INFLUENCE OF RESERVOIRS AND LAND USE CHANGES ON THE RIVER CONTRIBUTION: CASE STUDY OF THE GUADALQUIVIR ESTUARY

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INTRODUCTION AND OBJECTIVES

Mediterranean climate: the non-coincidence in time of demand and availability of water throughout the year.

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Interannual variability of the climate.

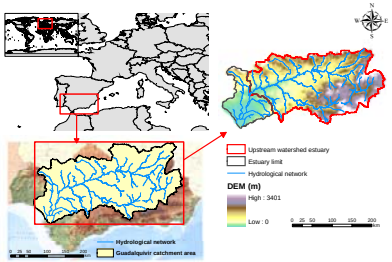
→ Reservoirs + Land use changes → Water quality

This work shows the modification of the Guadalquivir estuary and the river basins upstream during the second half of the 20th century, and its impact on the inflows to the system along time, maps of land use and cover, orthophotos taken in 1956 and 2004, water flow data analysis, rainfall and water quality series collected at different stations along the whole basin area, and information about the dams built in the watershed.

METHODS

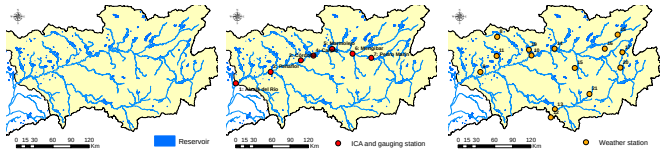
Study site description

+ Southwestern Spain.
+ Mediterranean climate context: strong intra and inter-annual variations in precipitation.
+ Strong Atlantic influence: precipitation linked to the arrival of storms from the ocean.
+ Since 1930s freshwater input is subject to intense regulation by the whole network of dams along the catchment, which ends in the Alcalá del Río dam, at the head of the estuary (80% of the river contribution to the estuary).
  - Mean daily value: 10 $m^3 s^{-1}$.
  - Discharge pulses (associated to rainfall):
    . Frequent values around 100 $m^3 s^{-1}$.
    . Extreme values: 1000 $m^3 s^{-1}$.
  - Values required to control the saline intrusion: 100 $m^3 s^{-1}$.



Available information and data sources

Reservoirs, flow, precipitation and water quality data:



Gaudalquivir SAIH.
Andalusian Government.
Watershed organism.
Meteorological Subsistem CLIMA .
ICA network of Andalusian Government.

Land use changes

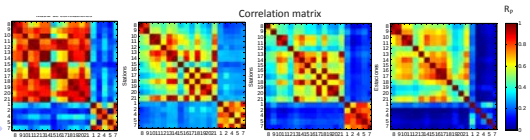
Use and coverage map of Andalusia, Ortophotos of Andalusia from 1956 and 2004

+ Analysis of evolution of variables.
+ Analysis of land use change since 1930.
+ Correlations
(Lineal correlation, Mann Kendall test).

RESULTS

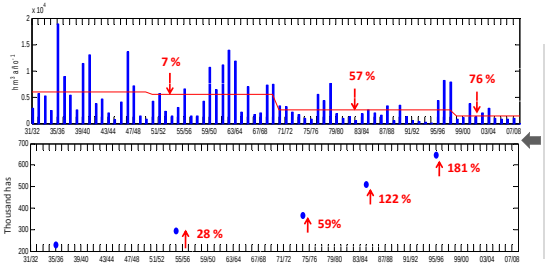
Influence of the reservoirs on water inflow to the estuary

Period	Reservoir volume increase (hm^3)	Accumulated reservoir volume (hm^3)	Increase from 1950 (%)	Annual inflow ($hm^3 año^{-1}$)
1930-1950	2008	2173	-	6015
1950-1970	2497	4670	107 %	5297
1970-1990	2060	6730	202 %	2351
1990-2009	2665	9395	325 %	1953



Rainfall and inflow in the first period (30s-50s and 50s-70s) shows higher correlation than in the second period (70s-90s and 90s-10s).

Inflow along the main channel shows a strong correlation until 90s (R_p 0.7 and 0.9), but then correlation decreases up to 0.2.



The most significant reduction of the water contribution to the estuary (up to a 70% of the antecedent regime,) takes place during the 70's-90's, when irrigated areas increases from 60 to 180%.

Land use class	Upstream watershed (hectare)		Estuary (hectare)	
	1956	2003	1956	2003
Crop with natural vegetation	62117	51518	6064	3765
Rice fields	-	-	6883	38872
Arable irrigated land	87411	136755	62584	90722
Non irrigated arable land	1164860	785386	303473	336417
Olive groves	919247	1206918	141617	86787
Vineyard	9690	10448	10580	10947
Cultivos leñosos en regadío	3406	24889	1576	12494
Crop mosaic	51049	51059	21001	18440
Greenhouse	2	185	38	3944

How does it affect to the water quality in the estuary during 1981-2008 period?

		Flow ($m^3 s^{-1}$)				Suspended sediments concentration (mg L^{-1})				Nitrates concentration (mg L^{-1})			
	Est.	q1	mean	q3	max	q1	mean	q3	max	q1	mean	q3	max
Alcalá del Río	1	15	29	41	1349	22	36	60	6370	6	14	24	71
	2	9	14	27	954	55	95	179	9141	9	13	20	41
	3	10	20	37	343	46	83	138	3615	5	9	14	49
	4	10	20	37	343	43	72	128	6906	4	8	13	57
	5	8	17	34	174	49	88	183	3481	6	10	15	30
	6	6	15	28	91	61	128	310	5358	5	11	16	52
Pedro Marín	7	2	7	15	53	39	106	199	3284	7	10	12	35

q1: quartile 1; mean: mean value; q3: quartile 3; max: máximum value.

The highest q3 of suspended sediments concentration was detected in stations at the head of the watershed, where the largest olive area is found .

The higher q3 and maximum of nitrates concentration was detected in the station further downstream, where the area under arable crops is larger.

CONCLUSIONS

✓ From the 90's the average daily flow at the flow gauges along the main channel in the Guadalquivir watershed lost semicontinuity because of the intense regulation. This can also be observed from the distorted relationship between flow and precipitation.

✓The annual regime of discharge from the Alcalá del Río dam has drastically decreased since the 70s, up to a 70% of the antecedent regime, not only due to the construction of dams in the upstream catchment area, whose storage capacity doubled during these decades, but also by the gradual and intense development of large irrigated agricultural areas upstream (which increased their area by 150% in that period).

✓ The predominance of freshwater conditions is reduced only to flood events, and this facts greatly influences the status of water quality in the estuary and the associated flows.

✓Land use influence water quality of the estuary due both pollutant loadings and a lower capacity of dilution and mixing than the value corresponding to the natural regime of the Guadalquivir River. This is probed by salinity increase in the lower and middle estuary (up to 30 PSU), and the persistence of extreme suspended solids concentrations after extreme floods (2000-10000 mg l^{-1} during several months); the latter is accentuated by the agricultural soil management, with high soil loss rates, especially in cropping systems such as olive orchards and herbaceous crops.

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