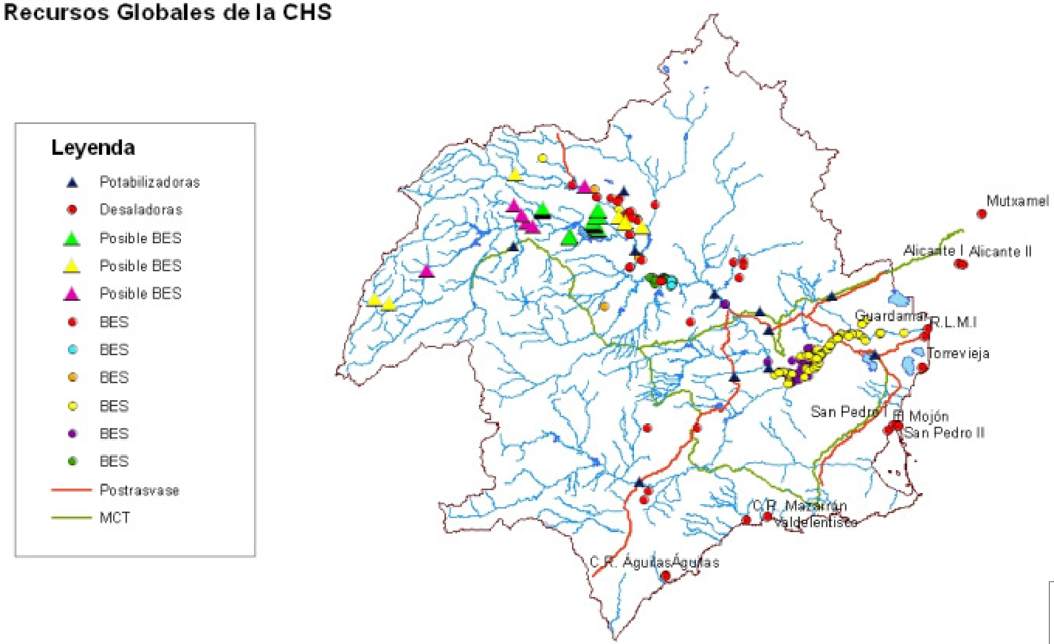
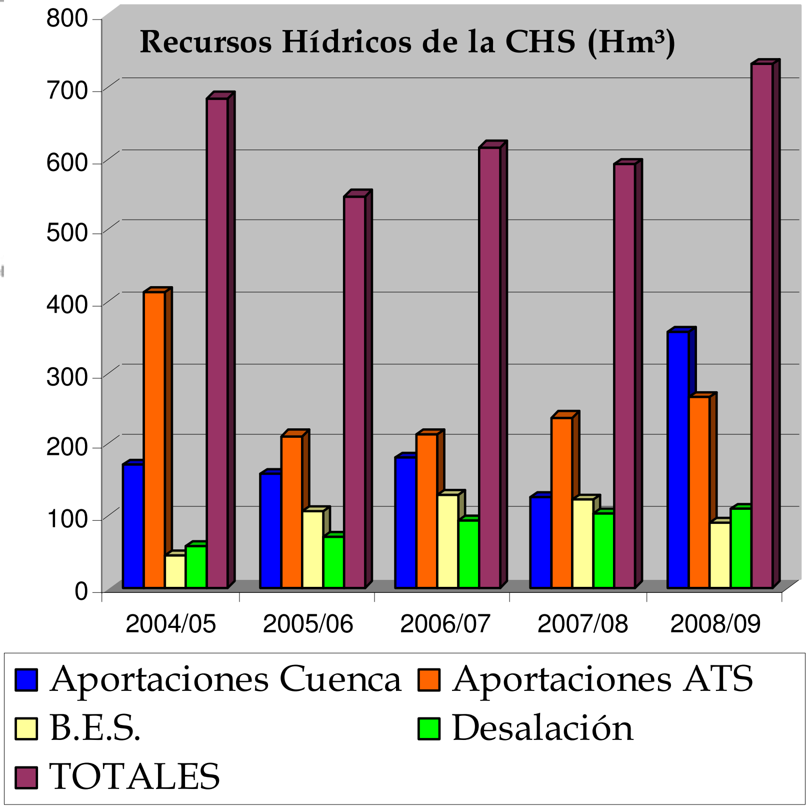
2. Indicators Used: **2.3 Last Drought (2005-2010)- Measures**

Recursos Globales de la CHS

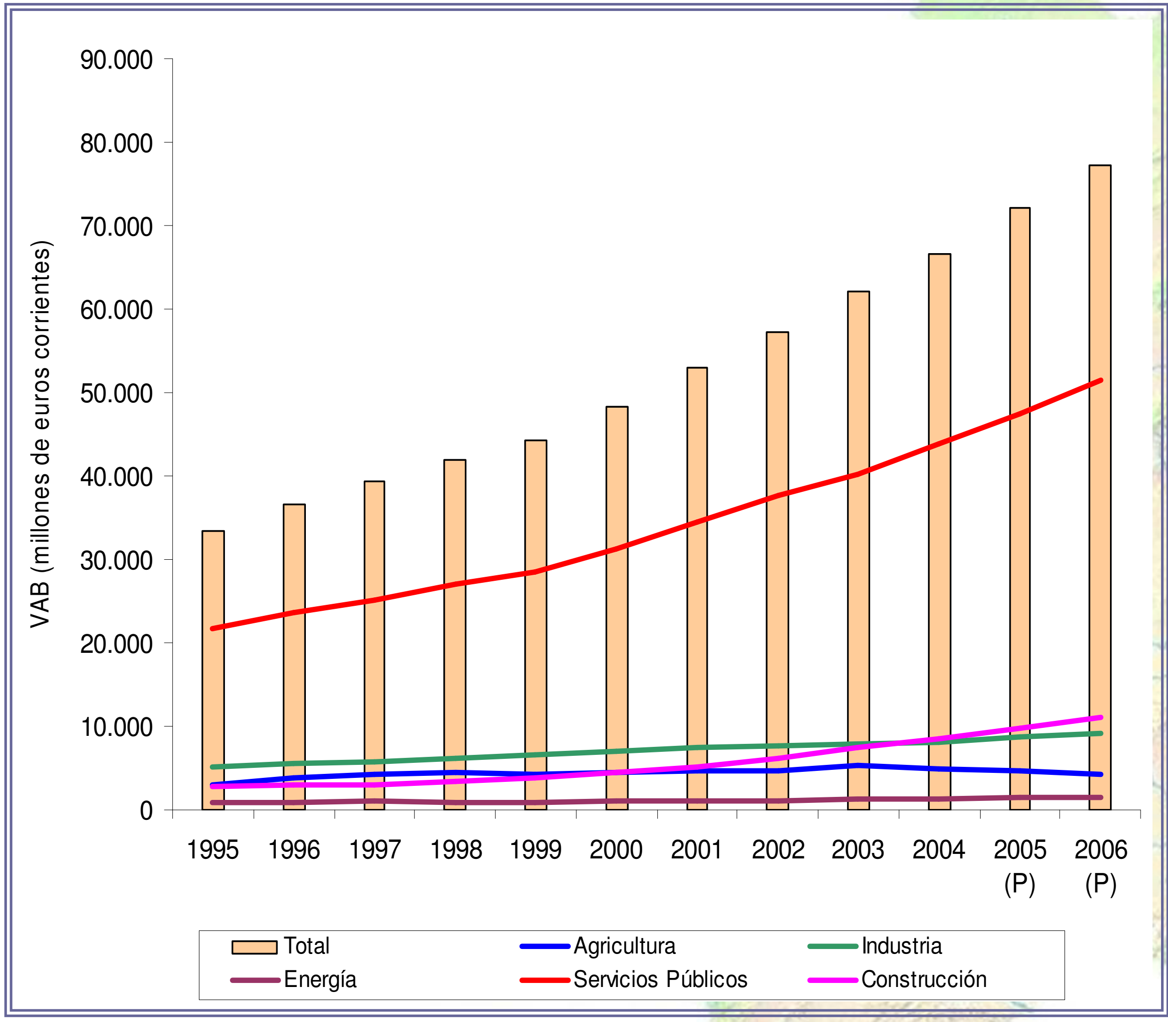




WATER RESOURCES IN CHS (Hm³)

Hydrological year	Natural water resources	Water Transfers	B.E.S.	Desalination	**TOTAL**
2004/05	171,628	414,001	43,582	56,6	685,811
2005/06	159,144	212,753	105,83	71	548,727
2006/07	181,008	213,786	128,96	93	616,754
2007/08	126,917	238,273	123,5	104,1	592,85
2008/09	357,124	265,594	90,66	110,2	823,578

2. Indicators Used: **2.3 Last Drought (2005-2010)- Consequences**



VAB evolution in CHS, by sectors

NO CONSTRAINTS (increasing the offer of resources and management of demands) granting:

1. **Domestic water supply**
2. **Urban water supply**
   - Services
   - Industry
3. **Decrease of environmental impacts**
4. **Agriculture. Decrease of socio-economic impacts**

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2. Indicators Used: **2.3 Last Drought (2005-2010)- Consequences**

