Trade-offs between Water Allocations and Environmental Flows: A Hydro-economic Analysis in the Ebro Basin

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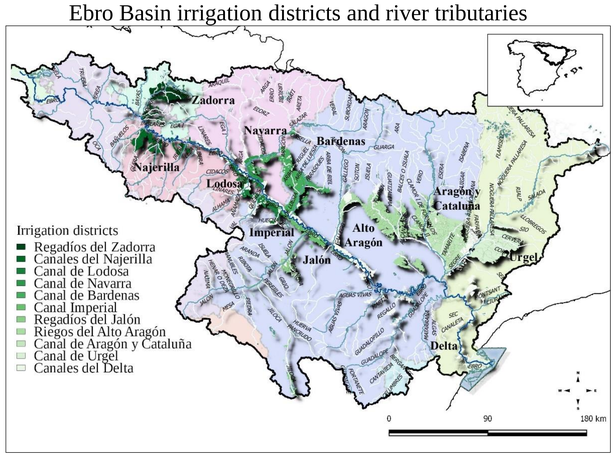
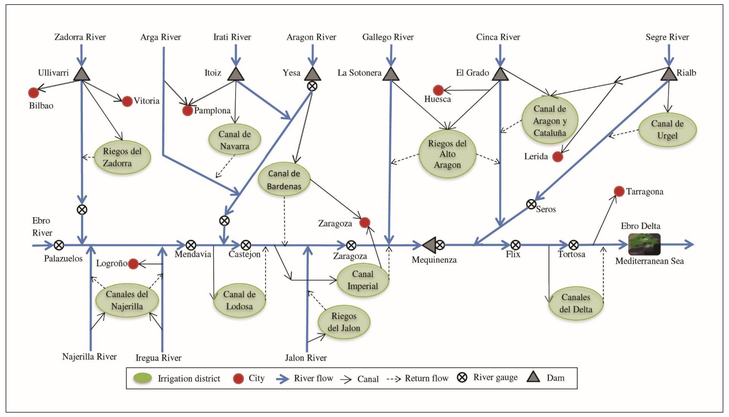
INTRODUCTION

- Addressing a more sustainable management of water resources involves new policies that require improved knowledge on water allocations and benefits from the economic and environmental uses of water
- Environmental uses have been mostly disregarded in traditional water management, but just recently the maintenance of environmental water flows is being considered as a key issue in water policies
- This study analyzes the spatial and sectoral allocation of water resources in the Ebro Basin (Spain), in order to inform the debate on the environmental flow in the Ebro mouth
- A hydro-economic model is developed to analyze the effects of different water allocation mechanisms under combinations of water availability and environmental flow scenarios
- Results show that the petition of raising the environmental flow at the Ebro mouth during droughts by the downstream state (Cataluña) would be very costly for all irrigation districts in the basin. One alternative for the downstream state to gain the support of the rest of states for raising the environmental flow would be to compensate the losses of irrigation districts in upstream states

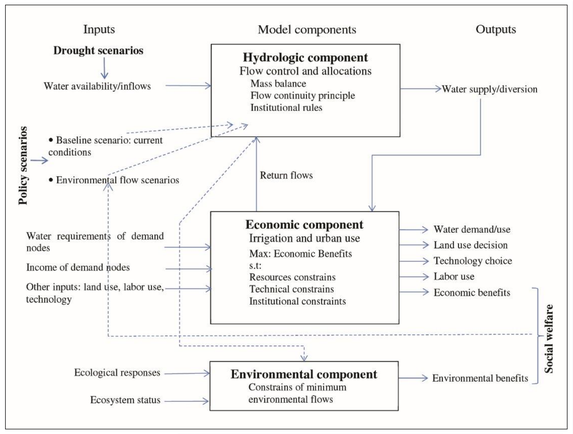
Ebro Basin irrigation districts and river tributaries



