System of Water Accounting in the Guadalquivir River Basin

UNIVERSIDAD DE CÓRDOBA. JULIO BERBEL

K.O MEETING OF THE 2013 HALTING DESERTIFICATION IN EUROPE PILOT PROJECTS

BRUSSELS 5 FEB.2014

Systems of water accounting in the Guadalquivir River Basin

- **SIWAG** No. 2013/13
- **Partners:**
  - **Universidad de Córdoba**
  - **EVREN (Evaluacion de recursos naturales)**
- **Period: 12 months 1/feb/2014 to 30/jan/2015**
- **K.O internal meeting** :
  - 27/01/2014
  - UCO/EVREN/ Confederación Hª Guadalquivir (Sevilla)
  - Agreement
    - To cooperate throught the project
    - To integrate results in Hydrological Plan (revision due for 2015)

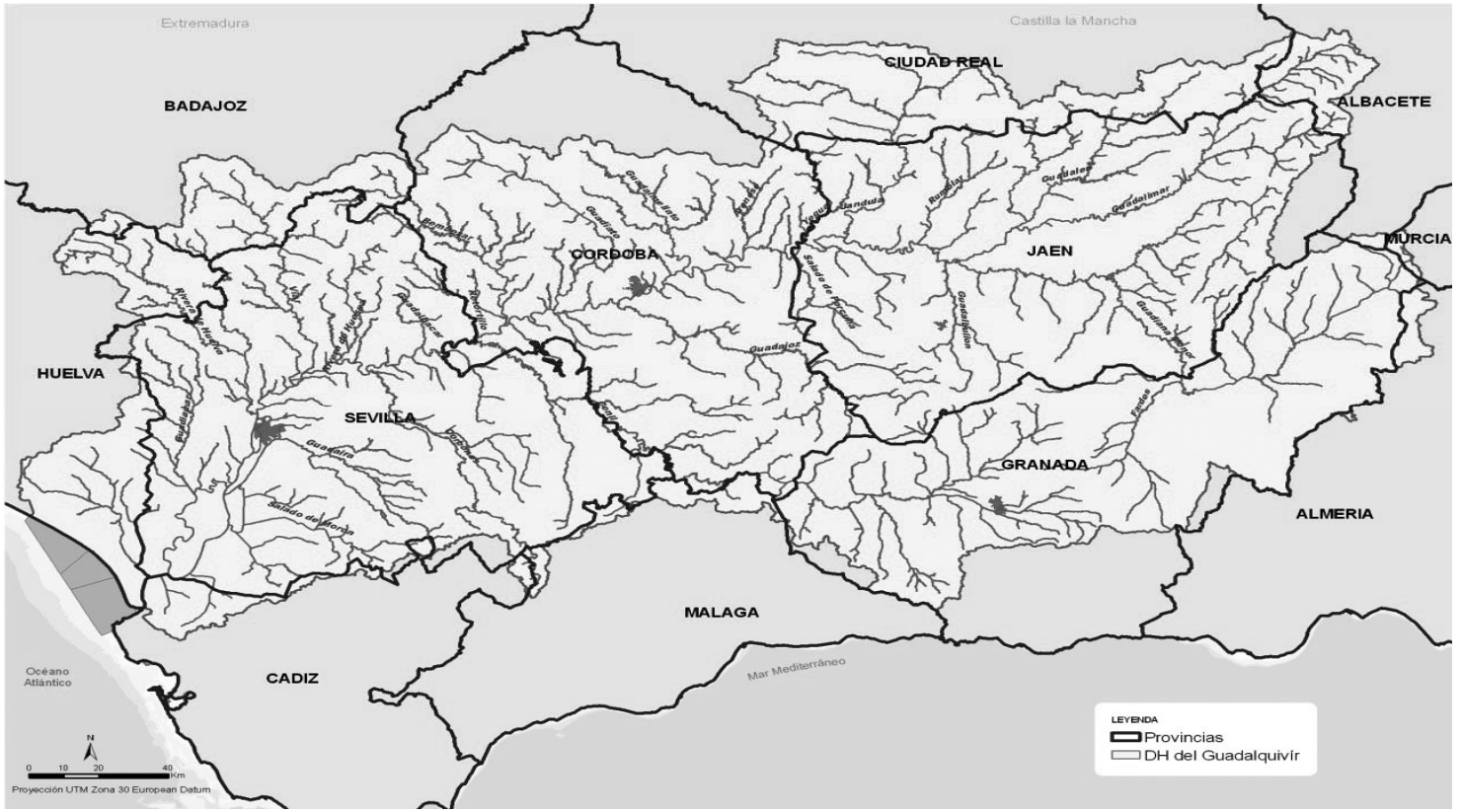
Guadalquivir: general

Area, population, economy

Est 2012	Croacia	Guadalquivir
Area (km^2)	56.542	57.527
Population	4.290.612	4.343.323
per capita GDP (eur)	13.413	16.739

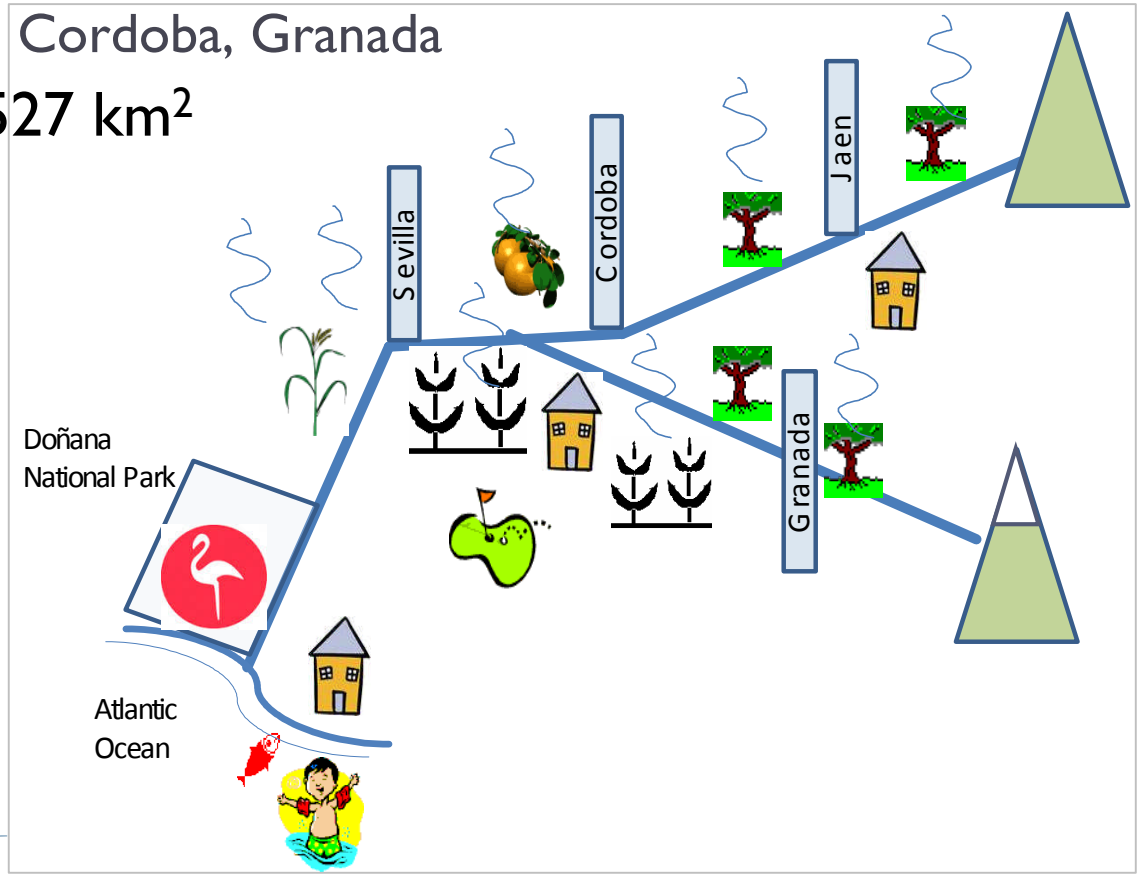
The basin

The basin has a Mediterranean climate with a heterogeneous precipitation distribution. The annual average temperature is 16.8°C,

