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Improving the Performance of Water Policies: Evidence from Drought in Spain

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Abstract: Water scarcity is a critical environmental issue worldwide, especially in arid and semiarid regions. In those regions, climate change projections suggest further reductions in freshwater supplies and increases of the recurrence, longevity and intensity of drought events. At present, one important question for policy debate is the identification of water policies that could address the mounting water scarcity problems. Suitable policies should improve economic efficiency, achieve environmental sustainability, and meet equity needs. This paper develops and applies an integrated hydro-economic model that links hydrological, economic and environmental elements to such issues. The model is used to conduct a direct comparison of water markets, water pricing and institutional cooperation, based on their economic, environmental and equity outcomes. The analysis is performed in the Jucar Basin of Spain, which is a good natural experiment for studying water scarcity and climate change policies. Results indicate that both institutional and water market policies are high performing instruments to limit the economic damage costs of droughts, achieving almost the same social benefits. However, the environmental effects of water markets are worrying. Another important finding is that water pricing is a poor policy option not only in terms of private and environmental benefits but also in terms of equity.

Keywords: water scarcity; climate change; water policies; hydro-economic modeling; economic and environmental benefits

1. Introduction

Water scarcity and water quality degradation are becoming widespread problems in most regions around the world. The reasons are the large increase in global water extractions in the last century from 600 to 3900 km^3, driven by the intensive growth of population and income, coupled with a questionable performance of water governance and policies [1].

The scale of the global growing overexploitation indicates that water mismanagement is quite common, and that sustainable management of basins is a complex and difficult task. At first, water scarcity resulted from surface extractions, but recently it is worsening because of the unprecedented depletion of groundwater brought about by falling pumping costs. Between 1960 and 2000, groundwater extractions rose from 310 to 730 km^3 per year pushing depletion up to 150 km^3 [2]. This staggering annual depletion ranges from 50 km^3 in the Indus-Ganges-Brahmaputra region to 24 km^3 in the USA, and is 13 km^3 in the Tigris-Euphrates region, and 9 km^3 in Northern China (NASA GRACE data estimations).

Water scarcity is increased gradually by the decisions on water extractions in river basins linked to land use and economic activities. The problems arising from water scarcity could become critical during drought periods. Climate change is projected to aggravate the severity and recurrence of drought events, especially in arid and semiarid regions [3]. In those regions, the combined effects of human-induced permanent water scarcity and climate change-induced droughts portend unprecedented levels of water resources degradation.

The sustainable management of water is quite challenging because of the different types of goods and services provided by water. These goods and services can be classified as private goods, common pool resources, or public goods, depending on the degree of exclusion and rivalry in consumption among consumers. A good is non-excludable when individuals cannot be excluded from their use, and a good is non-rival when consumption by one individual does not reduce availability to others. Treated drinkable water in urban networks is close to a private good (rivalry & exclusion), water in surface watercourses and aquifers is close to a common pool resource (rivalry & non-exclusion), while water sustaining ecosystems comes close to a public good (non-rivalry & non-exclusion) [4]. The management of water is governed by public policies because pure competitive markets fail to account for the common pool and public good characteristics of water.

The contribution of this paper is to develop and apply an innovative approach to inform the ongoing policy discussion addressing water scarcity and droughts. A hydro-economic model of the Jucar Basin in Spain is used to conduct a direct comparison of policies based on their economic, environmental and equity effects. Three policy alternatives are considered: (1) an institutional approach based on stakeholders' cooperation; (2) a water market policy; and (3) a water pricing policy. The assessment of the three policies provides information to stakeholders and decision makers about the tradeoffs between the policies in the allocation of water among sectors and locations. The paper is organized as follows. The three types of water policies are reviewed in Section 2. Then, the Jucar River Basin and the modeling framework are described in Section 3. Section 4 presents the drought and policy scenarios and the simulation results. Finally, Section 5 concludes with the summary and policy implications.

2. Types of Policy Instruments

Three types of policy instruments could address the market externalities created by the common pool and public good characteristics of water. The first type is the "Pigou solution", based on taxation of water extractions [5]. This is the water pricing approach that is being implemented in the European Water Framework Directive (WFD) [6]. The second type is the "Coase solution", which is based on privatizing the resource and trading [7]. This is the water market approach that has been implemented in Australia [8]. The third type is the common property governance [9], based on the evidence that coercive government rules can fail because they lack legitimacy and knowledge of local conditions. This is the institutional cooperative approach, where affected stakeholders design the rules and enforcement mechanisms for the sustainable management of common pool resources [10], although this approach has not received widespread attention in either research or policy circles.

Mainstream water policies in some countries are derived from the Dublin Statement on Water, which declares water an economic good [11], and are based on so-called economic instruments such as water markets or water pricing. Besides the European Union and Australia, both water pricing and water markets are being considered at present for solving the acute water scarcity problems in China [12].

These economic instruments can work well when water exhibits private good characteristics such as in urban networks, but work less well when water exhibits common pool resource or public good characteristics. There is a strong consensus among experts that water pricing could achieve sizable gains in efficiency and welfare in urban and industrial water networks [13], although implementation could face technical and political difficulties. Irrigation water from surface watercourses and aquifers exhibits common pool resource characteristics, and the use of economic instruments requires transforming the resource into a private good. This transformation is quite difficult, especially in arid and semiarid regions under strong water scarcity pressures, and would require the support of stakeholders.

Water pricing in irrigation, to achieve water conservation, has been the subject of debate since the 1990s. A string of the literature finds that irrigation water pricing has limited effects on water conservation [14,15], and some authors indicate that water markets seem far more effective than water pricing for allocating irrigation water [16]. Several studies in Spain support those previous findings, but also find that water pricing policy involves disproportionate costs to farmers [17,18]. In contrast, Tsur *et al.* [19] indicate that water pricing could achieve an efficient allocation of irrigation water without damaging farmers' benefits, if the pricing policy guarantees that all or part of the revenue collected by water agencies remains in the area and is reinvested in improving water use efficiency.