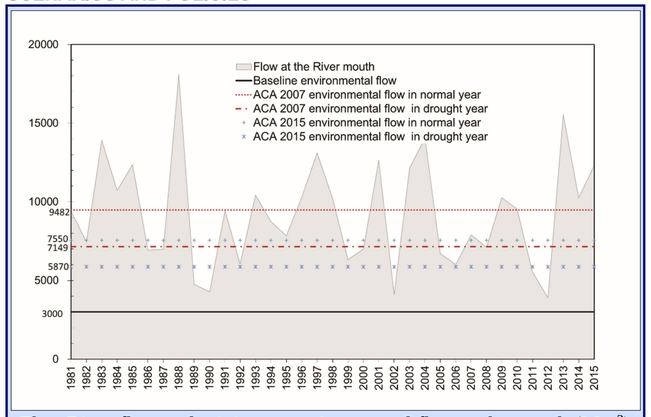
NETWORK OF THE EBRO BASIN



MODELING FRAMEWORK



SCENARIOS AND POLICIES



Ebro River flow and minimum environmental flow at the mouth (Mm^3)

Three environmental flow scenarios are simulated corresponding to the environmental restrictions established by the Ebro Basin Plan (3000 Mm^3) and the two proposals of ACA (2007) and ACA (2015) being requested by the Cataluña state

Three water allocation policies are considered to analyze the ACA (2007) and ACA (2015) proposals of environmental flow when there is water scarcity because of drought: proportional share (which is the current allocation mechanism), water markets, and priority of water use by upstream regions.

These alternative allocation policies result in very different benefit outcomes for stakeholders in downstream and upstream states. Since the downstream state (Cataluña) is asking for the huge increase of environmental flow in the mouth that is opposed by upstream states, the reasonable solution is that the bulk of the costs has to be borne by the downstream state. This solution correspond to the policy of upstream priority.

RESULTS FROM SCENARIOS

Outcomes from current and ACA 2015 flow scenarios with moderate drought

	Normal year	Moderate drought			
Environmental flow	3000	3000	5870 (ACA 2015)		
Policy	Baseline	Proportional	Proportional	Market	Priority
Irrigated area (1.000 ha)	528	349	327	343	331
Cereals	399	235	215	227	218
Vegetables	25	21	20	21	21
Fruit trees	104	93	92	95	92
Labor (1.000 AWU)	31.5	26.1	25.5	26.1	25.4
Water use (Mm^3)	5,802	4,181	3,908	3,692	3,841
Agriculture water diversions	5,400	3,779	3,506	3,292	3,439
Urban water demand	402	402	402	402	402
Flow at the river mouth	8,890	5,710	5,870	5,870	5,870
Benefits (10^6 €)	2,492	2,341	2,321	2,337	2,325
Irrigation benefits	635	484	464	480	468
Urban benefits	1,857	1,857	1,857	1,857	1,857
Price of water (€/m^3)	0.04	0.09	0.16	0.15	0.15

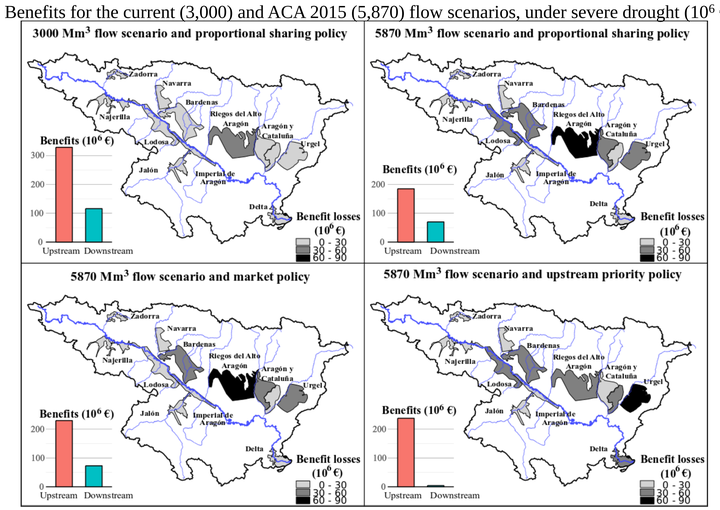
Outcomes from current and ACA 2015 flow scenarios with severe drought