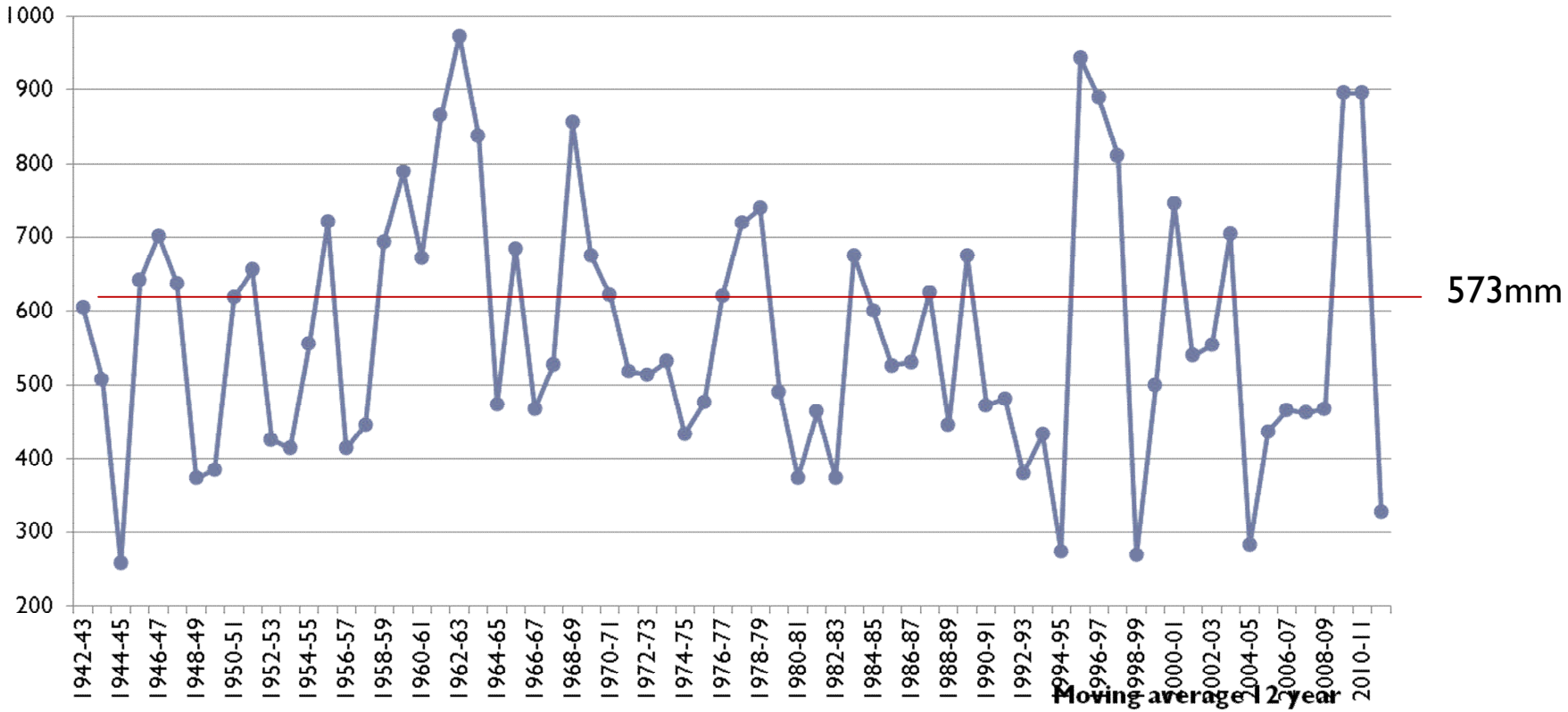


Guadalquivir river basin

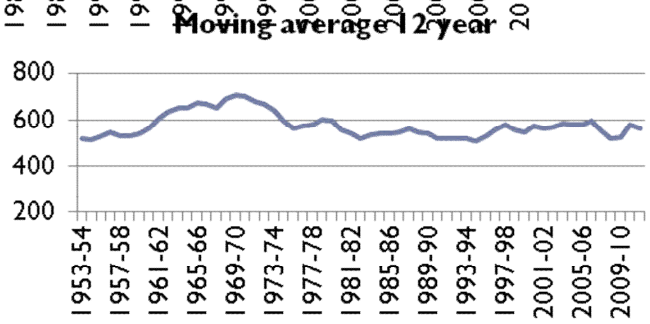
- The Guadalquivir River is the longest river in southern Spain (around 650 km)
- Population of 4,107,598 inhabitants
  - Main cities are: Seville, Cordoba, Granada
- Covers an area of 57,527 km^2
- Main land uses are:
  - Forestry: 49.1%
  - agriculture : 47.2%
  - urban areas: 1.9%
  - Wetlands: 1.8%
- Irrigation 850.00 ha
  - (25% land, 70% value)



Rain in a Mediterranean river (Guadalquivir)



Annual precipitation averages at 573 mm
(range between 260 mm and 983 mm)



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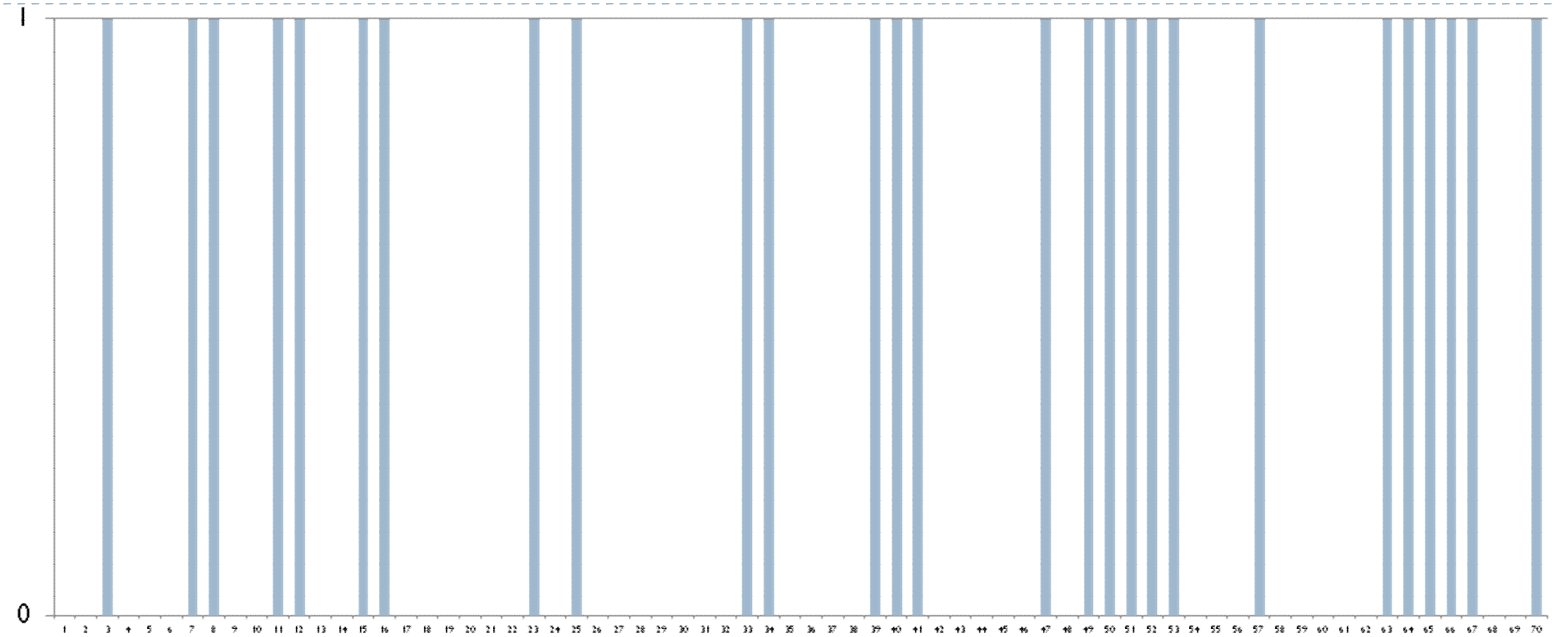
Dry years Guadalquivir



1942-2012, years below 15% of average

Libro Blanco del Agua, most severe drought in 200 years are:

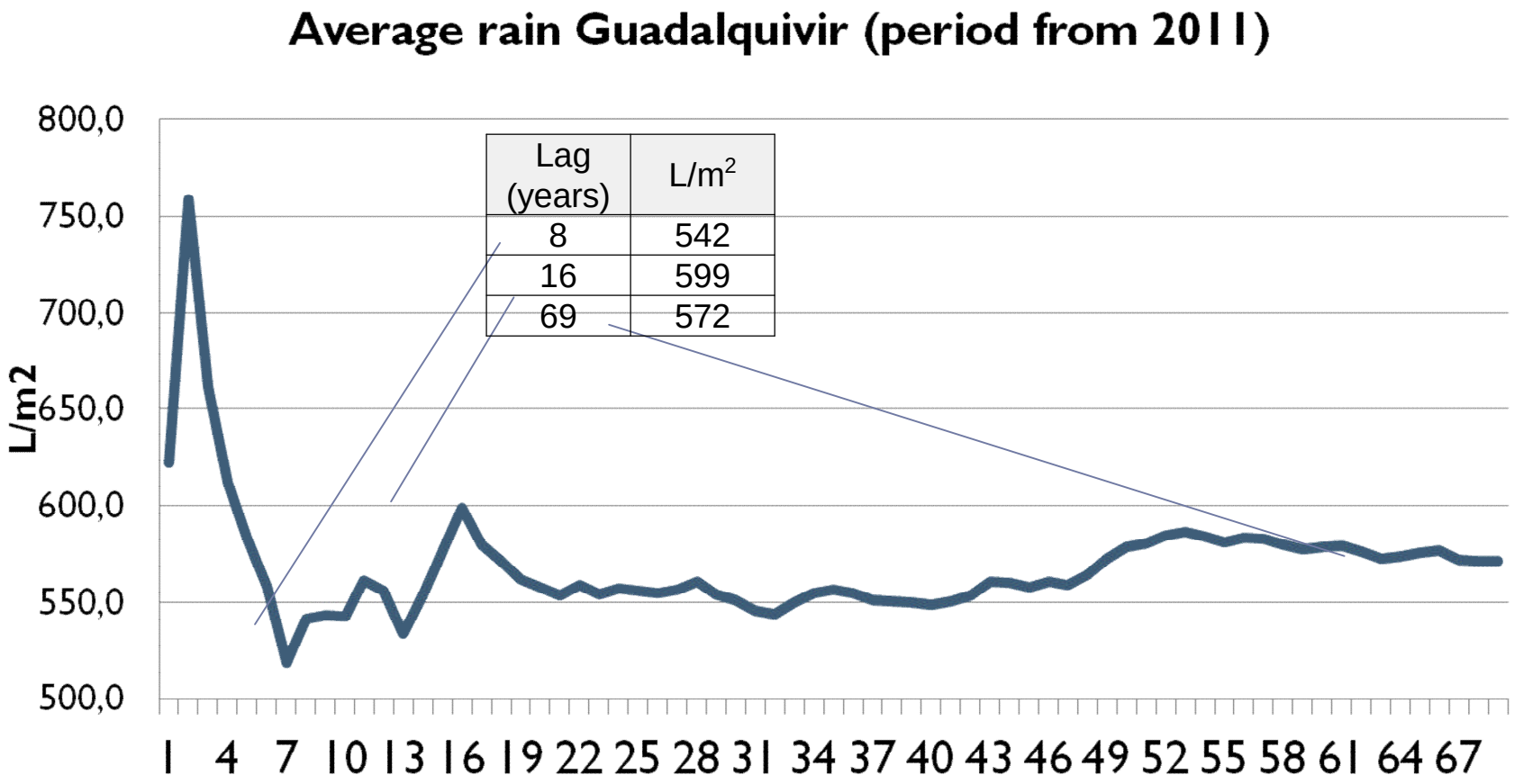
- Oct.1941 a sept.1945,
- Oct.1979 a sept.1983
- Oct.1990 a sept.1995

In XXI century from Oct 2005 to sept 2008.