In recent decades, the water market approach has been gaining ground in some parts of the world to allocate water to irrigation such as in Australia and Chile. Previous studies in the literature consider that water trading is a flexible and efficient way to address water allocation problems [20–22]. These studies indicate that water markets may increase water use efficiency, avoid the development of new costly water resources, and achieve significant welfare gains by reallocating water from crops with low to high marginal value of water. Numerous pre-requisites are needed for the design of well-functioning water markets such as the definition of water rights, the creation of legal and institutional frameworks for trade, and investments in infrastructure to facilitate water transfer [23].

The Murray-Darling Basin in Australia is the main agricultural area in the country. It is at present the most active water market in the world, and during the drought of 2002–2012, this market generated benefits in the range of several hundred million to 1 billion US dollars per year [24,25]. A challenge to water markets is the third party effects such as environmental impacts, which would reduce the benefits of trading. Water markets reduce streamflows because previously unused water allocations are traded, and also because gains in irrigation efficiency at a parcel level reduce drainage and return flows to the environment downstream. This reduction in basin return flows has been demonstrated in different settings [26–28]. Another worrying effect is the large surge in groundwater extractions, as shown in the last drought in the Murray-Darling Basin (Blewett [29] indicates that extractions between 2002 and 2007 were seven times above the allowed limits placed on groundwater users). The choice in Australia has been to mostly ignore the third party impacts of water markets [24].

Medellín *et al.* [30] estimate very large potential gains from water trading under droughts or climate change in California. These gains in the Central Valley of California are estimated at 1.4 billion US dollars. However, implementing these potential gains from trading is quite a challenge as the failure of the Water Bank experience in the 2009 drought shows. Water transfers were blocked by the water exporting regions and environmentalist NGOs.

Culp *et al.* [31] indicate that the highly complex institutional setting in western USA, including a set of restrictive laws and regulations on water rights, imposes significant obstacles to water trading. Thus, the transaction costs of trading are extremely high, limiting the achievement of the full potential of water markets. The issue of transaction costs has been analyzed by Regnacq *et al.* [32] for the case of California water markets. Their empirical results show the importance of the transaction costs linked to distance and institutional impediments in the decision to trade. Although part of these costs represents a legitimate means to avoid third party impacts (especially the natural environment), the rest of the costs could be reduced to increase trade. The attainment of the water markets solution seems to require well-functioning institutions, involving stakeholders' cooperation and more transparent administrative mechanisms.

In Spain, the approach to water management is based on institutional arrangements and relies on the river basin authorities. The basin authorities are responsible for water management, water allocation, control and enforcement, planning and waterworks. The special feature of this institutional arrangement is the key role played by stakeholders in managing the basin authority.

Stakeholders are part of the basin authorities, taking decisions in the basin governing bodies and in local watershed boards, and they are involved at all levels of decision making: planning, financing, waterworks, measures design, enforcement, and water management. The management of water is decentralized, with the basin authorities in charge of water allocation, and water user associations in charge of secondary infrastructure and water usage. The main advantage of this institutional setting is that stakeholders cooperate in the design and enforcement of decisions, rules and regulations, and therefore the implementation and enforcement processes are conducted smoothly [33].

Therefore, water allocation relies on the cooperation of stakeholders in basin authorities. Although water management in Spain is far from perfect, there have been recent mounting signs of successful experiences in the case of the La Mancha aquifers [34], where aquifer extractions have been curbed through stakeholders' cooperation.

Irrigated agriculture is the largest user of water in most arid and semiarid regions, and plays an important role in sustaining rural livelihoods and ecosystems. Adjustments to the shortfall of water supply in basins fall mainly on irrigation activities, which often trigger considerable economic and environmental impacts, and social conflicts. One important question for future policy debates is the identification of potential water management policies in irrigation. Suitable policies should improve economic efficiency, achieve environmental sustainability, and address equity when faced by growing scarcity, droughts and climate change.

Previous studies in the literature analyzed the advantages and limitations of the different approaches to allocate water in irrigation. We find that there is a gap in previous literature regarding the comparison between policy instruments in order to address the market externalities of water resources, and also to determine the relative efficacy of these different policy approaches. Filling this gap may improve the performance of water policies in many basins. The contribution of this paper is to apply state-of-art methodology in the direct comparison of three important water policy instruments: water markets, water pricing, and the status-quo institutional cooperation. The analysis is performed by formulating and applying an integrated hydro-economic model that links hydrological, economic, and environmental elements to assess the performance outcomes of these policies.

3. Materials and Methods

3.1. The Jucar River Basin

The Jucar River Basin (JRB) is located in the regions of Valencia and Castilla-La Mancha in Eastern Spain. It extends over 22,300 km^2 and covers the area drained by the Jucar River and its tributaries, mainly the Magro and the Cabriel Rivers (Figure 1). The Basin has an irregular Mediterranean hydrology, characterized by recurrent drought spells and normal years with dry summers.

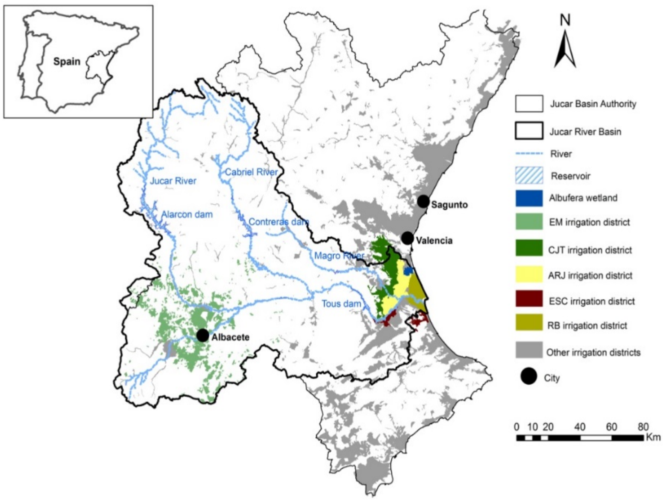

Figure 1. Map of the Jucar River Basin.

The JRB renewable water resources are nearly 1700 Mm^3/year but water extractions are very close to renewable resources, 1680 Mm^3, and the Basin is almost a closed water system. The main water use is irrigated agriculture with 1400 Mm^3, followed by urban and industrial uses of 270 Mm^3, which supply households, industries, and services of more than one million inhabitants (Table 1). There are also non-consumptive uses for hydropower, aquaculture and recreation.

Table 1. Water use by sector and origin in the JRB in a normal flow year (Mm^3). Source: CHJ [35].