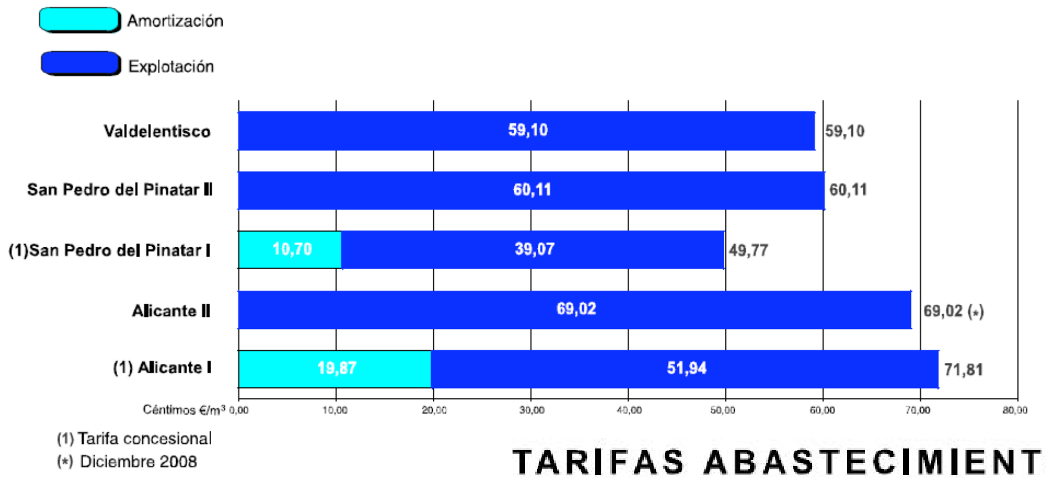
		MEDIA PERIODO SIN SEQUÍA (1990-92)	MEDIA PERIODO CON SEQUÍA (1993-94)	Δ (%)	MEDIA PERIODO SIN SEQUÍA (2002-2004)	MEDIA PERIODO CON SEQUÍA (2005-2006)	Δ (%)
SECANO	SUPERFICIE (Ha)	189.334	176.052	-7,0%	177.557	173.689	-2,2%
	RENDIMIENTO PRODUCTIVO (T/Ha) (*)	1,28	1,23	-3,9%	0,80	0,63	-21,6%
	PRODUCCIÓN (T)	242.935	217.042	-10,7%	141.997	108.867	-23,3%
	RENDIMIENTO ECONÓMICO (€ / Ha)	407	421	3,6%	180	146	-18,7%
	VALOR DE PRODUCCIÓN (M€ de 2002)	77,019	74,165	-3,7%	31,957	25,417	-20,5%
REGADÍO	SUPERFICIE (Ha)	156.383	141.664	-9,4%	156.494	152.821	-2,3%
	RENDIMIENTO PRODUCTIVO (T/Ha) (*)	15,97	14,84	-7,1%	17,27	16,91	-2,1%
	PRODUCCIÓN (T)	2.497.608	2.102.322	-15,8%	2.703.028	2.583.526	-4,4%
	RENDIMIENTO ECONÓMICO (€ / Ha)	5.701	5.476	-3,9%	6.959	6.154	-11,6%
	VALOR DE PRODUCCIÓN (M€ de 2002)	891,614	775,803	-13,0%	1.089	940	-13,6%
INVERNADERO	SUPERFICIE (Ha)	3.691	4.325	17,2%	6.455	5.985	-7,3%
	RENDIMIENTO PRODUCTIVO (T/Ha) (*)	157,47	144,48	-8,3%	140,26	135,10	-3,7%
	PRODUCCIÓN (T)	581.285	624.790	7,5%	905.438	808.579	-10,7%
	RENDIMIENTO ECONÓMICO (€ / Ha)	59.903	55.370	-7,6%	46.977	40.877	-13,0%
	VALOR DE PRODUCCIÓN (M€ de 2002)	221,121	239,447	8,3%	303,255	244,646	-19,3%
TOTAL	SUPERFICIE (Ha)	349.409	322.040	-7,8%	340.506	332.495	-2,4%
	RENDIMIENTO PRODUCTIVO (T/Ha) (*)	9,51	9,14	-3,8%	11,01	10,53	-4,4%
	PRODUCCIÓN (T)	3.321.829	2.944.153	-11,4%	3.750.462	3.500.972	-6,7%
	RENDIMIENTO ECONÓMICO (€ / Ha)	2.264	2.530	11,7%	4.183	3.641	-13,0%
	VALOR DE PRODUCCIÓN (M€ de 2002)	791,198	814,765	3,0%	1.424,190	1.210,511	-15,0%

2. Indicators Used: **2.3 Last Drought (2005-2010)- Consequences**

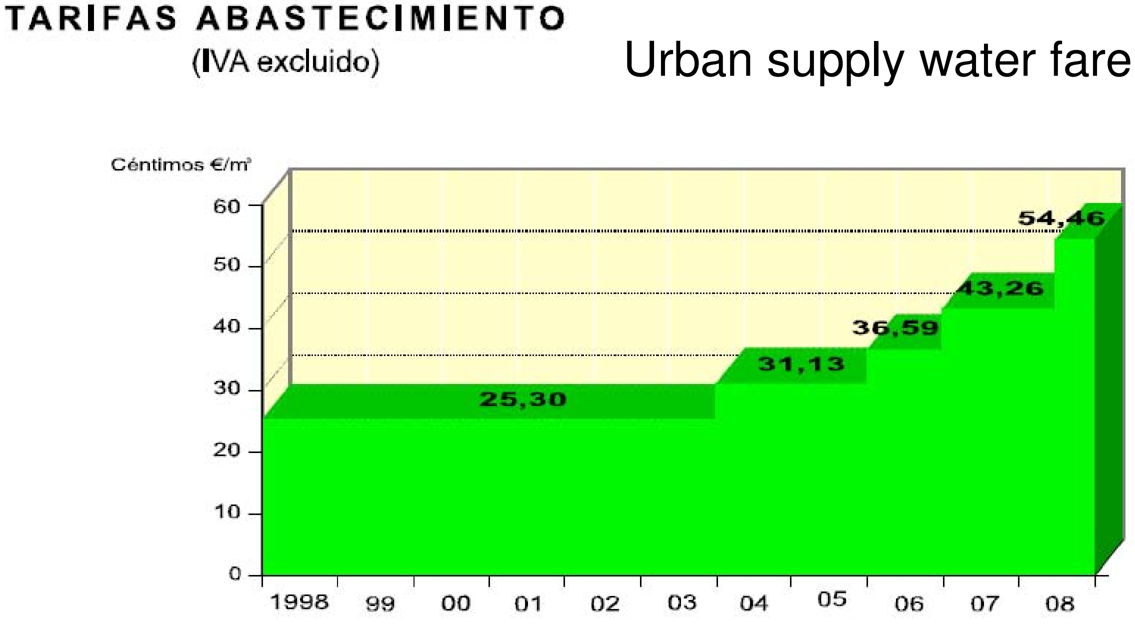
- Restrictions to irrigation supply, up to 50%.
- Increase of pressure on groundwater bodies.
- Great investment effort: **406,46 M€** from 04-05 to 08-09
- Water price (also connected with water scarcity):
  - Desalination water cost: up to 0,72 €/m3 (in 2008)
  - Urban supply water fare: 0,55 €/m3 (in 2008)
  - Abstracted water cost: up to over 0,25 €/m3

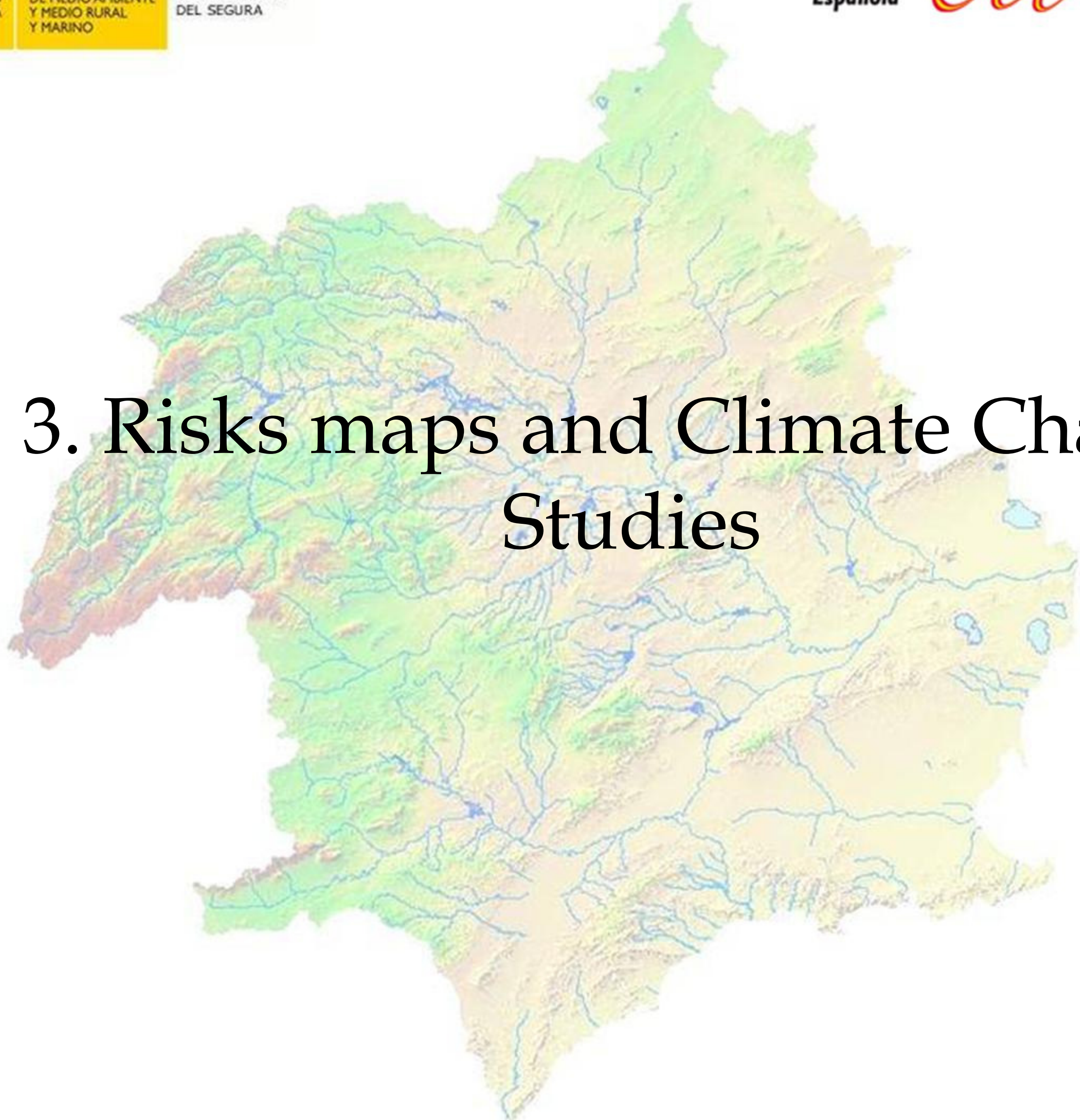
2. Indicators Used: **2.3 Last Drought (2005-2010)- Consequences**

Desalination water cost



Urban supply water fare





3. Risks maps and Climate Change Studies

3. Risk maps and climate change Studies

Adaptive capacity

- Today, one of the main aims is to develop strategies in order to build adaptive capacity for climate risks management.
- According to the Intergoverrnmental Panel on Climate Change (IPCC), "adaptive capacity" can be understood as the "ability to cope, adapt or recover from the effects of a hazard", or in this case, to climate change.
- Adaptive capacity is considered a necessary condition for designing and implementing effective adaptation strategies, and could be achieved by **increasing the knowledge** of potential climate risks **in individual river basins** (EC, 2009).