Drought (>3 years)

Desde 1977 10 años (29%) precedidos por uno o mas años secos

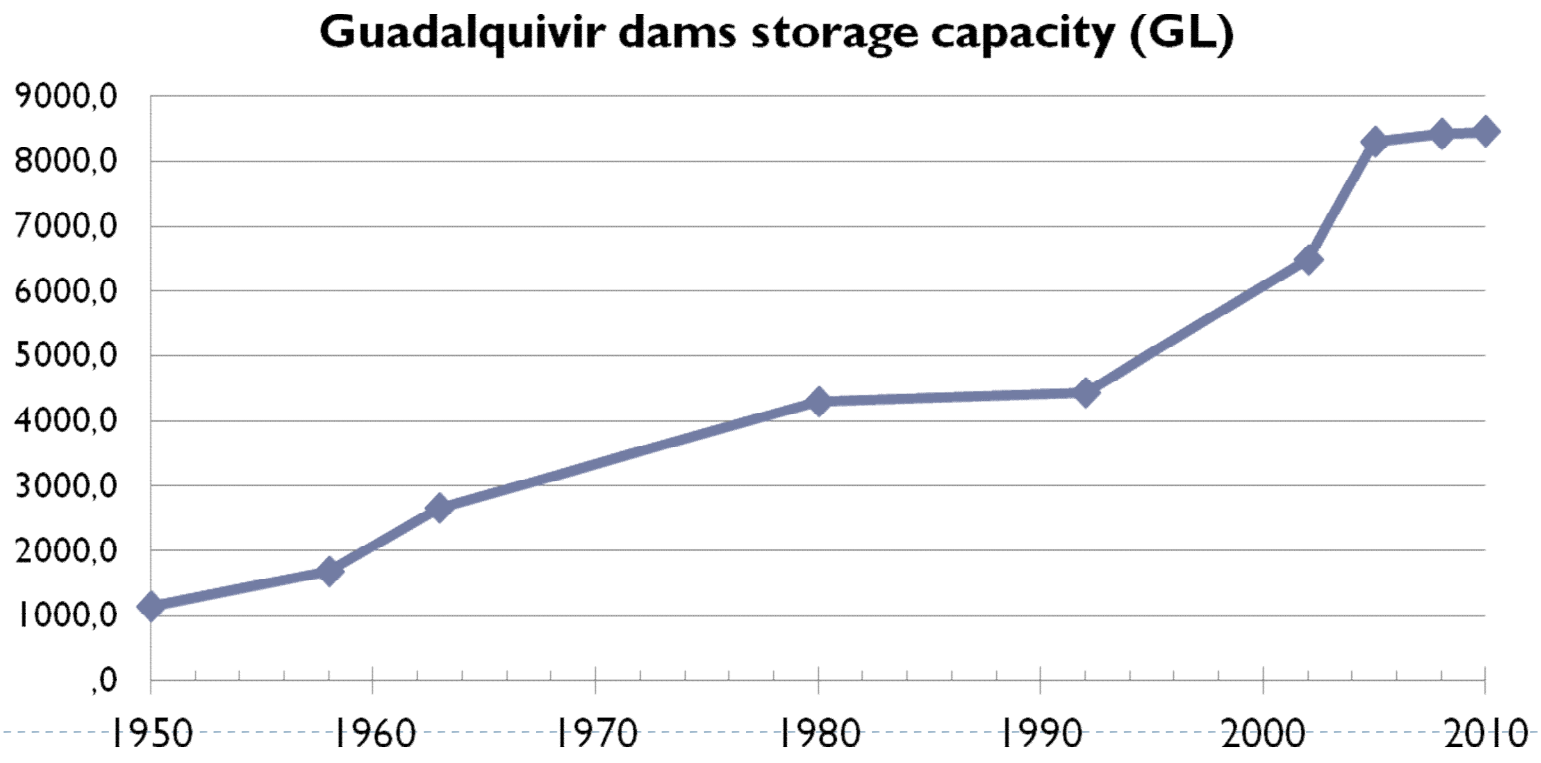
Period of rain in models (Guadalquivir)



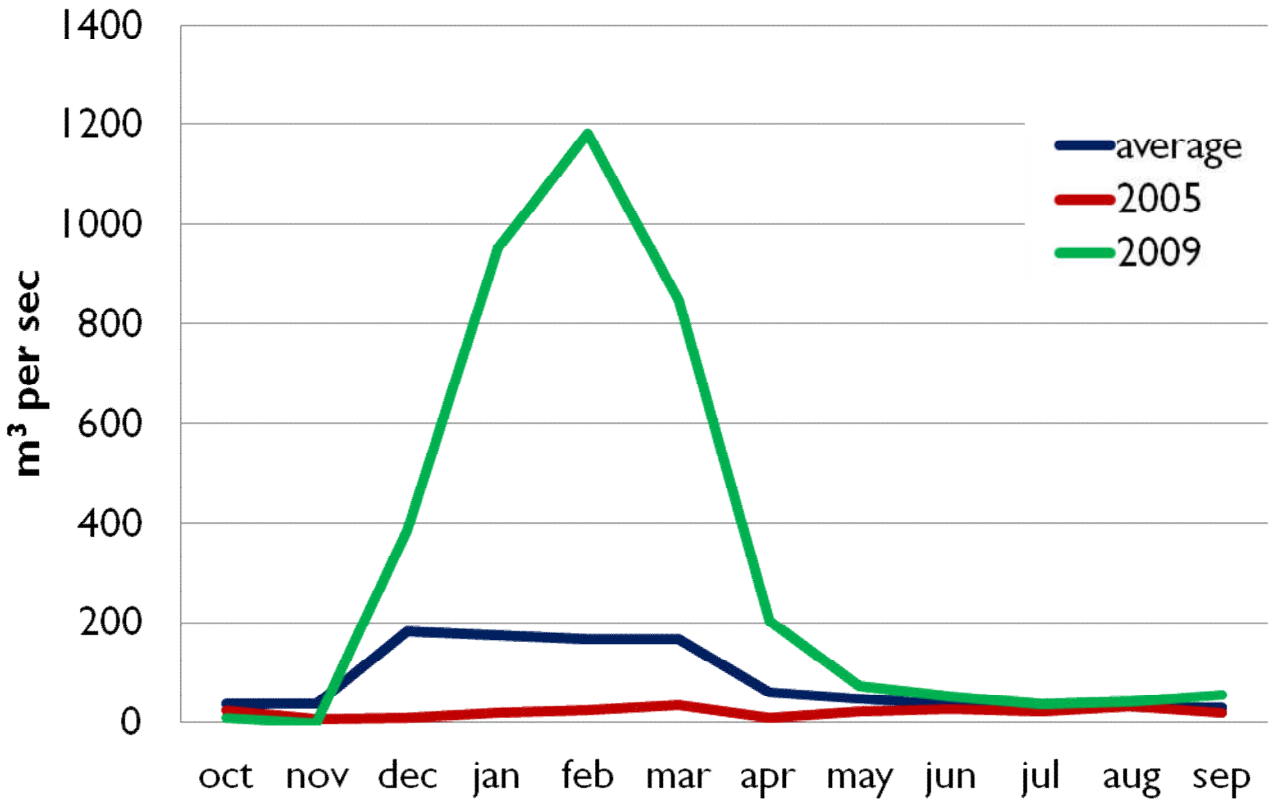
Lag (years)	L/m^2
8	542
16	599
69	572

Guadalquivir river basin figures

- Average renewable resources
  - 7,043 (arithmetic mean) and 5,078 GL/year (median),
  - Minimum 372 GL/year, Maximum of 15,180 GL/year
- 65 dams storage capacity 8,500 GL