	Normal year	Severe drought			
Environmental flow	3000	3000	5870 (ACA 2015)		
Policy	Baseline	Proportional	Proportional	Market	Priority
Irrigated area (1.000 ha)	528	304	139	153	141
Cereals	399	195	64	57	81
Vegetables	25	19	12	16	14
Fruit trees	104	90	63	80	46
Labor (1.000 AWU)	31,5	24.7	16.1	19.8	12.5
Water use (Mm^3)	5,802	3,635	1,704	1,413	1,491
Agriculture water diversions	5,400	3,533	1,302	1,211	1,089
Urban water demand	402	402	402	402	402
Flow at the river mouth	8,890	4,650	5,870	5,870	5,870
Benefits (10^6 €)	2,492	2,301	2,112	2,159	2,194
Irrigation benefits	635	444	255	302	237
Urban benefits	1,857	1,857	1,857	1,857	1,857
Price of water (€/m^3)	0.04	0.14	0.43	0.32	0.75

Upstream and downstream benefits under flow scenarios by climate (10^6 €)

Environmental flow/Policy	Climate					
	Moderate drought			Severe drought		
	Region			Region		
	Upstream	Downstream	Basin	Upstream	Downstream	Basin
Baseline (3,000 Mm^3)						
Proportional	357	127	484	328	116	444
ACA 2015 (5,870 Mm^3)						
Proportional	342	122	464	185	70	255
Market	359	121	480	229	73	302
Upstream priority	357	111	468	237	0	237
ACA 2007 (7,150 Mm^3)						
Proportional	202	75	277	Unfeasible[a]	Unfeasible	Unfeasible
Market	245	79	324	Unfeasible	Unfeasible	Unfeasible
Upstream priority	258	0	258	Unfeasible	Unfeasible	Unfeasible

Benefits for the current (3,000) and ACA 2015 (5,870) flow scenarios, under severe drought (10^6 €)



CONCLUSIONS

The model is used to analyze three scenarios of environmental flow at the river mouth under normal and drought climate conditions. The environmental flow scenarios are the current flow of 3,000 Mm^3 established in the Ebro Water Plan, and the ACA 2007 and 2015 proposals of the downstream state (Cataluña) of raising the minimum environmental flow at the Ebro mouth between two and three times. Additionally, three allocation policies (upstream priority, proportional sharing, and water markets) have been simulated to analyze the different ways of sharing the costs imposed by raising the current environmental flow. The allocation policies are implemented in order to comply with the environmental flows proposals under different water stress scenarios.

Results show that under the current environmental flow requirement of 3,000 Mm^3, drought events already generate important losses of benefits to farmers. The capability of response to drought conditions is higher in areas with profitable crops under advanced irrigation systems. The current minimum environmental flow requirement at the river mouth does not restrict the economic activities in the basin under any climate condition, and this flow level also facilitates a more flexible water management in the future.

Accepting the claims of Cataluña and raising the minimum environmental flow by two or three times at the Ebro mouth increase significantly the benefit losses sustained by farmers during droughts. These losses depend on the water allocation policy chosen. The policies considered are proportional sharing, water market, and priority of upstream regions. The comparison between these policies during droughts shows that the water market policy is a feasible alternative that achieves higher economic benefits in the basin. The policy of proportional sharing generates higher benefits than the policy of priority of upstream regions, and it is also more equitable by distributing the drought losses evenly among regions in the basin. This is because this policy favors the irrigation districts with low profitable crops and less advanced irrigation systems. The policy of upstream priority places the burden of adjusting to drought over the downstream region of Cataluña.

Our results indicate that the proposal by Cataluña of expanding environmental flows is very costly to farmers in other states of the basin. This negative impact could be reduced somehow by the policy of upstream priority, but benefit losses remain in some cases. One possibility to gain the support of these regions is by providing payments from the Cataluña downstream state to the upstream states to compensate for any remaining losses they could sustain because of the increase of environmental flow at the Ebro mouth.

Policy tradeoffs and other political economy aspects for a more sustainable management have been examined in the Ebro basin. This is an illustrative case for exploring the political viability of reallocating water to the environment, which may entail important lessons for other basin in arid and semiarid regions.

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