3. Risk maps and climate change Studies

Increasing the Knowledge: **Projections from ENSEMBLES European Project. RCMs** (Regional Climate Models) driven by GCM and ERA-40 Reanalyses. Scenario IE-EE **A1B**. Spatial resolution: 25km.

RT2B transient experiments 1951-2050 or 1951-2100 driven by GCM (Global Climate Models)

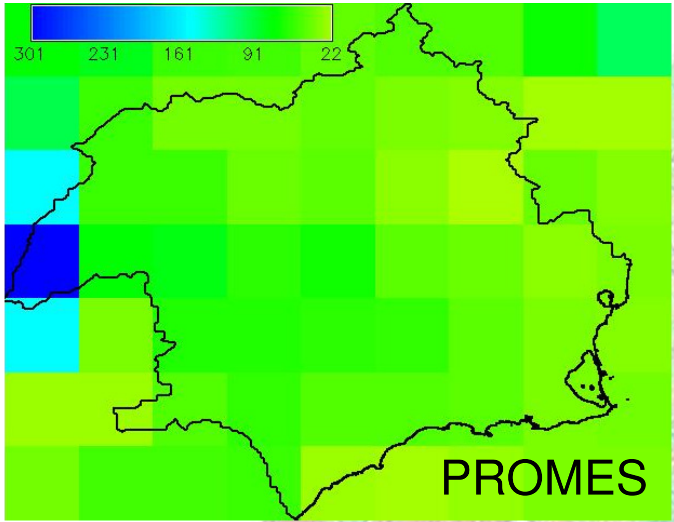
INSTITUTE	EXPERIMENT	DRIVEN BY	RCM	ACRONYM	PERIOD
C4I	RT2B	HadCM3Q16	**RAC3**	C4IRCA3	1951-2099
	RT3	HadCM3Q16		C4IRCA3	1961-2000
CNRM	RT2B	ARPEGE	**ALADIN**	CNRM-RM4.5	
CHMI	RT3	ARPEGE		CHMIALADIN	
KNMI	RT2B	ECHAM5-r3	**RACMO**	KNMI-RACMO2	
	RT3	ECHAM5-r3		KNMI-RACMO2	
OURANOS	RT2B	CGCM3	**CRCM**	OURANOSMRCC4.2.1	
	RT3	CGCM3		OURANOSMRCC4.2.3	
MPI	RT2B	ECHAM5-r3	**REMO**	MPI-M-REMO	1951-2100
	RT3	ECHAM5-r3		MPI-M-REMO	1961-2000
METNO	RT2B	HadCM3Q0	**HIRHAM**	METNOHIRHAM	
CHMI	RT3	HadCM3Q0		DMI-HIRHAM	
UCLM	RT2B	HadCM3Q0	**PROMES**	UCLM-PROMES	1951-2050
	RT3	HadCM3Q0		UCLM-PROMES	1961-2000
ETHZ	RT2B	HadCM3Q0	**CLM**	ETHZ-CLM	
	RT3	HadCM3Q0		ETHZ-CLM	
HC	RT2B	HadCM3Q0	**HadCM3Q0**	METO-HC_HadRM3Q0	
	RT3	HadCM3Q0		METO-HC_HadRM3Q0	
ICTP	RT2B	ECHAM5-r3	**RegCM**	ICTP-REGCM3	
	RT3	ECHAM5-r3		ICTP-REGCM3	
VMGO	RT2B	HadCM3Q0	**RRCM**	VMGO-RRCM	
	RT3	HadCM3Q0		VMGO-RRCM	

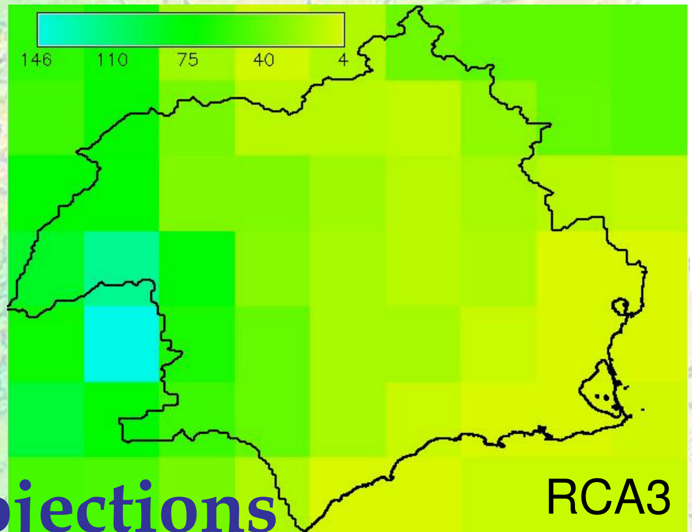
Some results presented

3. Risk maps and climate change Studies

P: Mean Annual Precipitation (mm)

DIF (mm)= $P_{\text{Control Period (1961-1990)}} - P_{\text{Projection (2021-2050)}}$



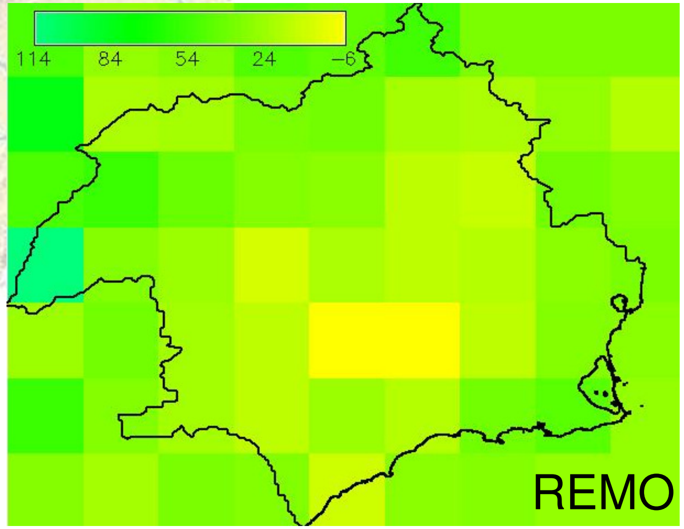


What is the future for Segura River Basin for 2050 horizon?

Important decrease in the P value on headwater basins, considering the RCMs results.

Example: RCMs projections

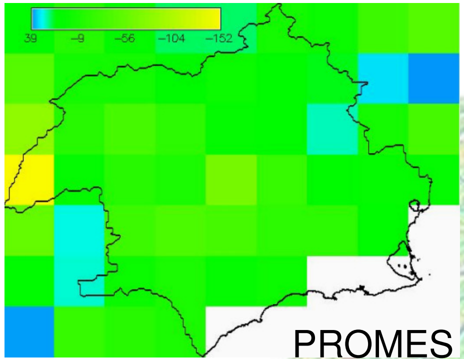
STATISTICS OF DIF	PROMES	RCA3	REMO
Min	21.5	4.3	-5.7
Max	301.1	145.5	113.7
Range	279.5	141.3	119.4
Mean	55.5	35.7	31.4
Standard Deviation	40.5	30.2	17.7
Coef. Var	72.8%	84.6%	56.6%