Guadalquivir river average monthly flow

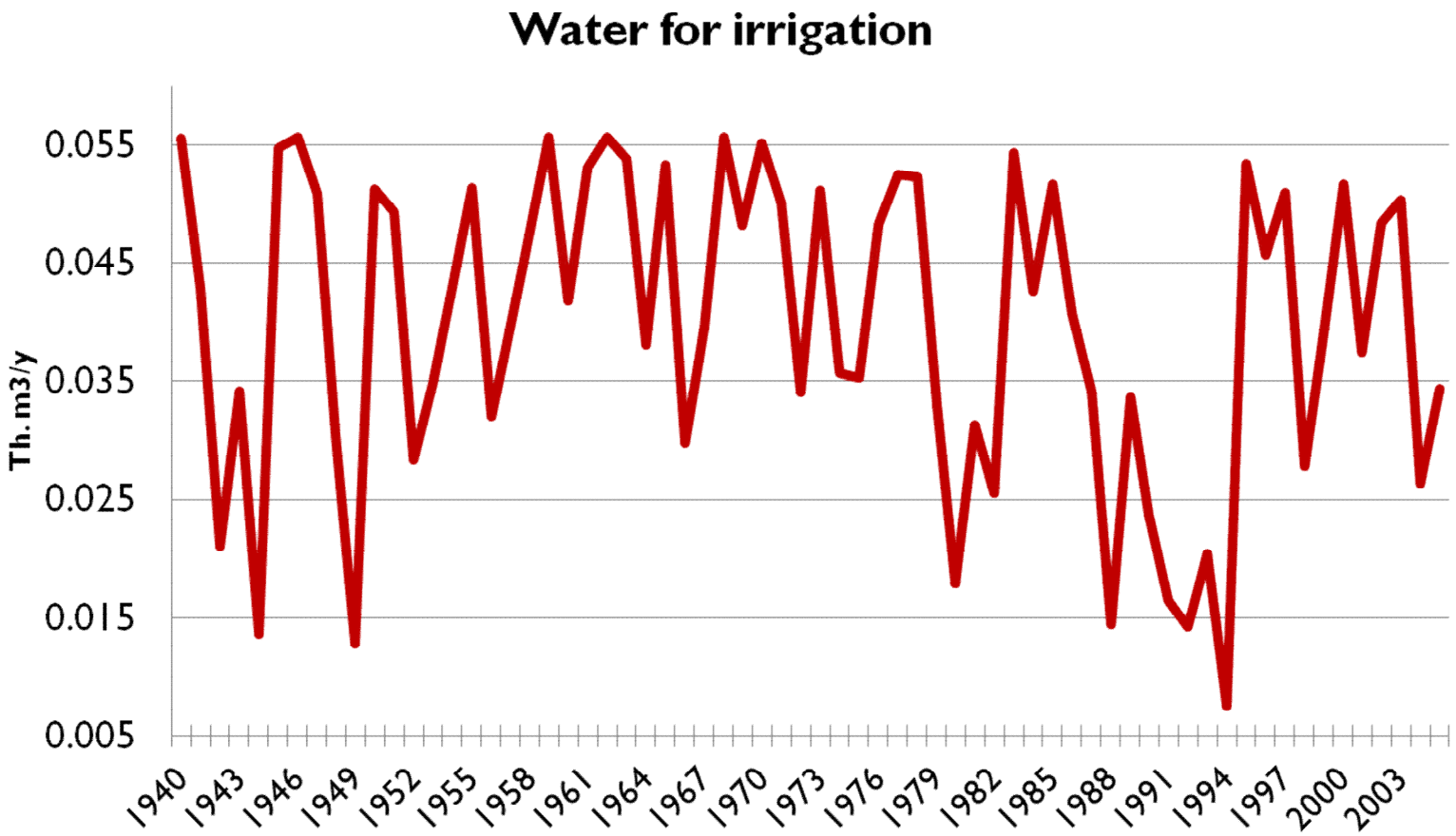


Origin of water

Origin of water (GL, 2005)	Irrigation	Urban +Industry	Total	
Regulated rivers	2,165.5	358.9	2,524.4	65%
Non regulated rivers	347.0	0.0	347.0	9%
Groundwater	830.0	136.8	966.8	25%
Recycled	30.0	0.0	30.0	1%
Total	3,372.5	495.7	3,868.2	

Source: CHG f(2010)

Unregulated river



Average water served is 67%of water rights

Use of water by sectors

Water used (2009, GL/y)	Surface water	Ground water	Recycled	Total use (GL/y)
1) Urban, total	358,6	120,9	0,0	479,5
1.1) Urban/domestic	*251,0*	*84,6*		*335,6*
1.2) Urban/Business	*107,6*	*36,3*		*143,8*
2) Irrigation	2.131,5	1.164,7	33,3	3.329,5
3) Industry	55,7	11,1		66,7
4) Energy (consumptive)	19,8			19,8
5) Others (tourism)	3,8			3,8
Total water used	**2.569,4**	**1.296,7**	**33,3**	**3.899,3**
6) Hydropower	135,2			135,2
Total uses	2.704,6	1.296,7	33,3	4.034,6

Economic analysis (preliminary)

Guadalquivir main economic data

	GDP (10^6 euro *)	% GDP	Water use (GL)	% use
Agriculture	2.755	5%	3.414	86%
Industry	6.167	10%	61	2%
Services/HH	48.634	82%	437	11%
Energy	1.926	3%	37	1%
Total	59.482	100%	3.949	100%

(*) Based on INE, preliminar data. Do not quote

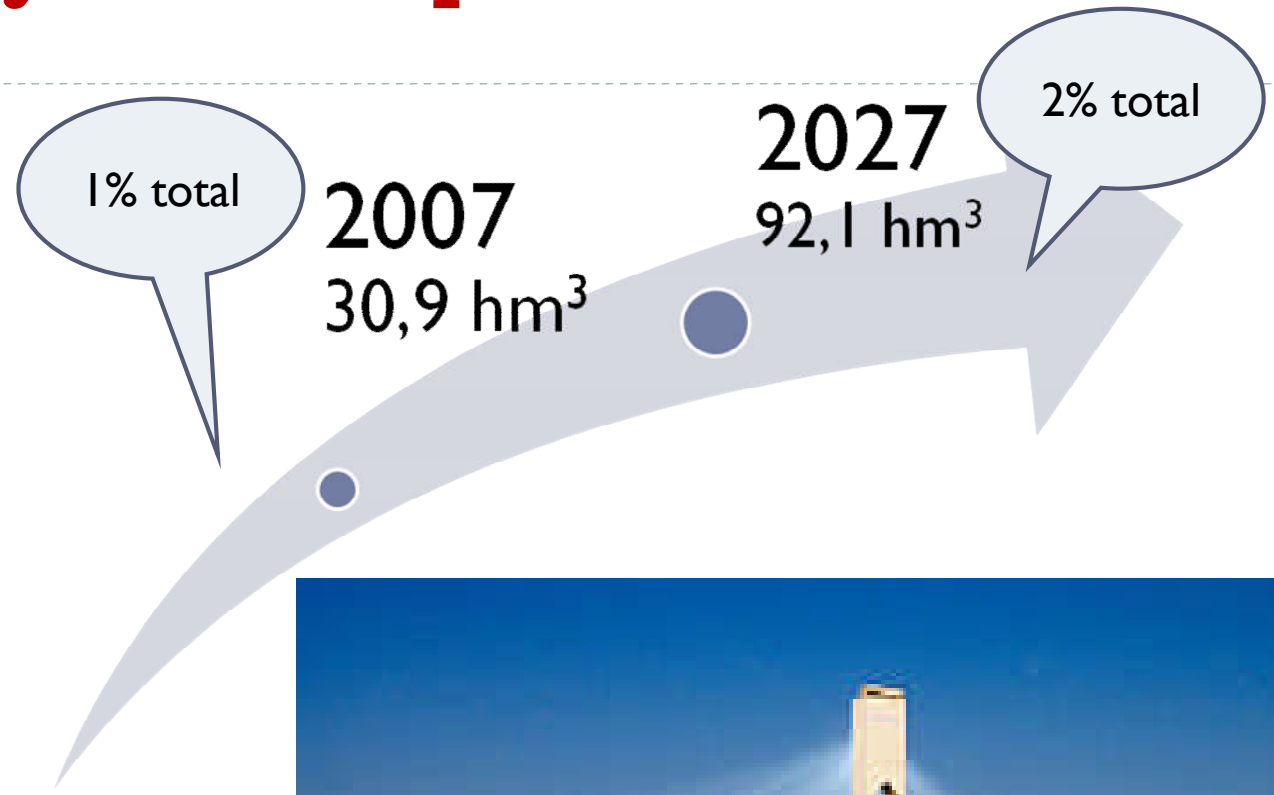
Difficult conversion from Administrative economic data to River basin, we should solve this issue.

Industrial sectors

Sector	GDP (10^6€*)	
Food& beverages	1.498	24%
Textil	223	
Wood & paper	396	
Chemistry	1.728	28%
Metals	891	
Transport , Machin & other	1.428	23%
Total	6.167	