Origin	Agriculture	Urban	Industrial	Total
Surface water	761	118	24	903
Groundwater	633	104	25	762
Reuse	11	0	1	12
Total	1405	222	50	1677

The irrigated area extends over 190,000 ha, and the main crops grown are rice, wheat, barley, garlic, lettuce, grapes, and citrus. There are three major irrigation areas located in the upper Jucar, the lower Jucar, and the bordering area of the Turia Basin. The Eastern La Mancha irrigation area (EM) is located in the upper Jucar, covering 100,000 ha. The irrigation districts of Acequia Real del Jucar (ARJ), Escalona y Carcagente (ESC), and Ribera Baja (RB) are in the lower Jucar, with an area of 35,000 ha. The irrigation district of Canal Jucar-Turia (CJT) is located in the bordering Turia Basin with an area of 22,000 ha (Table 2).

Table 2. The main water users in the JRB. Source. CHJ [35].

Water Users	Water Use (Mm^3)		
	Surface Water	Groundwater	Total
City of Albacete	17	0	17
EM aquifer irrigation district	13	386	399
Nuclear central of Cofrentes	14	0	14
City of Valencia	95	0	95
City of Sagunto	8	0	8
CJT irrigation district	70	91	161
ARJ irrigation district	213	0	213
ESC irrigation district	38	0	38
RB irrigation district	254	0	254
Other uses	193	285	478
Total JRB	915	762	1677

The expansion of water extractions in the Basin and the severe drought spells in recent decades have triggered considerable negative environmental and economic impacts. The growth of water extractions in recent decades has been driven especially by subsurface irrigation from the EM aquifer. The aquifer depletion, combined with other important water extractions in the Basin, and the recurrent drought spells have caused the water flows in the Jucar River to diminish. Environmental flows are dwindling in many parts of the Basin, resulting in serious damages to water-dependent ecosystems. There have been negative impacts on the downstream water users. For instance, the water available to the ARJ district has fallen from 700 to 200 Mm^3 in the last 40 years. Consequently, the dwindling return flows from the irrigation districts in the lower Jucar have caused serious environmental problems to the Albufera wetland, which is mostly fed by these return flows [36].

The Albufera wetland is the main aquatic ecosystem in the JRB. It is a fresh-water lagoon included in the RAMSAR list, and was declared a special protected area for birds (The RAMSAR convention is an international treaty for the conservation and sustainable utilization of wetlands). The Albufera wetland receives water from the return flows of the irrigation districts in the lower Jucar, mainly from the ARJ and the RB irrigation districts, and other flows originate from discharges of untreated and treated urban and industrial wastewaters. There is an important water quality problem driven by deficiencies in the sewage disposal and treatment systems in the adjacent municipalities, and by the reduced flows originating from the Jucar River that are used to improve the quality of wastewater discharges [37].

The increased frequency and intensity of drought spells during recent decades has been addressed by the Jucar Basin authority with investments in several long-term adaptation measures, such as construction of storage and regulation facilities, improvement of water efficiency through investment in irrigation systems, and installation of metering devices and special groundwater monitoring programs to control groundwater extractions.

3.2. The Modeling Framework

The comparison of policies is based on the hydro-economic model developed in Kahil *et al.* [38]. The model includes three components: (1) a reduced form hydrological sub-model; (2) a regional economic sub-model consisting of irrigation districts and urban centers; and (3) an environmental benefit sub-model. The reduced form hydrological sub-model is used to link the different components of the River Basin and to simulate the spatial hydrological impacts of droughts. The mathematical formulation of the reduced form hydrological sub-model is as follows:

$$Wout_d = Win_d - Wloss_d - Div_d^{IR} - Div_d^{URB} \tag{1}$$

$$Win_{d+1} = Wout_d + r_d^{IR} \cdot \left(Div_d^{IR}\right) + r_d^{URB} \cdot \left(Div_d^{URB}\right) + RO_{d+1} \tag{2}$$

$$Wout_d \geqslant E_d^{min} \tag{3}$$

where Equations (1)–(3) are the mass balance, the flow continuity, and the minimum-environmental flow constraints, respectively. These constraints determine the water available in the different river reaches that can be used after considering the environmental restrictions. $Wout_d$ is the water outflow from a river reach d; Win_d the water inflow to d; $Wloss_d$ the loss of water in d; Div_d^{IR} the water diversion to irrigation districts located in d; Div_d^{URB} the water diversion to urban and industrial activities located in d; Win_{d+1} the water inflow to the next river reach $d+1$; $\left[r_d^{IR} \cdot \left(Div_d^{IR}\right)\right]$ the return flows from irrigation districts; $\left[r_d^{URB} \cdot \left(Div_d^{URB}\right)\right]$ the return flows from urban and industrial activities; RO_{d+1} the runoff entering river reach $d+1$ from tributaries; and E_d^{min} the minimum environmental flow established for each river reach.

The regional economic sub-model accounts for the decision processes made by irrigation water users in the five major irrigation districts (EM, CJT, ARJ, ESC, and RB) and by urban users in the three main cities (Valencia, Albacete, and Sagunto). A farm-level programming component has been developed for each irrigation district, which maximizes farmers' private benefits from irrigation activities by choosing a crop mix subject to various technical and resource constraints. A Leontief production function technology is assumed with fixed input and output prices, in which farmers are price takers. The optimization problem is given by the following formulation:

$$Max\ B_k^{IR} = \sum_{ij} C'_{ijk} \cdot X_{ijk} \tag{4}$$

subject to

$$\sum_{i} X_{ijk} \leqslant Tland_{kj} \tag{5}$$

$$\sum_{ij} W_{ijk} \cdot X_{ijk} \leqslant Twater_k \tag{6}$$

$$\sum_{ij} L_{ijk} \cdot X_{ijk} \leqslant Tlabor_k \tag{7}$$

$$X_{ijk} \geqslant 0 \tag{9}$$

where B_k^{IR} is farmers' net benefits in irrigation district k. C'_{ijk} is a vector of coefficients of net income per hectare of crop i using irrigation technology j. The net income of each crop is equal to revenue minus direct and indirect costs, and amortizations. The decision variable in the optimization problem is X_{ijk}, corresponding to the area of crop i using irrigation technology j. Crops are aggregated into three representative crop groups: cereals, vegetables, and fruit trees. Irrigation technologies are flood, sprinkler, and drip.