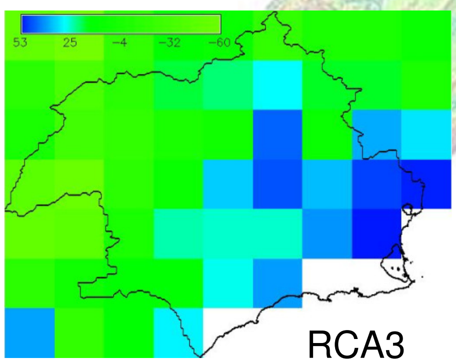


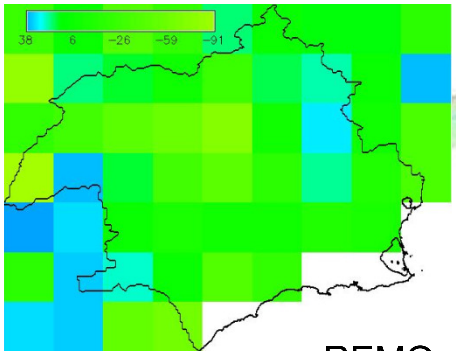
3. Risk maps and climate change Studies

DIF (%) = [(PControl Period - PModel)/ PControl Period]. 100

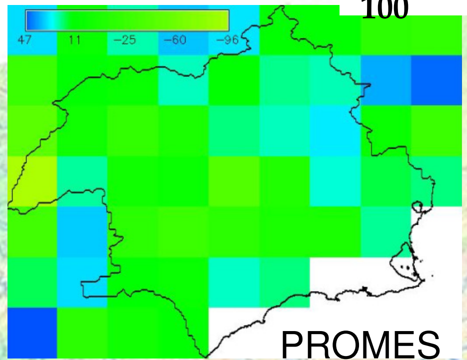
Periodo 1961-1990

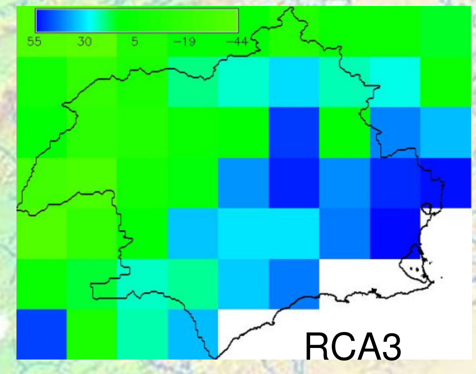


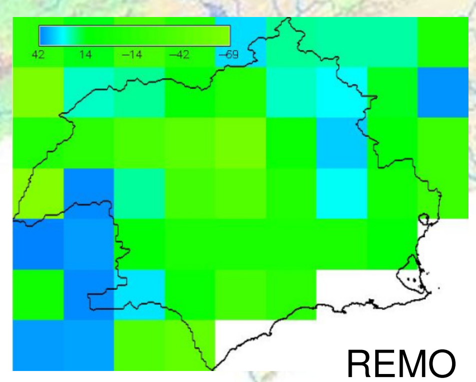




Periodo 2021-2050



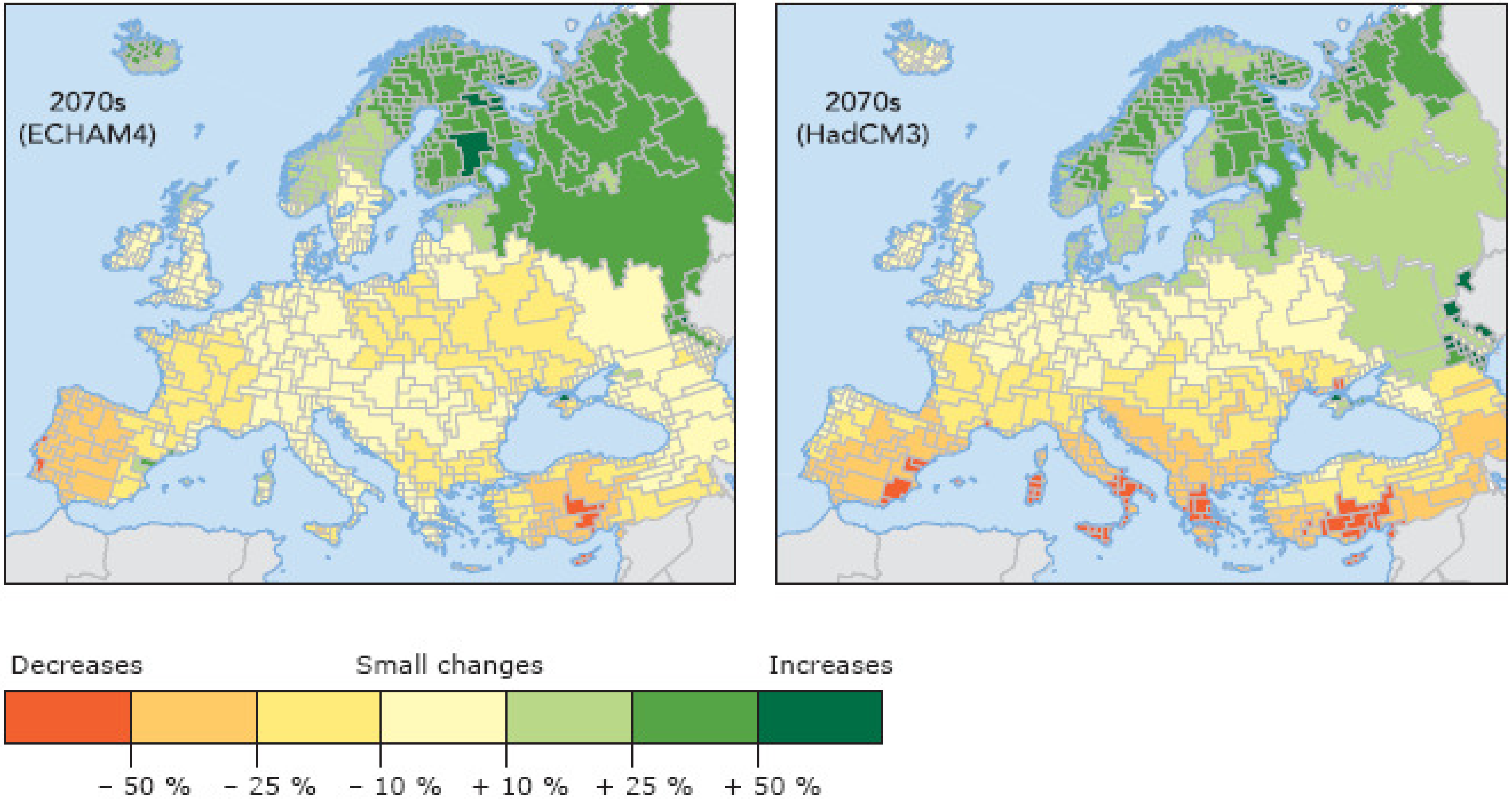




STATISTICS (mm)	1961-1990	2021-2050
RCA3		
Min	-60,1	-43,9
Max	52,9	54,6
Range	113,1	98,6
Mean	4,9	14,8
Std Dev	29,5	25,4
Variat Coef.	593,10%	171,70%
PROMES		
Min	-151,5	-95,5
Max	38,9	46,5
Range	190,4	142,1
Mean	-9,1	6,2
Std Dev	32,2	25,5
Variat Coef.	-355,82%	411,1
REMO		
Min	-90,5	-69,4
Max	37,7	42,1
Range	128,3	111,4
Mean	-7,3	0,1
Std Dev	32,1	29,5
Variat Coef.	-434,23%	3216,32%

3. Risk maps and climate change Studies

RIVER WATER FLOW



Note: Note that larger changes in seasonal averages are expected in some regions.

Source: Lehner *et al.*, 2001; EEA, 2004.

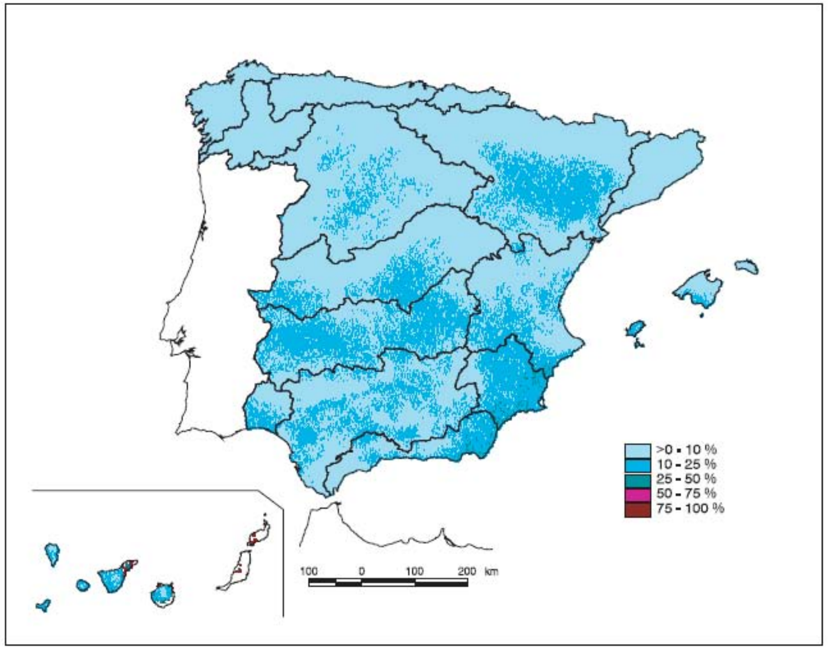
3. Risk maps and climate change Studies

FUTURE CLIMATE SCENARIO IN SPAIN

Runoff reduction, in %, in 2030 with respect to 2000

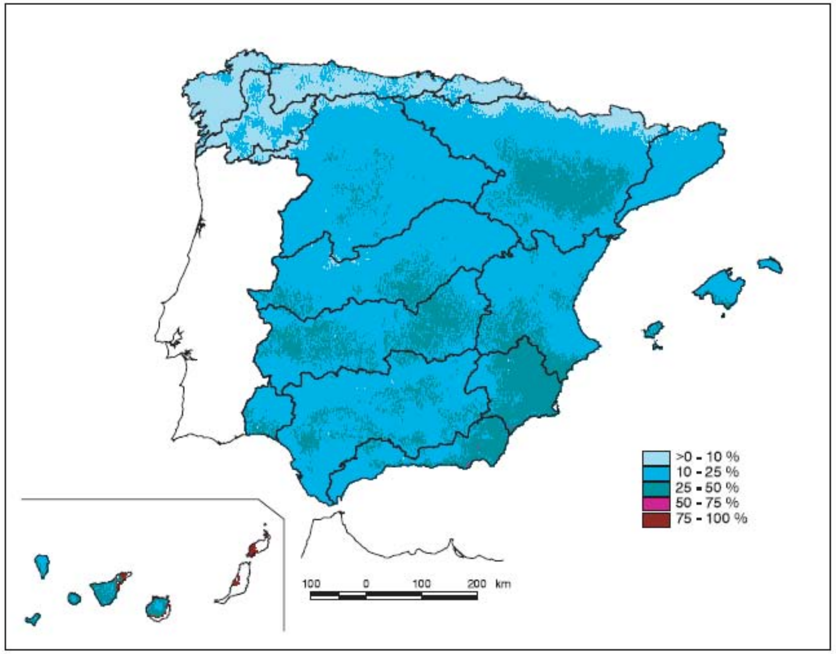
Scenario 1

(Temperature increase in 1ºC)



Scenario 2

(Temperature increase in 1ºC and 5% decrease of annual average precipitation)