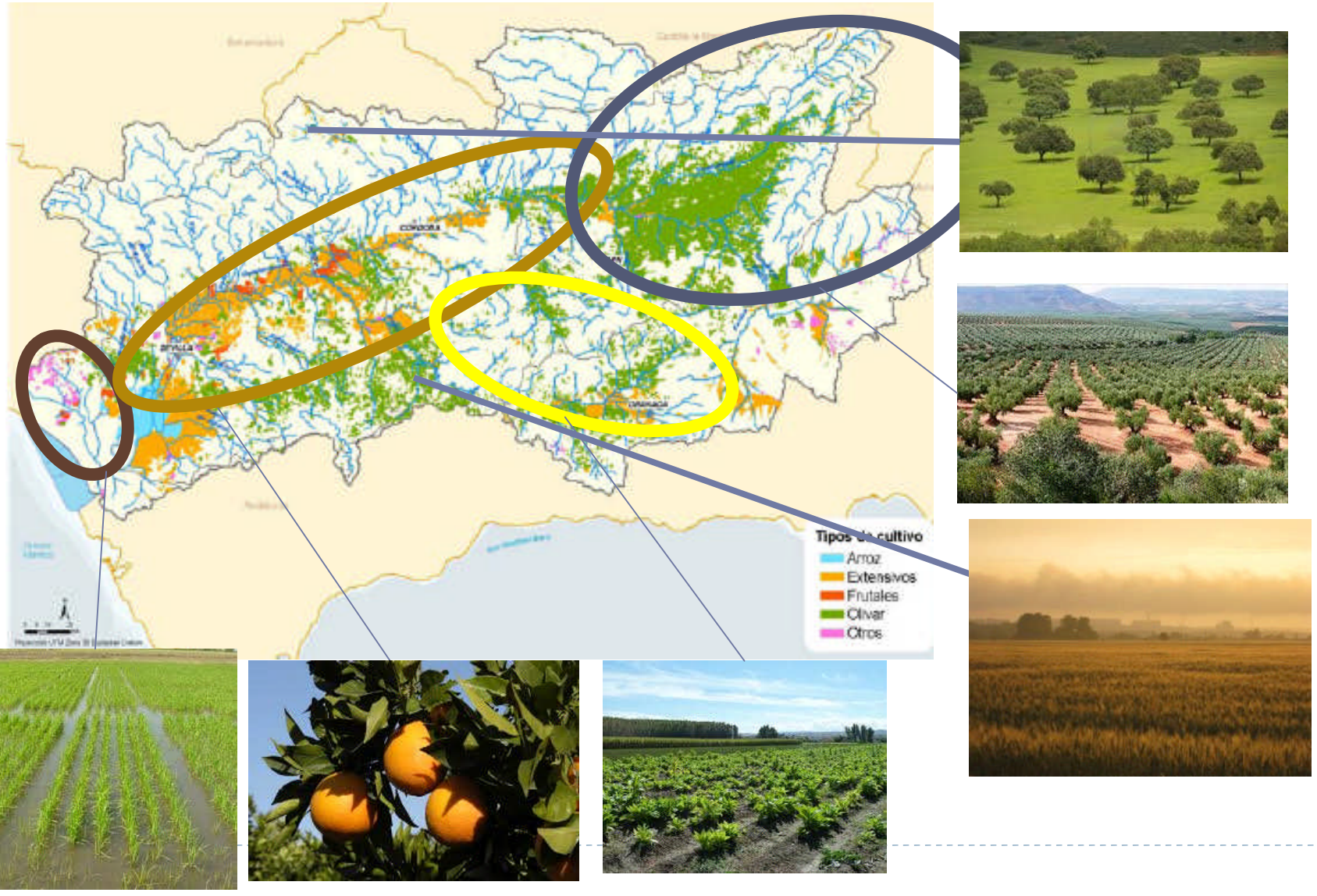
(*) Based on INE, preliminar data. **Do not quote**

Energy consumptive use of water



Guadalquivir: agriculture

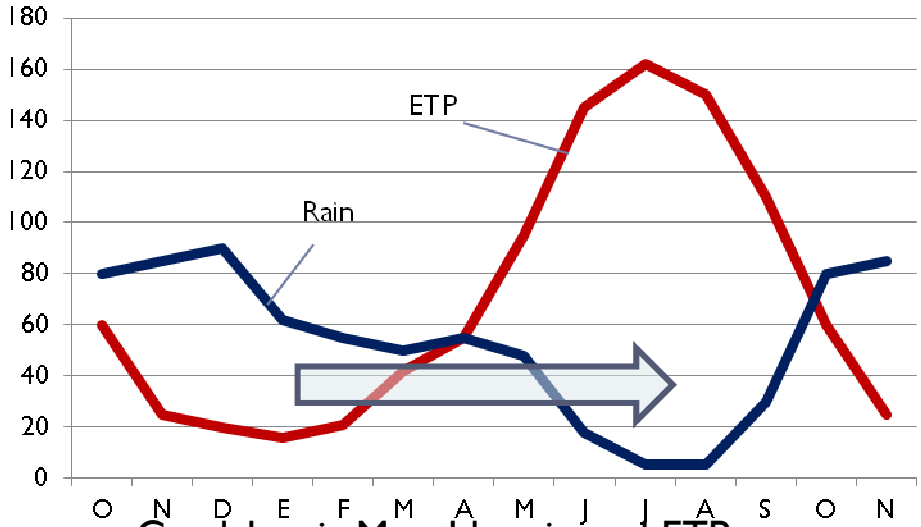
Agricultural systems



Irrigation as solution

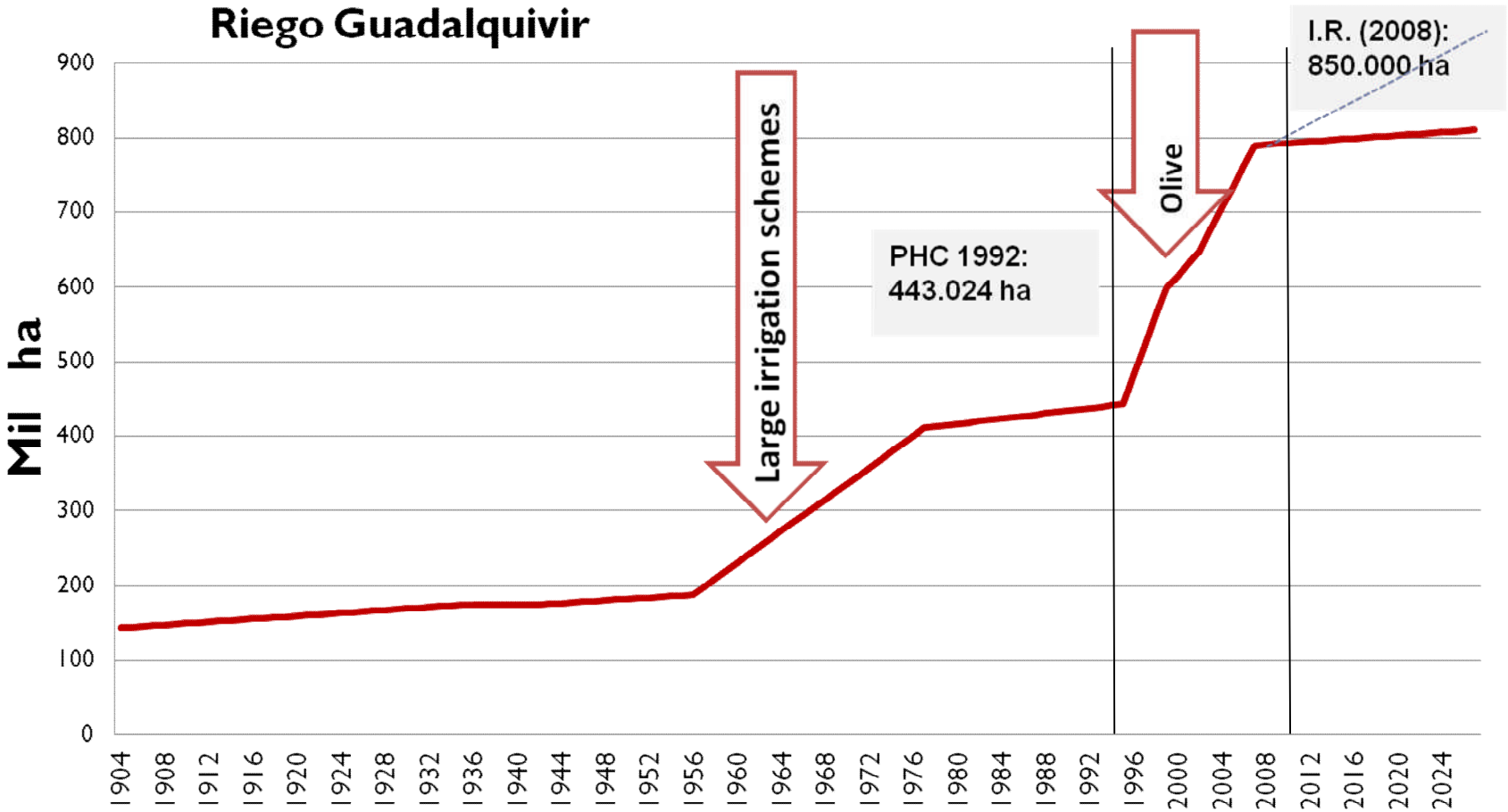
- Irrigation to increase production and profit
  - New crops are available
  - Higher yields of crops irrigated versus rain fed
- Irrigation to reduce risk
  - More stable production (yields stabilized)
  - More crops available (risk diversification)

Move water from:
- Winter to summer
- Wet to dry years
- Mountains to valleys
- Less to highly productive areas