Constraint Equation (5) represents the available area for irrigation equipped with technology j in irrigation district k, $Tland_{kj}$. The water constraint Equation (6) represents irrigation water availability in irrigation district k, $Twater_k$, which depends on surface and subsurface water extractions for that district. Parameter W_{ijk} is gross water requirements per hectare of each crop i using irrigation technology j. The labor constraint Equation (7) represents labor availability in irrigation district k, $Tlabor_k$. Parameter L_{ijk} is labor requirements per hectare of crop i using irrigation technology j.

For urban water uses, an economic surplus optimization scheme has been developed for each city in the Basin. The optimization problem maximizes social surplus given by the consumer and producer surplus from water use in each city, subject to several physical and institutional constraints. The optimization problem is:

$$Max\ B_u^{URB} = \left(a_{du} \cdot Q_{du} - \frac{1}{2} \cdot b_{du} \cdot Q_{du}^2 - a_{su} \cdot Q_{su} - \frac{1}{2} \cdot b_{su} \cdot Q_{su}^2 \right) \tag{9}$$

subject to

$$Q_{du} - Q_{su} \leqslant 0 \tag{10}$$

$$Q_{du},\ Q_{su} \geqslant 0 \tag{11}$$

where B_u^{URB} is the consumer and producer surplus of city u. Variables Q_{du} and Q_{su} are water demand and supply by/to the city u, respectively. Parameters a_{du} and b_{du} are the intercept and slope of the inverse demand function, while parameters a_{su} and b_{su} are the intercept and slope of the water supply function. Equation (10) states that supply must be greater than or equal to demand. The quantity supplied, Q_{su}, is the connecting variable between urban use optimization components and the reduced form hydrological sub-model.

The environmental benefits sub-model accounts for the environmental benefits generated by the main aquatic ecosystem in the JRB, the Albufera wetland. The sub-model considers only water inflows to the Albufera wetland originating from irrigation return flows of the downstream ARJ and RB irrigation districts. Inflows and benefits of the Albufera wetland are given by the following expressions:

$$E_{Albufera} = \alpha \cdot r^{IR}_{ARJ} \cdot \left(D^{IR}_{ARJ}\right) + \beta \cdot r^{IR}_{RB} \cdot \left(D^{IR}_{RB}\right) \tag{12}$$

$$B_{Albufera} = \begin{cases} \rho_1 \cdot E_{Albufera}\ if\ \ 0 \leqslant E_{Albufera} \leqslant E_1 \\ \delta_2 + \rho_2 \cdot E_{Albufera}\ if\ \ E_1 < E_{Albufera} \leqslant E_2 \\ \delta_3 + \rho_3 \cdot E_{Albufera}\ if\ E_{Albufera} > E_2 \end{cases} \tag{13}$$

where Equation (12) determines the quantity of water flowing to the Albufera wetland, $E_{Albufera}$. Parameters α and β represent the shares of return flows that feed the wetland from the ARJ and RB irrigation districts, respectively. The products $[r^{IR}_{ARJ} \cdot (D^{IR}_{ARJ})]$ and $[r^{IR}_{RB} \cdot (D^{IR}_{RB})]$ are return flows from the ARJ and RB irrigation districts, respectively.

Equation (13) represents economic environmental benefits, $B_{Albufera}$, from the ecosystem services that the Albufera wetland provides to society. The environmental benefit function is assumed to be a piecewise linear function of water inflows, $E_{Albufera}$, to the wetland. This function expresses shifts in the ecosystem status when critical thresholds of water inflows E_1 and E_2 are reached, following the approach of Scheffer *et al.* [39]. The reason is that ecosystems do not always respond smoothly to changes in environmental conditions, and they may switch abruptly to a contrasting alternative state for certain critical levels. Time series data of various hydrological and chemical indicators have been collected to characterize the ecosystem health status of the wetland [35], along with economic valuation studies of the Albufera and other wetlands [40–42]. The specification and estimation of the environmental benefit function are described in Kahil *et al.* [38].

Detailed information on the technical coefficients and parameters of the hydro-economic model has been collected from field surveys, expert consultation, statistics, and reviewing the literature [35,43–47]. This information covers water inflows to the Basin, water diversion to users, urban water prices and costs, efficiency of primary and secondary conveyance channels, crop yields and prices, subsidies, production costs, amortizations, crop water requirements, crop labor requirements, land and labor availability, and groundwater extractions.

4. Comparison of Water Policies

Results from running the hydro-economic model are used to analyze the economic and environmental effects of the three alternative water policies designed to cope with scarcity and drought: the current institutional arrangement of the basin authority, water markets, and water pricing. Water markets and water pricing are implemented differently. First, the model is run to maximize the private benefits of irrigation and urban use. This solution entails the optimal water allocations and optimal shadow prices (Shadow prices reflect the economic value of water to users and their willingness to pay for it. In technical terms, the shadow price of water is the marginal value of water for the particular user, or the value the user obtains from applying an additional unit of water. In the water market policy, water is exchanged until the shadow prices are equalized among all users, following the equi-marginal rule). Two policies can be implemented to achieve this optimal solution. One is water markets, where trading among users leads to the optimal water allocations (which generate the corresponding shadow prices). The other policy is water pricing, where water taxes are used to align current water prices with the optimal shadow prices (which generate the corresponding water allocations). The resulting benefits for farmers are quite different under water markets and water pricing, since farmers make revenue when selling water with markets, but with water pricing, they lose revenue because of the water taxes.

The model provides results on the private benefits of users, environmental benefits, water use and return flows, and inflows to the Albufera wetland. Social benefits are assumed to be the sum of the private benefits from irrigation and urban use, and the environmental benefits (Table 3).

Table 3. Policies under drought: institutional cooperation, water markets, and water pricing.