3. Risk maps and climate change Studies

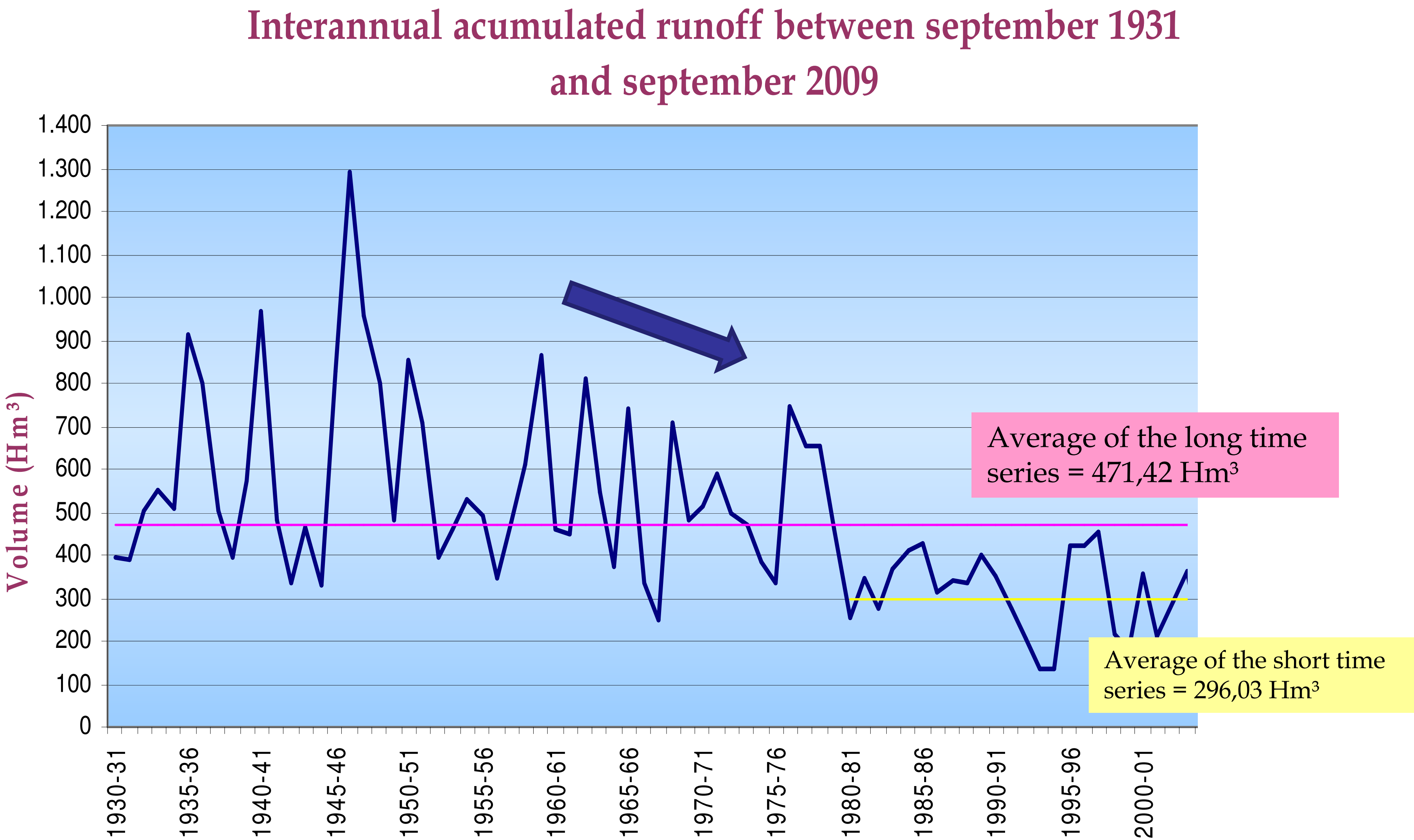
Runoff reduction, in %, for each Spanish river basin, in each of considered climate scenarios.

Ámbito	Escenario 1	Escenario 2
Norte I	-3	-10
Norte II	-2	-10
Norte III	-2	-9
Duero	-6	-16
Tajo	-7	-17
Guadiana I	-11	-24
Guadiana II	-8	-19
Guadalquivir	-8	-20
Sur	-7	-18
Segura	-11	-22
Júcar	-9	-20
Ebro	-5	-15
C.I. Cataluña	-5	-15
Galicia Costa	-2	-9
Baleares	-7	-18
Canarias	-10	-25
España	-5	-14

Fuente: Libro blanco del agua (2000)

According with Spanish water management guidelines, natural resources of the Segura River Basin will be reduced in 11%, in 2027, as long as no further studies had been carried out,

3. Risk maps and climate change Studies



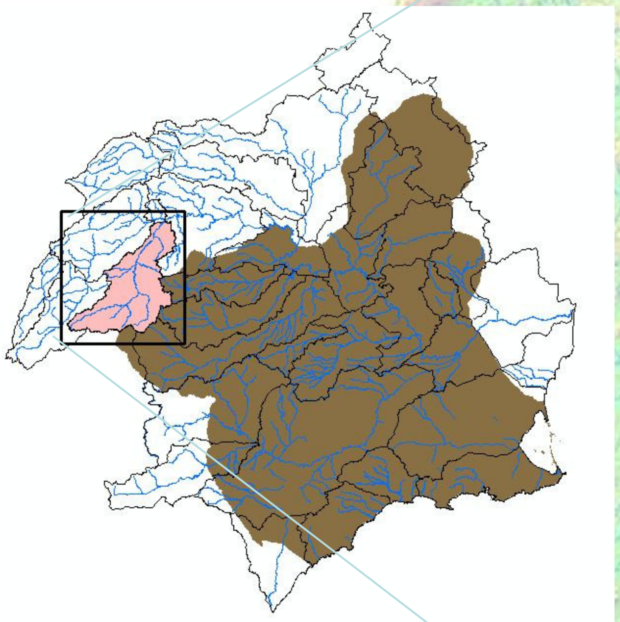
Possible causes in the runoff decrease

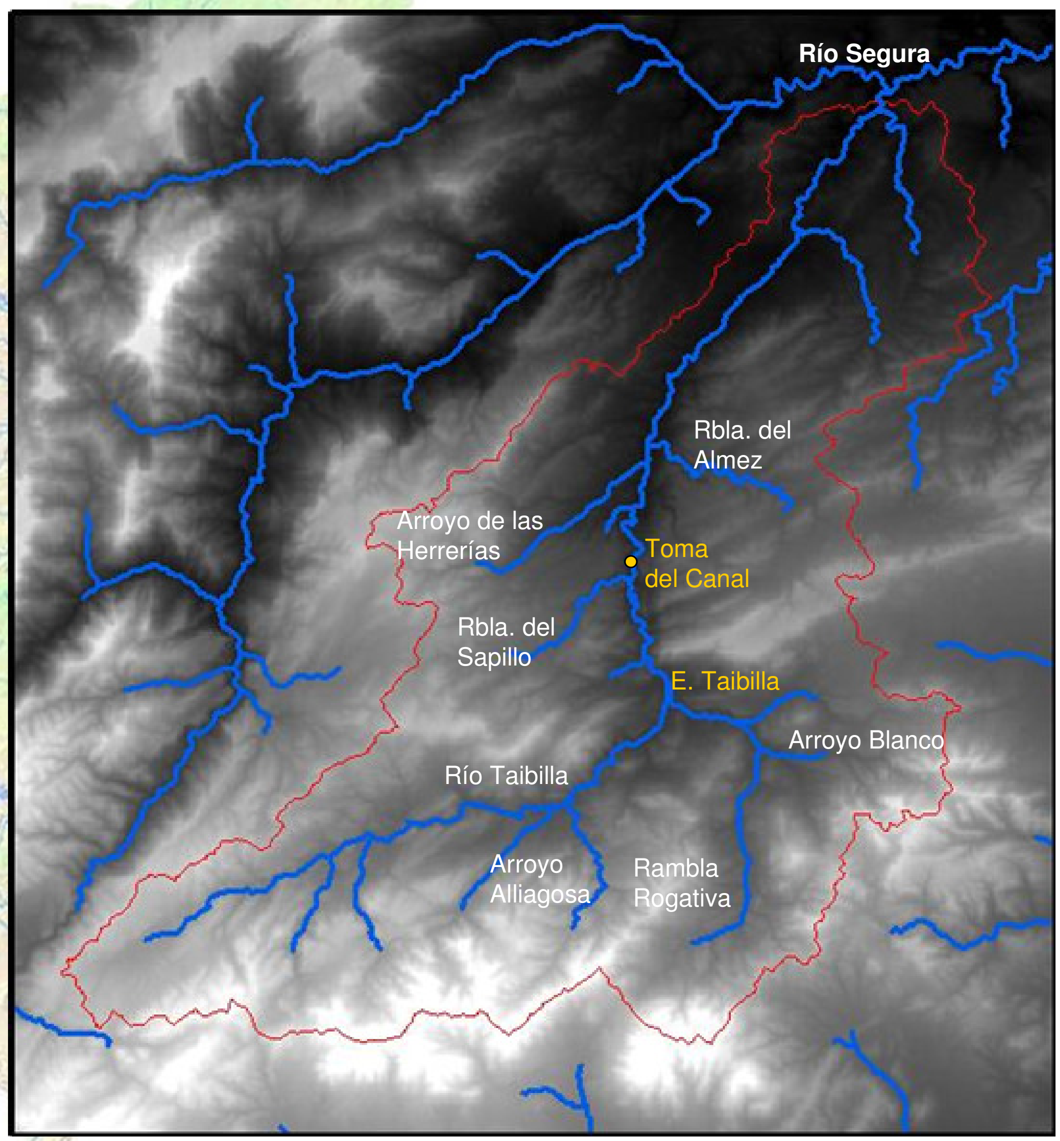
- Climate variability and change (rainfall, temperature, wind, relative humidity, radiation …) and theirs effects in the evaporation, evapotranspiration, and finally in the water balance in the basin.
- Drought events and its impacts in the water cycle (soil moisture, aquifers recharge, groundwater, and surface water).
- Changing in land use (refforestation, abandon of agricultural activities …)

In the vulnerability studies to droughts and water scarcity at regional level, the future scenarios of climate change must be considered for the basin.