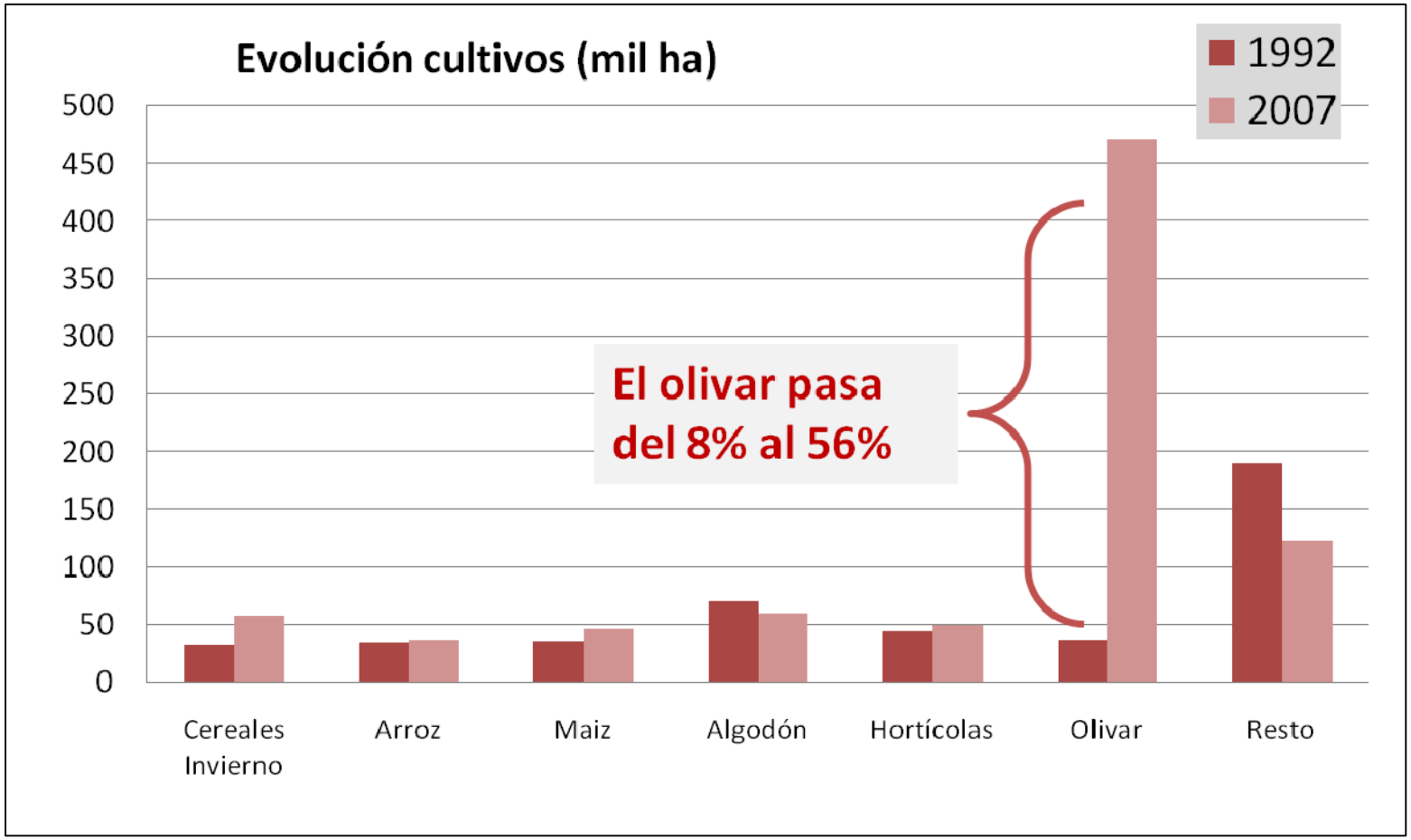


Guadalquvir Monthly rain and ETP (mm)

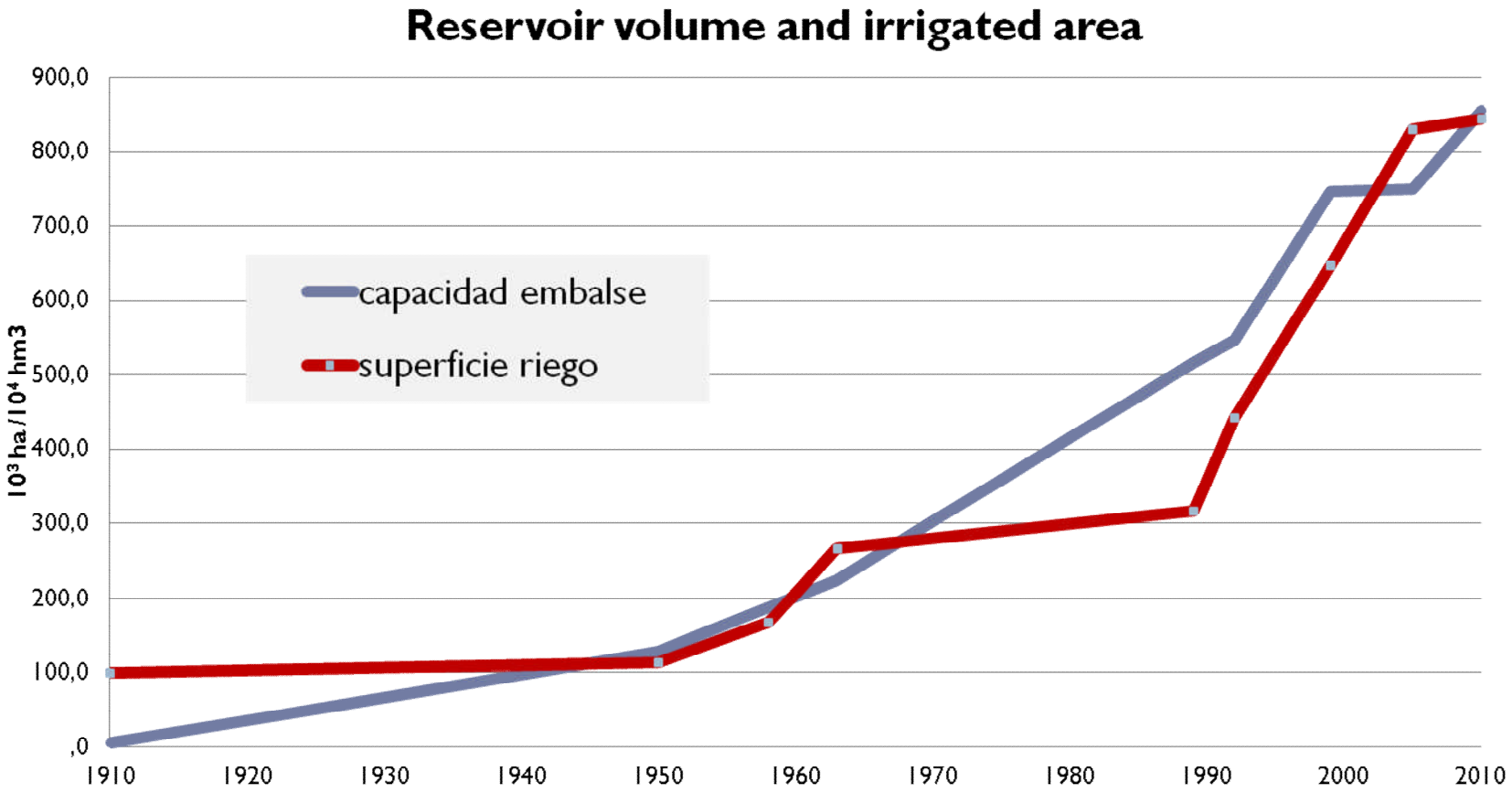
Irrigation increase



Crop change (irrigated)

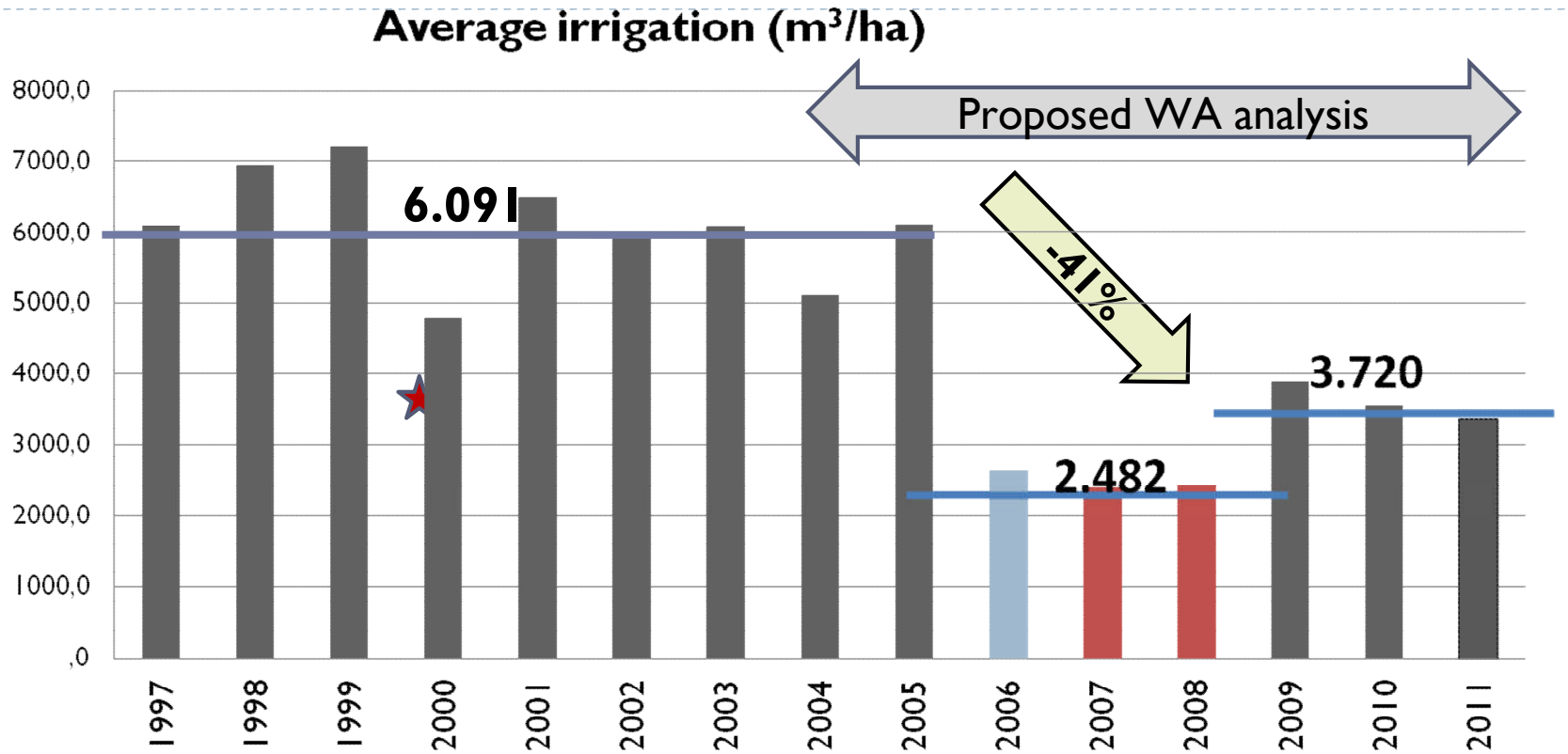


Supply (reservoirs) and demand (area)