Drought Scenario	**Normal Year**	**Mild Drought**			**Severe Drought**		
Type of Water Policy	**Current Situation (Institutional Cooperation)**	**Institutional Cooperation**	**Water Markets**	**Water Pricing**	**Institutional Cooperation**	**Water Markets**	**Water Pricing**
			Water Use (Mm^3) ^{a}				
Irrigation districts	1030	908	908	908	683	683	683
EM	399	359	363	363	304	316	316
CJT	155	132	150	150	107	146	146
ARJ	200	180	197	197	131	185	185
ESC	33	30	32	32	18	31	31
RB	243	207	166	166	123	4	4
Urban use	119	105	105	105	74	74	74
Traded water	-	-	40	-	-	120	-
Environmental flows (inflows to Albufera)	60	52	50	50	34	29	29
			Private and Environmental Benefits (million Euros) ^{b}				
Private benefits							
Irrigation districts	190	171	175	93	136	148	54
EM	80	72	72	37	61	62	31
CJT	45	40	42	33	36	39	17
ARJ	34	31	32	17	23	25	4
ESC	7	7	7	5	4	5	2
RB	24	21	22	1	12	17	0
Urban use	283	276	276	276	241	241	241
Total	473	447	451	369	377	389	295
Environmental benefits	75	37	32	32	22	19	19
Social benefits	548	484	483	401	399	408	314

Note: ^{a} Water allocations to irrigation, urban use and environment in million cubic meters. ^{b} Private benefits from irrigation and urban use, and environmental benefits in million Euros.

Two drought scenarios are considered, mild drought and severe drought. The reduction of water inflows over normal levels is 22 percent for mild droughts, and 66 percent for severe droughts. More information on the characterization of drought scenarios can be found in Kahil *et al.* [38]. The model simulates the outcomes of the three alternative policies to deal with these two drought scenarios.

Institutional cooperation is the baseline policy, and represents the current water management to cope with scarcity and droughts. The basin authorities are the main administrative bodies responsible for water management, and they are organized around the governing boards, the stakeholder boards, and the management services. An important feature of basin authorities is the involvement of stakeholders, which has been a permanent characteristic since their creation in the 1920's. Stakeholders include water users, public administrations, farmers' unions and environmental groups. The stakeholders' representatives are present in all governing and participation bodies at the basin scale, and run the watershed boards at the local scale [33].

This approach entails flexible adaptive changes in water allocations based on the negotiation and cooperation of users, where water stakeholders are involved in the decision making process, including the environmental concerns. The water allocations that result from cooperation are observed in the data from both normal and drought periods.

The *water market* policy opens up water trading between economic agents in irrigation districts and urban centers. Economic theory predicts that water markets achieve welfare gains by reallocating water from low to high marginal values of water, and this efficient use of water maximizes the total private benefits summed over agents. The model is used to test the water market policy alternative, and empirically estimate the market potential welfare gains. Water trade becomes more pronounced as drought severity intensifies, reaching 120 Mm^3 under severe drought. The main effect is the improvement of irrigation efficiency, but also the subsequent fall in irrigation return flows, which further reduce the environmental flows in the basin.

The *water pricing* policy achieves also the efficient use of water by adjusting water prices to balance water demand with the available water supply during drought. This policy alternative is in line with the water pricing policy advocated by the European Water Framework Directive, reiterated in the recent Blueprint to Safeguard Europe's Water Resources [6]. Water prices in each irrigation district and urban center are set equal to the marginal value of water at the efficient level of water use, which is the market-clearing price. This water tax revenue is collected by the public and private water agencies responsible for water supply. All or part of this revenue may be employed outside the basin areas, representing a loss of benefit from both individual farmer and basin perspectives. One advantage of the *water pricing* policy is that it assures the financial viability of the water agencies, which could guarantee their operation without the need of public subsidies. As indicated above, the water taxes levied with water pricing involve significant revenue losses for farmers.

Social benefits under the *institutional* or baseline policy in normal flow conditions amount to 548 million Euros. Private benefits are 190 million Euros for irrigation and 283 million for urban demand, from using 1030 and 119 Mm^3 of water, respectively. Environmental benefits provided by the Albufera wetland are 75 million Euros, and the Albufera wetland receives 60 Mm^3 of return flows from the ARJ and RB irrigation districts, which support the ecological status of the wetland.

4.1. Mild Drought Scenario

Mild drought events reduce social benefits by 65 million Euros under the institutional and water market policies, but the social benefits are reduced by 150 million Euros under water pricing. The environmental losses are close to 40 million Euros under all policies, cutting environmental benefits by half. The difference among policies is the irrigation losses, which are below 20 million under institutional and water market policies, but escalate to 100 million under water pricing. Therefore the large benefit losses from the water pricing policy are driven by the large impact of pricing on irrigation profits.

The environment sustains significant benefit losses derived from the reduction of water inflows to the Albufera wetland. These water inflows under water markets and water pricing fall below the critical threshold E_1, creating a regime shift in the wetland. The institutional policy achieves higher environmental benefits because it allocates more water to the Albufera wetland, avoiding further desiccation and ecosystem degradation.

The effects on the urban sector are moderate both in terms of water allocations and private benefits. The reason is the priority rules under the institutional policy, and also the availability of additional water sources at higher costs from neighboring basins in the case of Valencia and Sagunto (Turia Basin), or groundwater in the case of Albacete.

Farmers face diminishing water use from drought and reduced crop acreage, mostly cereals because these are the less profitable crops. The allocation of irrigation water to the RB, ARJ and CJT districts changes between the institutional and water market policies. Water markets allocate 40 Mm^3 less water to RB, and this water is assigned to ARJ and CJT. These water exchanges are driven by the differences among water shadow prices in districts. As indicated above, the shadow prices of water are the marginal values of water in each location, and therefore water exchanges reallocate water from locations with low marginal values of water to locations with high marginal values where water is more profitable. However, the private benefits of all irrigation districts are almost the same under both the institutional and water market policies.

The opportunity costs of policies incurred by farmers are the benefit losses sustained under each policy. A steep increase in the opportunity costs of a particular policy would be met by opposition from farmers leading to policy failure, given that other feasible policies are less costly. The costs of the water pricing policy are very high for farmers compared to the institutional or water market policies, with irrigation benefits falling by half when water pricing is implemented instead of the other policies. The reason for these high costs is the large losses sustained by farmers from taxing water. Opposition to the water pricing policy would be strong in the RB, EM and ARJ districts, where the opportunity costs of implementing water pricing are especially damaging to farmers. This empirical finding shows that the institutional and water market policy options are much more feasible and equitable than water pricing, because water pricing involves disproportionate costs to farmers.