3. Risk maps and climate change Studies

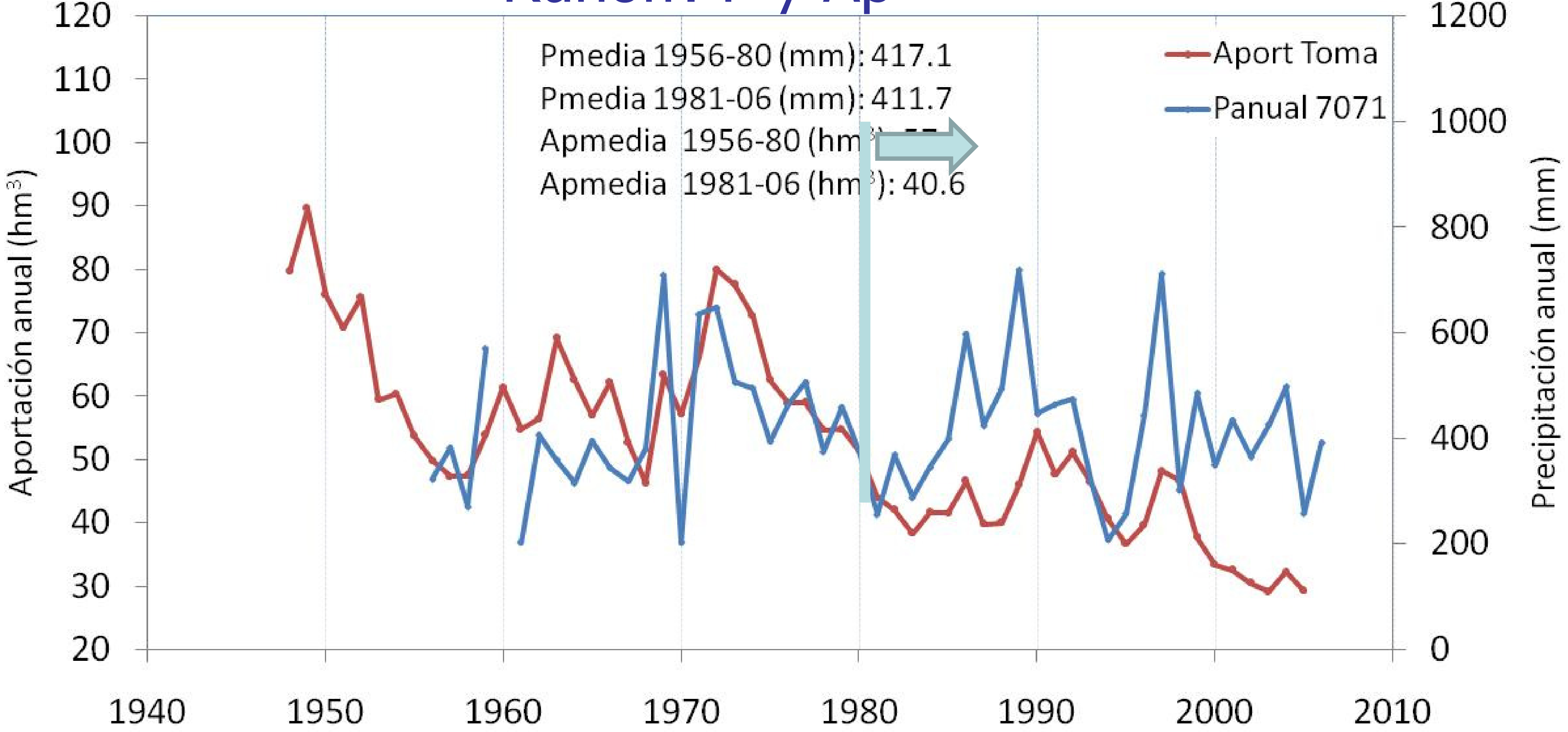
Case of study: Taibilla River basin





3. Risk maps and climate change Studies

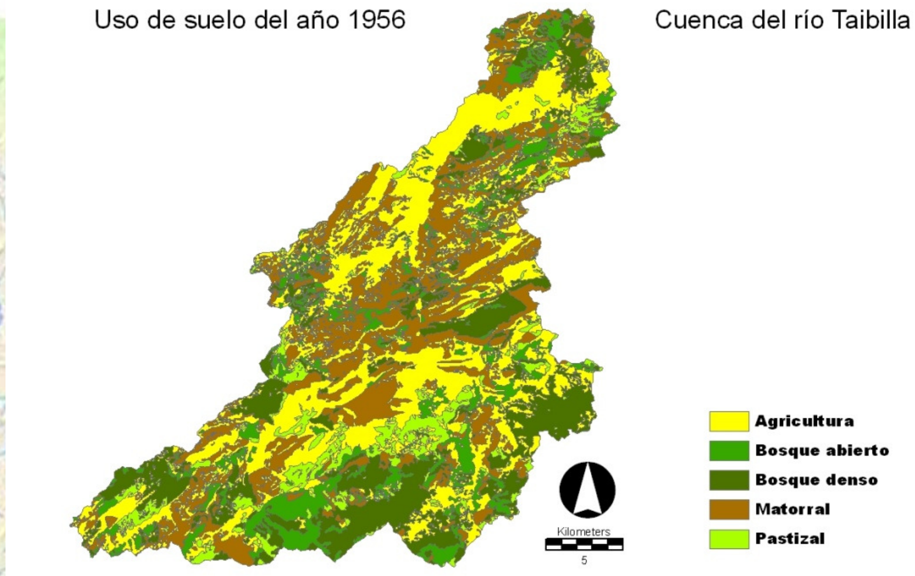
Analysis of time patterns of Precipitation and Runoff: P y Ap

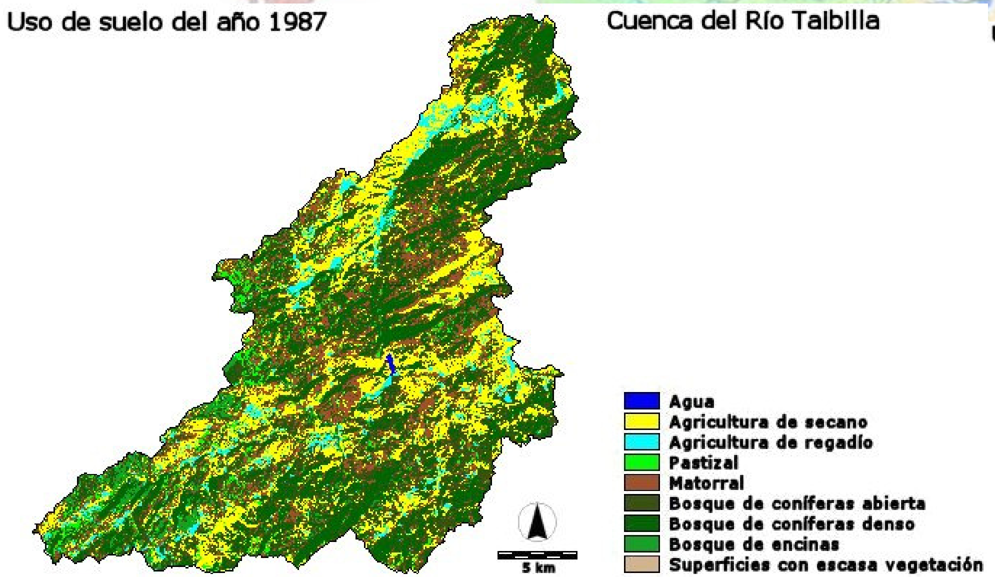


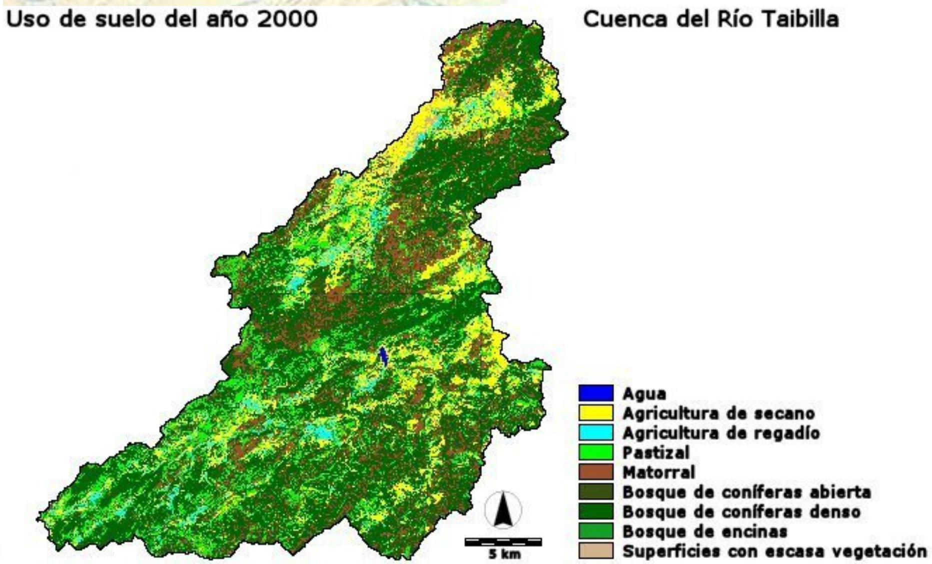
The time series do not present the same time pattern. From '80 decade, the runoff is not a simple response to the rainfall. There is a "desacoupling."