Source: Arguelles et al 2012

Reduction in average dose (m^3/ha)



Date	Area (ha)	Increase (ha)	m^3/ha	Increase m^3/ha	Use (hm^3)	Increase hm^3
1992 (PHC)	443.024	--	6.485	--	2.874	--
2004 (ETI)	801.157	**81%**	4.350	**-33%**	3.485	**21%**
2008 (P.H)	845.000	**92%**	3.720	**-43%**	3.162	**10%**

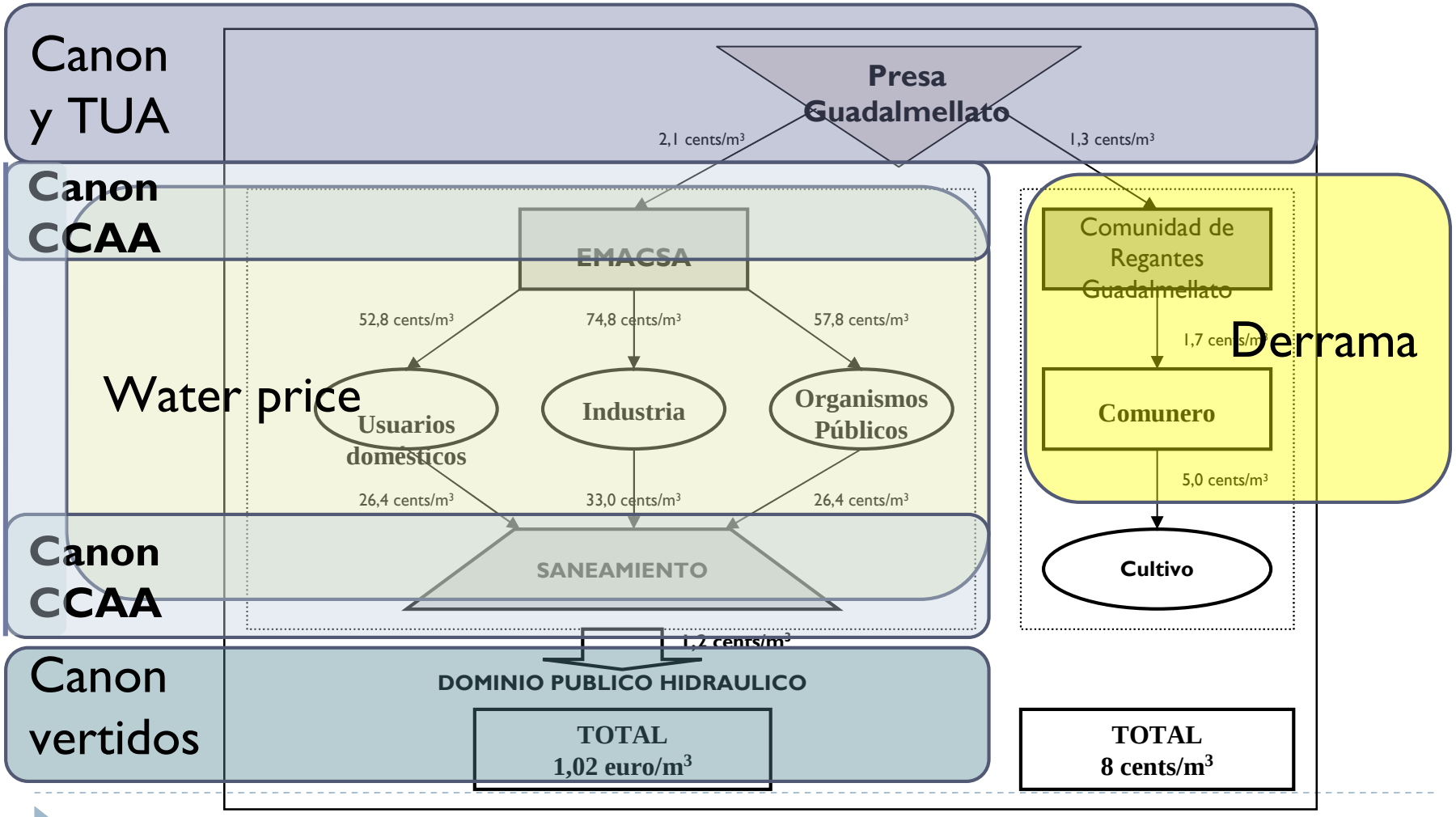
Gross water use Abril/Oct. (2011, own estimation).

Deficit irrigation

Crop	Area 2007 (ha)	Dosis m³/ha	Needs Max (m³/ha)	RIS
Olive	471.090	2.281	3.678	0,62
Cotton	55.000	6.048	8.632	0,70
Cereals	55.850	1.500	4.049	0,37
Vegetables	46.804	6.104	5.918	1,03
Maize	44.974	6.621	8.882	0,75
Fruits	21.992	5.386	3.879	1,39
Cítrus	20.038	5.501	4.888	1,13
Sugar beet	20.036	3.730	6.732	0,55
Sunflower	18.033	1.500	4.853	0,31
Rice	36.978	14.000	13.196	1,06
Total	849.243	3.141	4.194	0,72

Guadalquivir others

Instruments for cost recovery

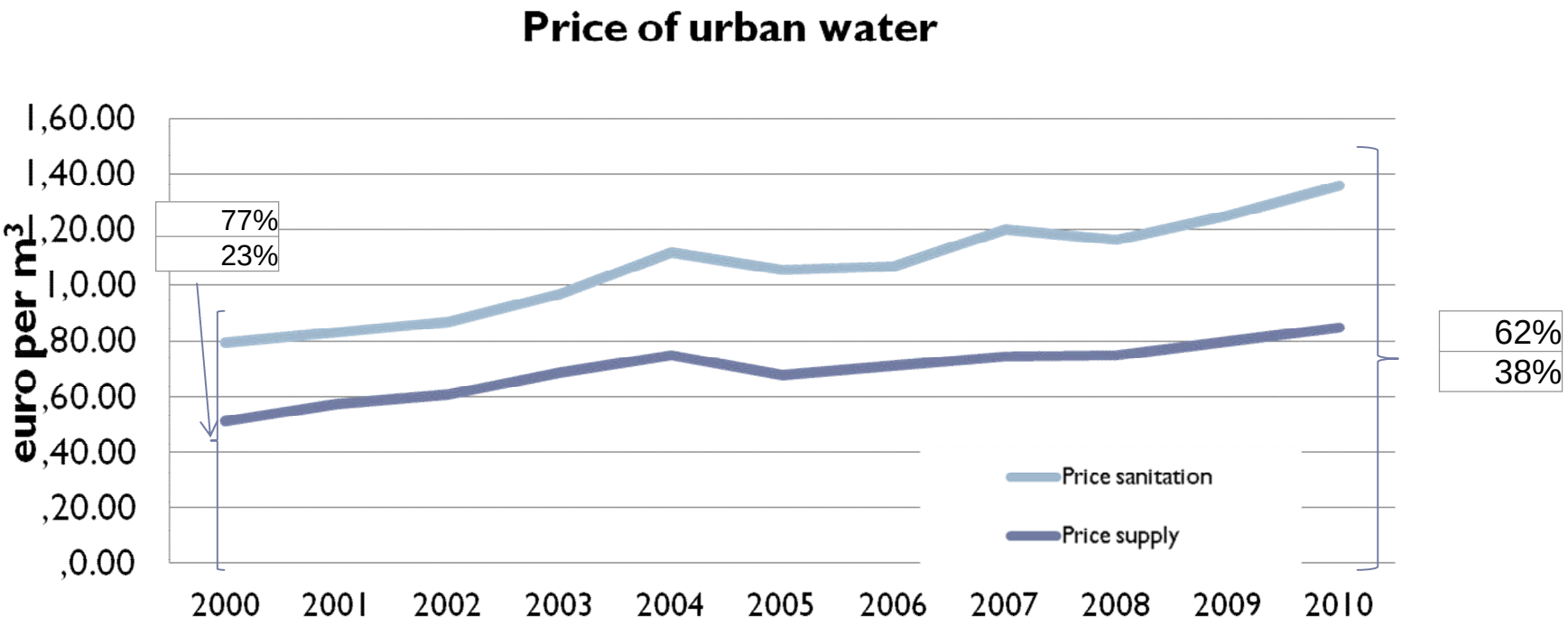


Expenditure for water services

Organism	Regulated water	Groundwater	Urban distribution	Urban sanitation	Sanitation self	Irrigation distrib	*Total*
Confederacion Hidrografica	30,39			1,34	0,19		*31,92*
Others	0,00		0,00	0,00		3,07	*3,,07*
Total national	***30,39***		***0,00***	***1,34***	***0,19***	***3,07***	***34,99***
Auntonumous Goverm.							*0,00*
Utilities		9,86	68,12	47,44			*125,42*
Irrigators		148,79				238,11	*386,90*
Industriy self supply		0,90			29,94		*30,85*
Total	**30,39**	**159,56**	**68,12**	**48,78**	**30,13**	**241,18**	**578,16**