4.2. Severe Drought Scenario

The effects of severe drought are more pronounced than those of mild drought, although they show similar patterns. The fall in social benefits is almost 150 million Euros under the institutional and water market policies, but social benefits losses escalate to almost 250 million under water pricing. Environmental benefits sustain quite large losses, although the institutional policy allocates slightly more environmental flows to the Albufera wetland.

The irrigation benefits by district are almost the same under the institutional and water market policies, and the main difference is the change in water allocation to the RB, ARJ and CJT districts. Compared to the institutional policy, water markets are driven by the shadow prices of water, reallocating water from locations with low marginal value of water to locations with high marginal value. Water trading allocates more water to the ARJ, ESC, EM and CJT districts by reducing the allocation of the RB district by 120 Mm^3.

Choosing the water pricing policy under severe drought is quite detrimental to farmers because water taxes escalate, and they cannot generate revenue by selling water. The implementation of water pricing instead of the institutional or water market policies, makes farmers lose two thirds of their private profits. In districts such as RB and ARJ, the private benefits of farmers are almost entirely wiped out. The opportunity costs for farmers of the water pricing policy are disproportionate.

The total costs and their distribution among those who bear them from confronting a severe drought in the Jucar Basin by the irrigation, urban and environmental sectors depend on the policy selected by decision makers, and these costs are given by the benefit losses incurred by each sector. These costs are 42 million Euros for the urban sector (283–241) and 53 million for the environment (75–22) regardless of the policy chosen, but these costs triple from 50 million Euros (190–140) to almost 150 million (190–54) for the irrigation sector by selecting the water pricing policy instead of the other policies.

4.3. Additional Measures to Protect The Environment

Protecting environmental flows, especially during droughts, is a major challenge in almost all basins in arid and semiarid regions. In these basins, regulators face a challenge to enforce environmental flows not only because they have to control surface and subsurface extractions, but also because the irrigation returns component of environmental flows is even more difficult to regulate than water extractions. Examples of these management difficulties include basins where water management efforts are quite sophisticated, such as the Jucar basin in Spain, the Murray-Darling Basin in Australia, and the Central Valley in California (In the Jucar Basin, there was a desiccation of the Jucar mainstem during the last drought [34]. In the Murray-Darling Basin, groundwater depletion reached 104 km^3 during the last drought [29]. In the Central Valley of California, groundwater depletion has reached 80 km^3 during the current drought [48]).

Two additional measures are considered for the JRB to protect environmental flows, one associated with water markets and the other with the institutional policy. The first measure follows the example of the Murray-Darling Basin, where a very expensive program is being implemented to recover water for the environment using a public water buyback program [49]. Although expensive, this seems to be a workable policy to reap most of the private benefits of pure water markets while protecting ecosystems, and this could be called the environmental water market. The second measure is to improve the current institutional stakeholder cooperation in Jucar, by including environmental stakeholders as full participants. These augmented environmental flows are achieved by the negotiation among all economic and environmental stakeholders, which appears to be a sustainable institutional policy.

Both the environmental water market and the sustainable institutional policies achieve large gains in environmental benefits, above 200 Million Euros in mild and severe droughts, with social benefits in the Basin reaching around 730 million Euros under mild drought and 660 million Euros under severe drought [38,50].

5. Conclusions

The sustainable use of water resources requires a reliable understanding of the main processes and their linkages, an accurate assessment of impacts, and improving management by stakeholders and governance by policy makers to deal with water scarcity, droughts and climate change. Sound management and governance is quite a challenge because of the wide and complex range of goods and services provided by water, including private goods, common pool resources, and public goods.

This paper presents an empirical assessment of three water policy instruments to address water scarcity and droughts: water pricing, water markets, and common property governance. A direct comparison of the three policies is made by developing and applying an integrated hydro-economic model of the Jucar Basin in Spain, analyzing the economic and environmental effects of each policy.

Water pricing and water markets are economic instruments that work well when water is a private good, but less well when water is a common pool resource or public good. Studies in California and Australia demonstrate the large gains of water markets, both potential gains in California [22,30] and actual gains in Australia [24,25].

We present evidence from Spain, a community with an ancient tradition of cooperation among stakeholders in water user associations dating back centuries. Evidence from Spain regarding alternative proposed policy instruments is derived from the Jucar Basin, where water markets, water pricing, and institutional policies are simulated under drought.

The empirical results highlight that both institutional and water market policies are economically-efficient instruments to limit the economic damage costs of droughts, achieving similar social benefits in terms of private and environmental benefits. This finding is important because it shows that in the case of Jucar, the status quo institutional policy can attain almost the same private benefits as water markets.

The advantages of water markets compared to the institutional policy of stakeholders' cooperation are a slight reduction in land fallowing, a small improvement in irrigation efficiency, and a more even distribution of drought losses among irrigation districts, important for equity concerns. Water markets minimize private economic damages from drought but disregard the environmental benefits. Results show that water markets entail a reduction of water for environmental purposes, causing faster ecosystem regime shifts compared to the current institutional setting. The reason lies with the public good characteristic of environmental flows, which are external to markets, leading to excessive ecosystem degradation. This is important when planning for a future with climate change and emerging social demands for and economic benefits from aquatic ecosystem protection.

Water pricing is the policy advocated by the European WFD. This policy poses important implementation challenges in arid and semiarid regions such as Spain, where irrigation is the largest user of water, with strong impacts on the supply of a wide range of ecosystem services. The water pricing policy for managing drought is detrimental to farmers. Implementing water pricing instead of water markets or institutional policies, increases farmers' losses by 80 and 100 million Euros, a high percentage of their base incomes, under mild and severe drought, respectively.

These benefit losses are the opportunity costs of the water pricing policy to farmers, and the steep opportunity costs of water pricing would be economically and politically damaging. The main empirical finding on water pricing is that farmers lose from half to two thirds of their net benefits when the water pricing policy is implemented during drought, instead of the water market or institutional policies. Enforcing water pricing will become a difficult task facing tough political and technical hurdles.