3. Risk maps and climate change Studies

Land use change: Scenarios 1956, 1987 y 2000

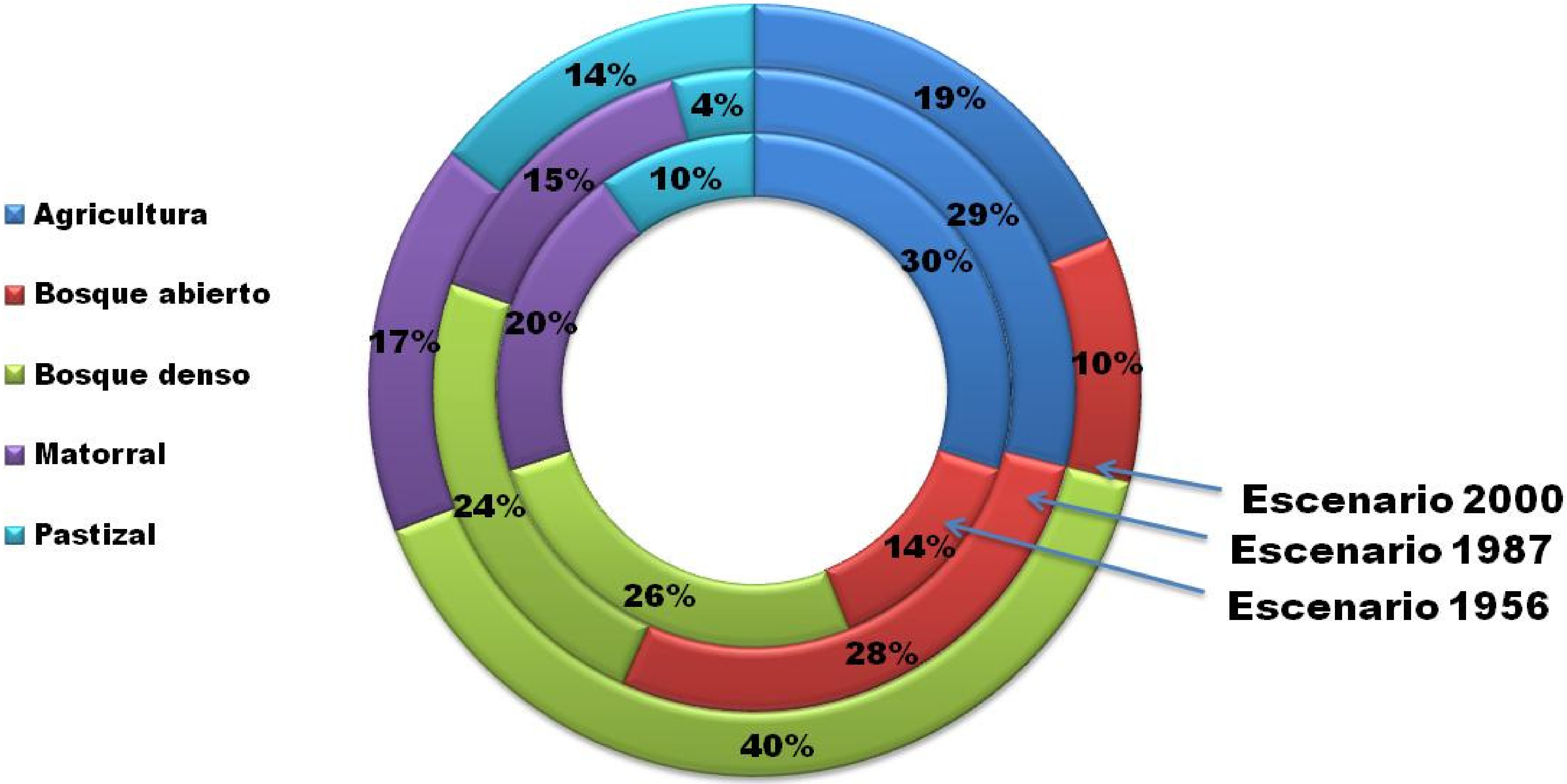






3. Risk maps and climate change Studies

Land use change: Scenarios 1956, 1987 y 2000



-Noticeable variations in the land uses of the basin. Possible causes: abandon of rural areas, with irrigation areas abandoned which are occupied by vegetation.

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FUTURE CLIMATE SCENARIO IN EUROPE

Climate variable	Observed change	Projected change (without mitigation)	References
Temperature	Global: increase 0.76 °C in last 100 years 1990s warmest decade for 150 years; 1998 and 2005 warmer than any individual year since 1850 Europe: increase 1.1 °C, winters increase more than summer, largest increase over Iberian Peninsula, south-east Europe and Baltic States	Global: best estimated increase 1.8–4.0 °C during this century (range 1.1–6.4 °C) Europe: mean increase 2.1–4.4 °C by 2080 (range 2.0–6.2 °C) with larger increases in eastern and southern Europe.	IPCCa,b, 2007; EEA, 2006; Schröter, 2005.
Precipitation	Global: trends highly variable in space and time have been observed during the last century Northern Europe: 10–40 % more precipitation South and east Europe: 20 % less precipitation	Northern Europe: annual precipitation increase 1–2 % per decade. Decrease in summer precipitation Southern Europe: Overall decrease in annual precipitation. 5 % decrease in summers.	IPCCa,b, 2007; JRC, 2005; Klein Tank *et al.*, 2002.
Extremes	Temperature extremes are more intense and more frequent than some decades ago Globally, more intense and longer dry periods Significantly more wet days in mid and northern Europe, fewer wet days in southern Europe More heavy rain events in most parts of Europe, strongly linked to the North Atlantic Oscillation Increasing trend in consecutive dry days	Heat waves are expected to increase in frequency and severity in a warmer world More frequent extreme precipitation events in entire Europe. Northern Europe: more frequent summer droughts, despite more intense precipitation events during these periods. Southern Europe: more droughts in all seasons.	Klein Tank, 2004; Meehl and Tebaldi; 2004, Moberg and Jones, 2005; Stott *et al.*, 2004. Alexander *et al.*, 2006; Frei *et al.*, 2006; Haylock and Goodess, 2004.
Sea level	Sea levels rose by 0.17 m during 20th century 1.8 mm year^{-1} 1961–2003 3.3 mm year^{-1} 1993–2003	0.2–0.6 m by 2100. Increased Greenland-Antartic melt may add 0.1–0.2 m to this Larger values can not be excluded (due to factors not yet sufficiently understood)	IPCCa,b, 2007.

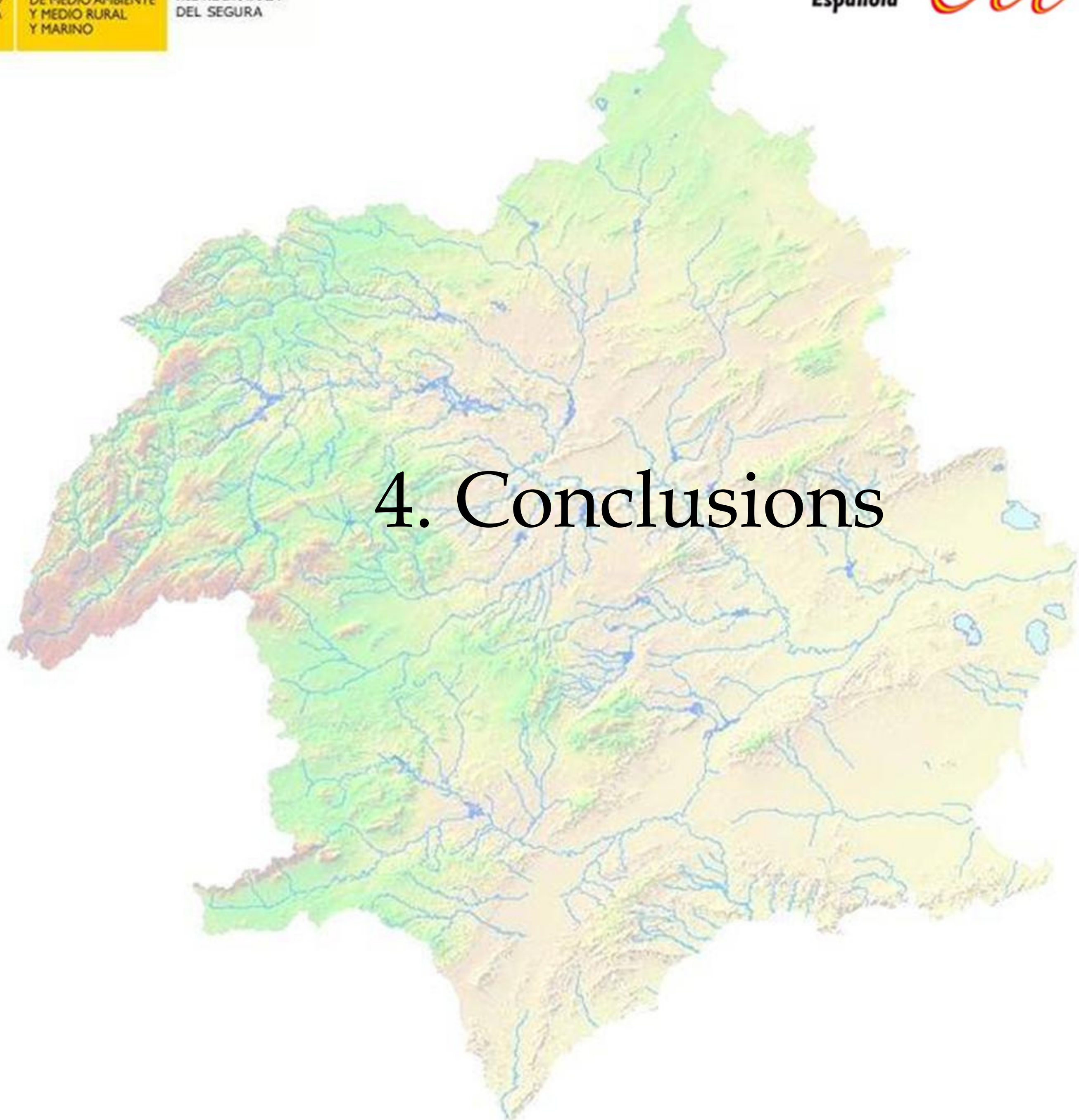
3. Risk maps and climate change Studies

Building risk drought maps

Risk maps of droughts, briefly, involve:

1. spatial variation of the statistical characteristics of the extreme dry events, such as the annual maximum dry spell length (AMDSL), and
2. vulnerability studies related to demands and capacity to give supply: - urban demand (related with population), - agricultural demand (perspective of increase of irrigation areas), …