Million euro (illustration, **do not quote)**

Price increase



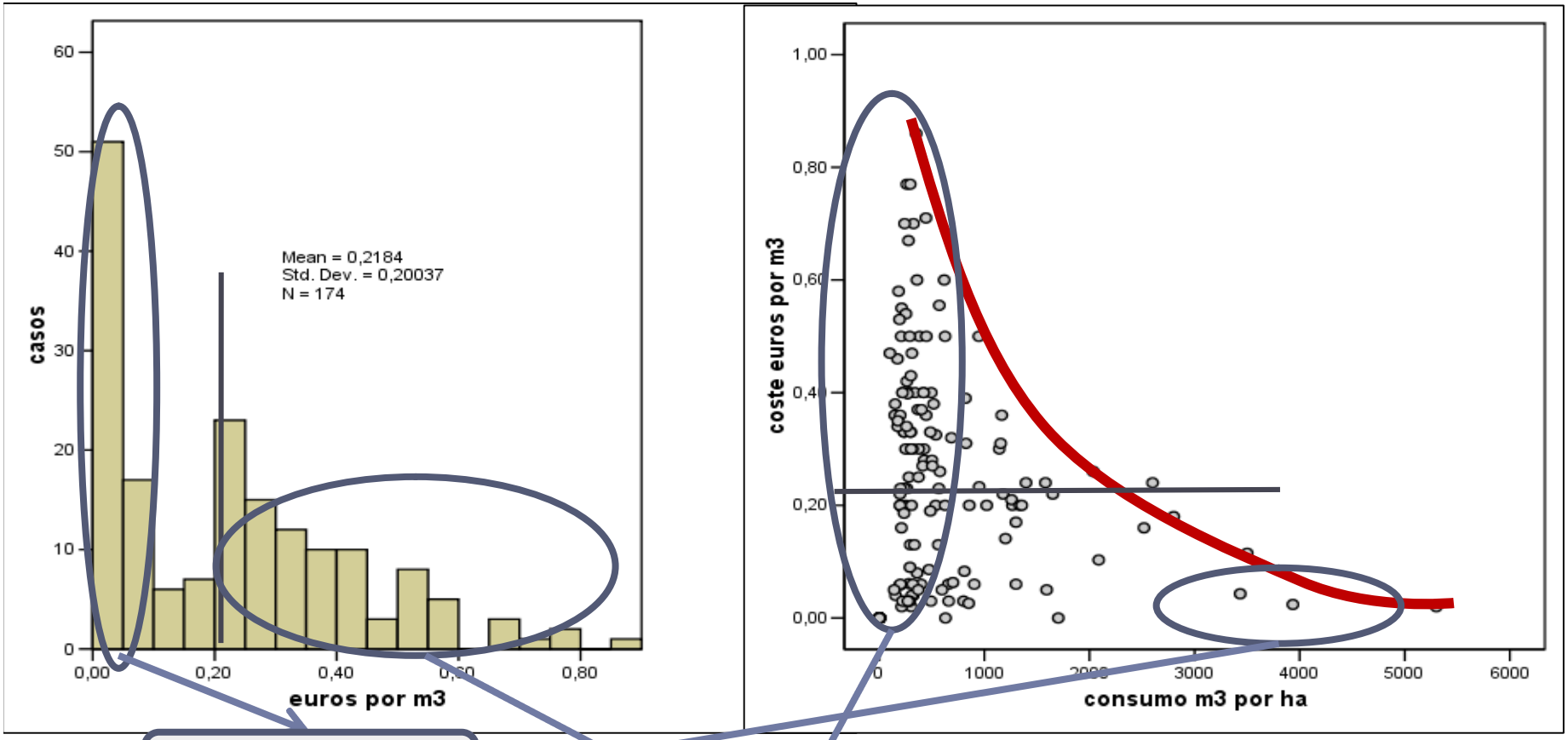
Source, INE, data in constant price 2010 reference

Reduction in urban use

Average domestic use (L/p/day)			
Año	Sevilla	Andalucia	Spain
1991	176	190	180
2000	140	183	168
2006	132	176	160
2009	125	143	145

Source: (1) Sevilla-Emasesa, Salgueiro, R, ; Andalucía,Spain, INE

Cost increase, reduction in dosis



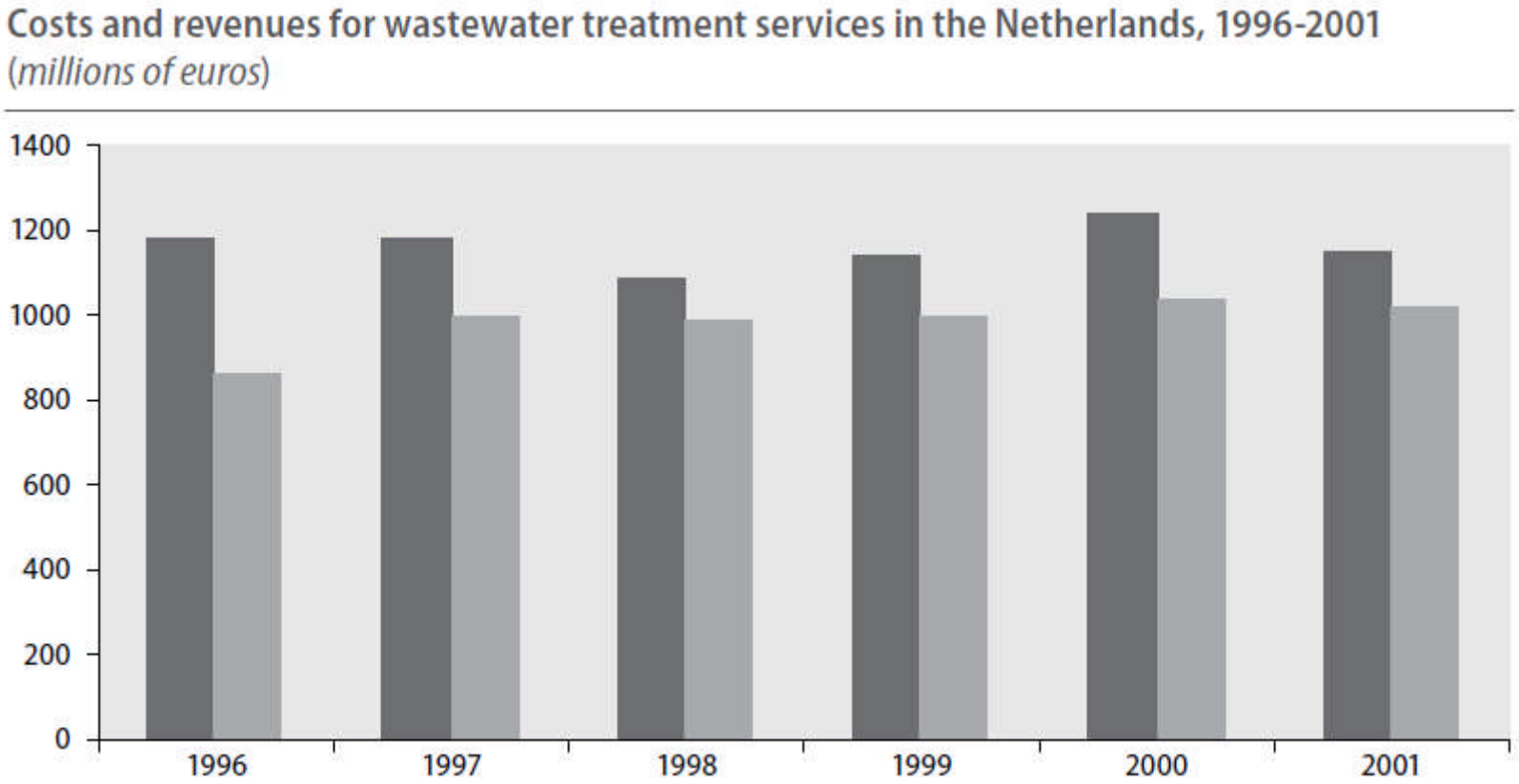
Impact of irrigation modernization

Year	1999-2002	2009-2012	Increase
Irrigated area (ha)	36,040	33,132	- 8%
Water rights (m^3ha^{-1})	8,000	6,000	- 25%
Water use (m^3ha^{-1})	6,526	5,159	- 21%
ETc	8,259	8,405	+ 2%
Effective Rain (m^3ha^{-1})	1,556	2,372	+ 52%
Irrigation needs (m^3ha^{-1})	6,703	6,033	- 10%
Relative Irrigation Supply	0.97	0.86	- 12%
Water costs (euro $ha^{-1)}$	249	278	+ 11%
Water costs (euro m^{-3})	€0.038	€0.053	+ 41%
% Energy costs	25%	43%	+ 77%
Crops	Cotton (26%) Maize (24%) Sugarbeet (18%) Citrus (9%) Vegetables (4%) Other (9%)	Citrus (23%) Cotton (22%), Maize (16%) Sugarbeet (8%) Vegetables (5%) Other (14%)	Citrus (+13%) Cotton (-4%) Maize (-8%) Sugarbeet (-10%) Vegetables (+1%) Other (+5%)

Berbel et al (unpublished) Analysis of studies on the rebound effect of water saving measures

Concluding remarks

Use of WAfor cost recovery analysis



These figures can be compiled from the hybrid supply and use tables.

Final points

- A good opportunity to study
  - Impact of agriculture modernization (water saving, cost increase)
  - Impact of deficit irrigation
  - Large mediterranean basin
  - Good available data (althought in different format)
- Possible integration of Water Accounts in Basin Hydrological Plan 2015
- Open to suggestions
- Thank you for the opportunity