The empirical results show that water market and institutional policies are much more economically attractive and equitable than water pricing, because water pricing involves disproportionate costs to farmers. There are also additional measures for these two policies that could enhance the protection of environmental flows. One measure is public water buyback programs for water markets, in order to reap the benefits of water markets while protecting ecosystems. The other measure is greening the cooperation in the institutional policy, by including the environment as a full stakeholder in the process of water allocation among sectors and spatial locations. However, protecting the environment with water pricing will require adding further "environmental" and "resource use" costs to water prices (in WFD terminology), resulting in highly disproportionate costs to farmers.

Water management in the JRB is based on the negotiation and cooperation of stakeholders, which seems to provide a worthwhile prospect for sustainable water management in irrigation. In fact, this approach achieves better environmental outcomes compared to other policy instruments, and almost the same outcomes in terms of farmers' private benefits and social benefits compared to the water market policy. However, the status quo institutional-based approach poses difficult implementation challenges in real-world situations. The reasons are that institutions may involve asymmetric negotiation power among the stakeholders, while the severe scarcity of water resources may considerably reduce incentives for cooperation.

The evidence from the JRB highlights that, despite these limitations, the status quo institutional-based approach of stakeholders' cooperation was able to reduce environmental and economic damages during the last drought period, and to surrogate social conflicts by cooperation. The JRB experience suggests that the implementation of the institutional approach in managing water resources requires sufficient institutional capacity to deal with power asymmetry and resource scarcity, as well as available social capital supporting cooperation, which is particularly necessary for the promotion of self-regulation initiatives.

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References

1. United Nations Development Programme (UNDP). *Human Development Report 2006: Beyond Scarcity: Power, Poverty and the Global Water Crisis*; UNDP: New York, NY, USA, 2006.
2. Konikow, L. Contribution of global groundwater depletion since 1900 to sea-level rise. *Geophys. Res. Lett.* **2011**, *38*. [CrossRef]
3. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2014: Impacts, Adaptation, and Vulnerability*; Contribution of Working Groups II to the Fifth Assessment Report of the IPCC; IPCC: Geneva, Switzerland, 2014.
4. Booker, J.; Howitt, R.; Michelsen, A.; Young, R. Economics and the Modeling of Water Resources and Policies. *Nat. Resour. Model.* **2012**, *25*, 168–218. [CrossRef]
5. Pigou, A. *The Economics of Welfare*; Macmillan: New York, NY, USA, 1920.
6. European Commission (EC). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Blueprint to Safeguard Europe's Water Resources*; COM(2012) 673 Final; European Commission: Brussels, Belgium, 2012.
7. Coase, R. The problem of social cost. *J. Law Econ.* **1960**, *3*, 1–44. [CrossRef]

8. National Water Commission (NWC). *Water Markets in Australia: A Short History*; NWC: Canberra, Australian, 2011.
9. Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; Cambridge University Press: Cambridge, UK, 1990.
10. Ostrom, E.; Burger, J.; Field, C.; Norgaard, R.; Policansky, D. Revisiting the Commons: Local Lessons, Global Challenges. *Science* **1999**, *284*, 278–282.
11. International Conference on Water and the Environment (ICWE). *The Dublin Statement and Report of the Conference*; World Meteorological Organization: Geneva, Switzerland, 1992.
12. Che, Y.; Shang, Z. Water Pricing in China: Impact of Socioeconomic Development. In *Water Pricing Experiences and Innovations*; Dinar, A., Pochat, V., Albiac, J., Eds.; Springer: Dordrecht, The Netherlands, 2015.
13. Hanemann, W. Determinants of Urban Water Use. In *Urban Water Demand Management and Planning*; Bauman, D., Boland, J., Hanemann, W., Eds.; McGraw-Hill: New York, NY, USA, 1998.
14. Moore, M. The bureau of reclamations new mandate for irrigation water conservation-purposes and policy alternatives. *Water Resour. Res.* **1991**, *27*, 145–155. [CrossRef]
15. Scheierling, S.; Young, R.; Cardon, G. Determining the price responsiveness of demands for irrigation water deliveries *versus* consumptive use. *J. Agric. Resour. Econ.* **2004**, *29*, 328–345.
16. Cornish, G.; Bosworth, B.; Perry, C.; Burke, J. *Water Charging in Irrigated Agriculture. An Analysis of International Experience*; FAO Water Report No. 28: Rome, Italy, 2004.
17. Garrido, A.; Calatrava, J. Trends in water pricing and markets. In *Water Policy in Spain*; Garrido, A., Llamas, M., Eds.; CRC Press: Leiden, The Netherlands, 2009.
18. Calatrava, J.; Guillem, A.; Martinez-Granados, D. Análisis de alternativas para la eliminación de la sobreexplotación de acuíferos en el Valle del Guadalentín. *Econ. Agrar. Recur. Nat.* **2011**, *11*, 33–62.
19. Tsur, Y.; Dinar, A.; Doukkali, R.; Roe, T. Irrigation water pricing: Policy implications based on international comparison. *Environ. Dev. Econ.* **2004**, *9*, 735–755. [CrossRef]
20. Easter, K.; Dinar, A.; Rosegrant, M. The Performance of Water Markets: Transaction Costs, Interjurisdictional Barriers and Institutional Options. In *Conflict and Cooperation on Trans-Boundary Water Resources*; Just, R., Netanyahu, S., Eds.; Kluwer: Norwell, MA, USA, 1998.
21. Connor, J.; Schwabe, K.; King, D.; Kaczan, D.; Kirby, M. Impacts of climate change on lower Murray irrigation. *Aust. J. Agric. Resour. Econ.* **2009**, *53*, 437–456. [CrossRef]
22. Howitt, R.; Medellín, J.; MacEwan, D.; Lund, J. Calibrating disaggregate economic models of agricultural production and water management. *Environ. Model. Softw.* **2012**, *38*, 244–258. [CrossRef]
23. Dinar, A.; Rosegrant, M.; Meinzen-Dick, R. *Water Allocation Mechanisms: Principles and Examples*; Policy Research Working Paper No. WPS 1779; World Bank: Washington, DC, USA, 1997.
24. Kirby, M.; Bark, R.; Connor, J.; Qureshi, E.; Keyworth, S. Sustainable irrigation: How did irrigated agriculture in Australia's Murray-Darling Basin adapt to the Millennium drought? *Agric. Water Manag.* **2014**, *145*, 154–162. [CrossRef]
25. Connor, J.; Kaczan, D. Principles for economically efficient and environmentally sustainable water markets: The Australian experience. In *Drought in Arid and Semi-Arid Environments: A Multi-Disciplinary and Cross-Country Perspective*; Schwabe, K., Albiac, J., Connor, J., Hassan, R., Meza, L., Eds.; Springer: Dordrecht, The Netherlands, 2013.
26. Qureshi, M.; Schwabe, K.; Connor, J.; Kirby, M. Environmental water incentive policy and return flows. *Water Resour. Res.* **2010**, *46*. [CrossRef]
27. Howe, C.; Schurmeier, D.; Shaw, W. Innovative Approaches to Water Allocation: The Potential for Water Markets. *Water Resour. Res.* **1986**, *22*, 439–449. [CrossRef]
28. Kahil, M.T.; Connor, J.; Albiac, J. Efficient water management policies for irrigation adaptation to climate change in Southern Europe. *Ecol. Econ.* **2015**, *120*, 226–233. [CrossRef]
29. Blewett, R. *Shaping a Nation. A Geology of Australia*; Geoscience Australia-ANU Press: Canberra, Australia, 2012.
30. Medellín, J.; Howitt, R.; Lund, J. Modeling Economic-Engineering Responses to Drought: The California Case. In *Drought in Arid and Semi-Arid Environments: A Multi-Disciplinary and Cross-Country Perspective*; Schwabe, K., Albiac, J., Connor, J., Hassan, R., Meza, L., Eds.; Springer: Dordrecht, The Netherlands, 2013.
31. Culp, P.; Glennon, R.; Libecap, G. *Shopping for Water: How the Market can Mitigate Shortages in the American West. Discussion Paper 2014-05*; Stanford Woods Institute for the Environment: Washington, DC, USA, 2014.