4. Conclusions



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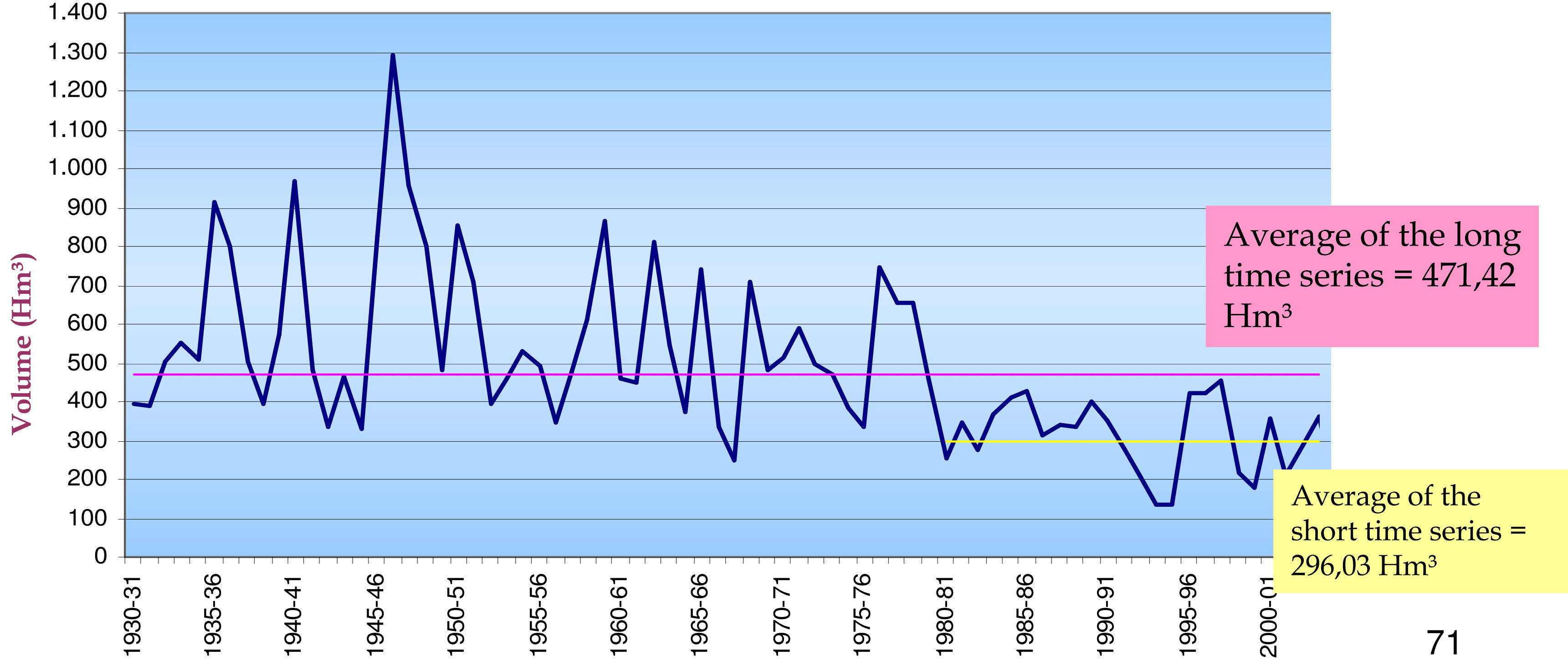
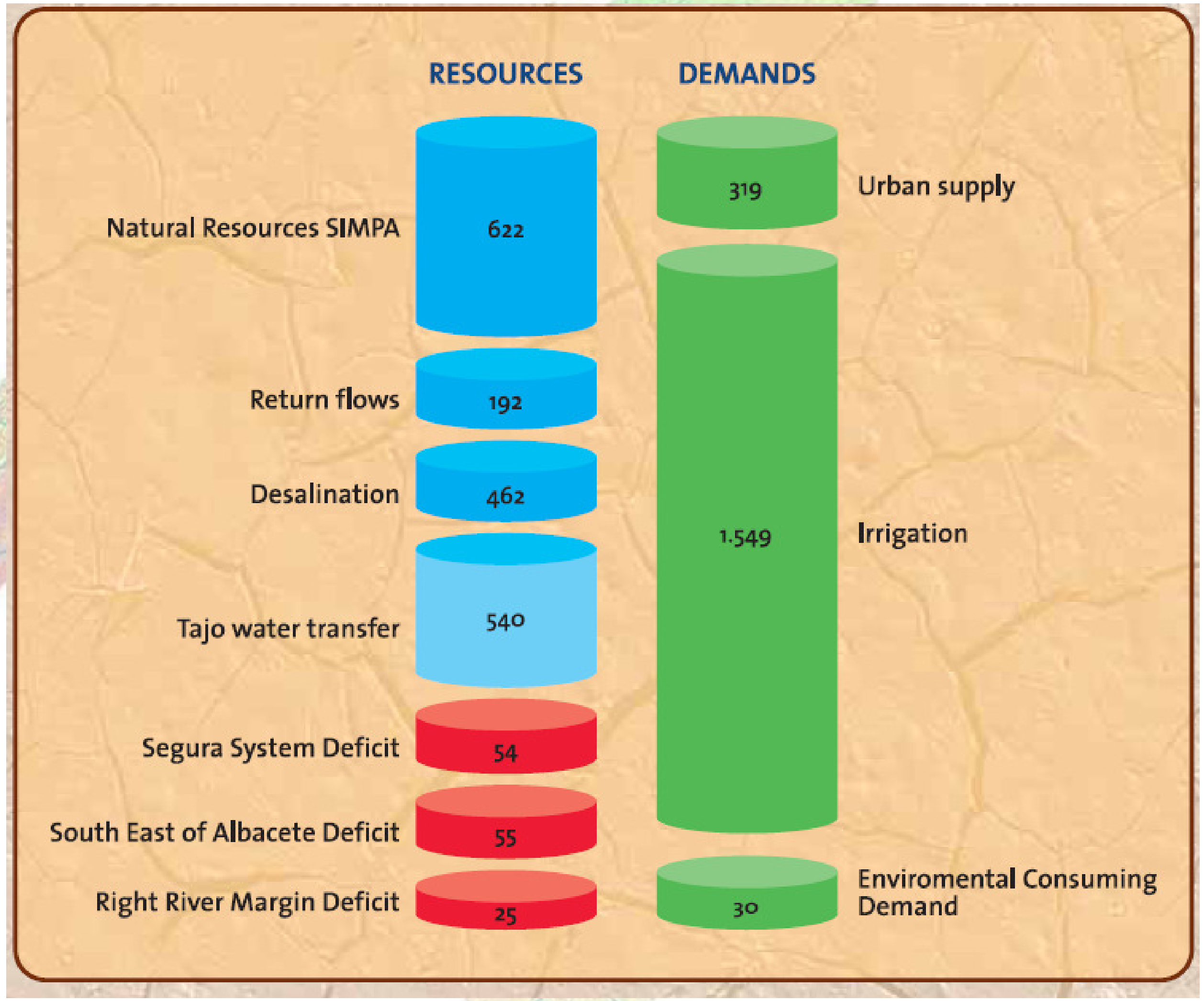
4. Conclusions: water scarcity

Segura River Basin (S.R.B.)	442 m³/inhab/year
SPAIN	2.460 m³/inhab/year

Interannual acumulated runoff between september 1931 and september 2009

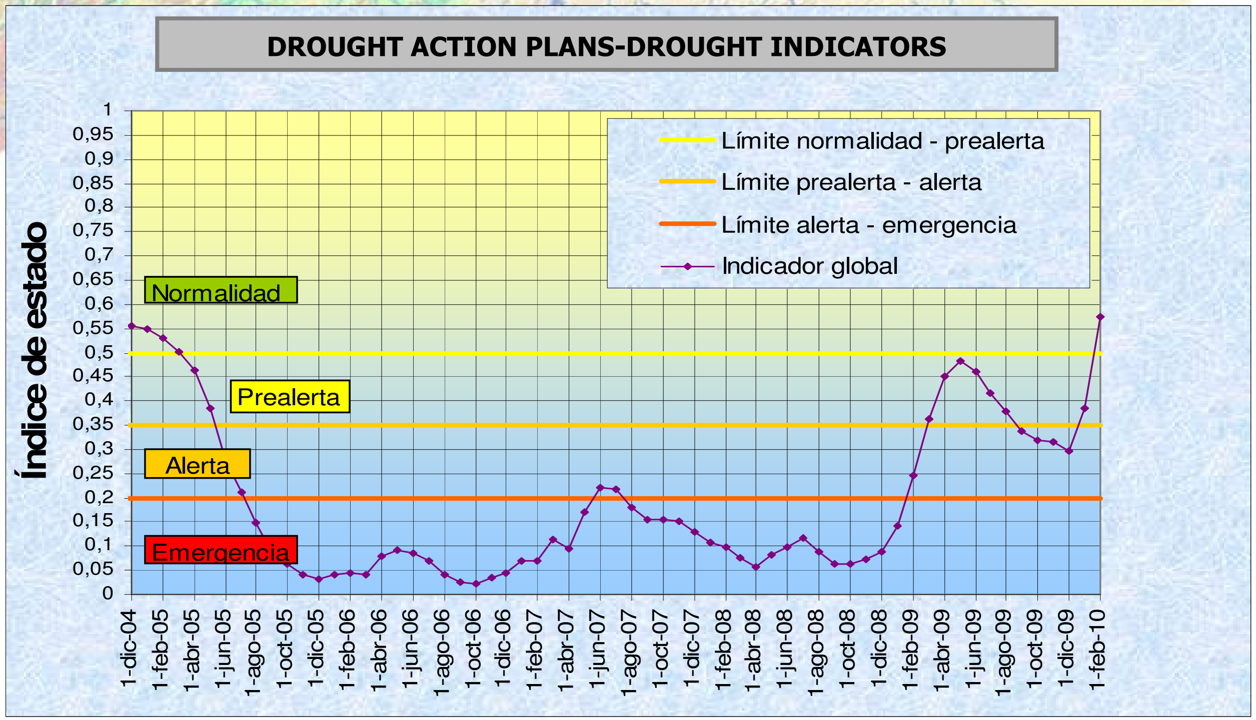


4. Conclusions: Balance



4. Conclusions: drought management

- New desalination plants were constructed
- Operation of the Well Strategic Network
- Restrictions to irrigation supply, up to 50%
- Emergency investments in new infrastructures to increase water resources or to improve demand management
- Modernization of irrigation systems



4. Conclusions: drought consequences

- Restrictions to irrigation supply, up to 50%.
- Increase of pressure on groundwater bodies.
- Great investment effort: **406,46 M€** from 04-05 to 08-09
- Water price (also connected with water scarcity):
  - Desalination water cost: up to 0,72 €/m3 (in 2008)
  - Urban supply water fare: 0,55 €/m3 (in 2008)
  - Abstracted water cost: up to over 0,25 €/m3

4. Conclusions: Climate Change

According with Spanish water management guidelines, natural resources of the Segura River Basin will be reduced in 11%, in 2027, as long as no further studies had been carried out,

Ámbito	Escenario 1	Escenario 2
Norte I	-3	-10
Norte II	-2	-10
Norte III	-2	-9
Duero	-6	-16
Tajo	-7	-17
Guadiana I	-11	-24
Guadiana II	-8	-19
Guadalquivir	-8	-20
Sur	-7	-18
Segura	-11	-22
Júcar	-9	-20
Ebro	-5	-15
C.I. Cataluña	-5	-15
Galicia Costa	-2	-9
Baleares	-7	-18
Canarias	-10	-25
España	-5	-14

Fuente: Libro blanco del agua (2000)

THANKS FOR YOUR ATTENTION

For further information, please visit: http://www.chsegura.es