32. Regnacq, C.; Dinar, A.; Hanak, E. The gravity of water: Water trade friction in California. In Proceedings of the Meetings of the Allied Social Science Association, San Francisco, CA, USA, 3–5 January 2016.
33. Albiac, J.; Esteban, E.; Tapia, J.; Rivas, E. Water scarcity and droughts in Spain: Impacts and policy measures. In *Drought in Arid and Semi-Arid Environments: A Multi-Disciplinary and Cross-Country Perspective*; Schwabe, K., Albiac, J., Connor, J., Hassan, R., Meza, L., Eds.; Springer: Dordrecht, The Netherlands, 2013.
34. Esteban, E.; Albiac, J. The problem of sustainable groundwater management: The case of La Mancha aquifers, Spain. *Hydrogeol. J.* **2012**, *20*, 851–863. [CrossRef]
35. Confederación Hidrográfica del Júcar (CHJ). *Esquema Provisional de Temas Importantes*; Ministerio de Medioambiente: Valencia, Spain, 2009.
36. García-Molla, M.; Sanchis, C.; Ortega, M.; Avellá, L. Irrigation Associations Coping with Drought: The Case of Four Irrigation Districts in Eastern Spain. In *Drought in Arid and Semi-Arid Environments: A Multi-Disciplinary and Cross-Country Perspective*; Schwabe, K., Albiac, J., Connor, J., Hassan, R., Meza, L., Eds.; Springer: Dordrecht, The Netherlands, 2013.
37. Sanchis, C. La Albufera de Valencia: Cincuenta años de eutrofia. *Métode* **2011**, *70*, 32–41.
38. Kahil, M.T.; Dinar, A.; Albiac, J. Modeling water scarcity and droughts for policy adaptation to climate change in arid and semiarid regions. *J. Hydrol.* **2015**, *522*, 95–109. [CrossRef]
39. Scheffer, M.; Carpenter, S.; Foley, J.; Walker, B. Catastrophic shifts in ecosystems. *Nature* **2001**, *413*, 591–596. [CrossRef] [PubMed]
40. Del Saz, S.; Perez, L. El valor de uso recreativo del parque natural de L'Albufera a través del método indirecto del coste de viaje. *Estud. Econ. Apl.* **1999**, *11*, 41–62.
41. Woodward, R.; Wui, Y. The economic value of wetland services: A meta-analysis. *Ecol. Econ.* **2001**, *37*, 257–270. [CrossRef]
42. Brander, L.; Florax, R.; Vermaat, J. The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature. *Environ. Resour. Econ.* **2006**, *33*, 223–250. [CrossRef]
43. Generalitat Valenciana (GV). *Base de Datos 1T de Superficies de Cultivos por Término Municipal Para la Generalitat Valenciana 2009*; Departamento de Agricultura, Generalitat Valenciana: Valencia, Spain, 2009.
44. Gobierno de Castilla La Mancha (GCLM). *Base de Datos 1T de Superficies de Cultivos Por Término Municipal Para Castilla La Mancha 2009*; Departamento de Agricultura, Gobierno de Castilla La Mancha: Albacete, Spain, 2009.
45. Instituto Nacional de Estadística (INE). *Censo Agrario 2009*; INE: Madrid, Spain, 2009.
46. Confederación Hidrográfica del Júcar (CHJ). *Sistema Júcar: Datos Del Año Hidrológico 2012–2013*; Ministerio de Medioambiente: Valencia, Spain, 2012.
47. Ministerio de Medio Ambiente y Medio Rural y Marino (MARM). *Análisis de la Economía de Los Sistemas de Producción: Resultados Técnico-Económicos de Explotaciones Agrícolas de Valencia y Castilla La Mancha en 2009. Subsecretaria de Medio Ambiente, Medio Rural y Marino*; MARM: Madrid, Spain, 2010.
48. University of California Center for Hydrologic Modeling (UCCHM). *UCCHM Water Advisory # 1*; University of California: Irvine, CA, USA, 2014.
49. Wheeler, S.; Loch, A.; Zuo, A.; Bjornlund, H. Reviewing the adoption and impact of water markets in the Murray-Darling Basin, Australia. *J. Hydrol.* **2014**, *518*, 28–41. [CrossRef]
50. Kahil, M.T.; Dinar, A.; Albiac, J. Cooperative water management and ecosystem protection under scarcity and drought in arid and semiarid regions. *Water Resour. Econ.* **2015**. [CrossRef]