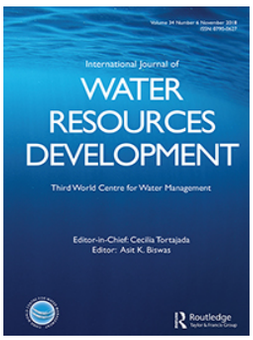

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The limited success of formal water markets in the Segura River basin, Spain

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ABSTRACT

The Segura basin in south-eastern Spain is one of the most water-scarce regions in Europe. Its water economy has characteristics that constitute very favourable conditions for water market activity, and there are significant trading opportunities. However, the traded volumes have been rather small even though most of the water market activity in continental Spain is concentrated there. This paper describes the few formal water market experiences in the Segura basin since water trading was legislated on and regulated in 1999. As a result of this analysis, some hypotheses are made regarding the causes of the limited operation of this economic instrument.

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Introduction

The Segura River basin (SRB) is one of the most water-scarce regions not only in Spain but throughout Europe. On top of the low rainfall, there is a large demand for water for the production of highly profitable fruit and vegetable crops, alongside sizeable population growth and the expansion of tourism over the last two decades. Against this backdrop of increasing scarcity, where there is high awareness regarding the conservation of water resources and their dependent ecosystems, the allocation of water generates major conflicts among users, which come to a head during frequent drought episodes (Calatrava & Martínez-Granados, 2012).

Water markets are one of the most promising instruments for reallocating water resources in mature water economies (Randall, 1981). They are capable of increasing the economic efficiency of water use and reducing the economic impact of scarcity (Easter & Huang, 2014). This was the purpose of the 1999 Water Law Amendment (Law 46/1999), which legislated and regulated the operation of water markets in Spain with the aim of flexibilizing the system of public water concessions (Rey, Garrido, & Calatrava, 2014).

Law 46/1999 provided, subject to application to and authorization by the respective basin authority, for voluntary water trading between concession holders entering into a private

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agreement to temporarily transfer their water use rights for a price ('compensation') through a 'temporary lease contract'. Users can enter into lease contracts with users in the same river basin, provided that they are for the same or a higher-priority use. Although this mechanism is designed for water allocation in times of scarcity, its operation is not confined to drought periods.

Later, during the 2005–08 drought, the Ministry of the Environment authorized lease contracts between users in different river basins as an exceptional emergency measure to abate water supply problems in the hardest-hit areas (Garrido, Rey, & Calatrava, 2013). Pursuant to Law 15/2005 (annually extended by additional legislation during droughts), inter-basin lease contracts using the existing infrastructure were authorized. This resulted in several agreements between users in the Segura and Tagus basins and the Almanzora and Guadalquivir basins, respectively.

Apart from the legal concept of lease contracts between users, Law 46/1999 provided for the possibility of basin authorities setting up water use rights exchange centres (WUREC). Through these exchange centres, the basin authorities could make public water rights purchase offers (PWRPOs) to holders interested in temporarily or permanently transferring their concessions, which they should then transfer to other interested holders (Calatrava & Gómez-Ramos, 2009), in the manner of the water banks operating in the United States of America (Garrido, Rey et al., 2013; Hadjigeorgalis, 2009; Loomis, Quattlebaum, Brown, & Alexander, 2003). The first WURECs were set up in the Guadiana, Júcar and Segura River basins in 2004. But they did not enter into operation until at the start of the 2005–08 drought, when Law 9/2006 reinforced their effectiveness and they were allowed to cater to other demands. In particular, apart from transferring resources to other users (the original goal), WURECs could use the purchased rights to target environmental uses or transfer rights to the regional governments in each basin.

In theory, the potential for the operation of water markets in the SRB is huge. On top of the droughts, generally lasting over two years, there is a chronic water shortage. This structural scarcity has led to the mobilization of all possible sources of supply, including a very high level of urban water reuse and a significant development of seawater desalination capacity (Martínez-Granados & Calatrava, 2017). Despite the diversity of the water resources used in the basin, demand still clearly outweighs supply, resulting in 'basin closure' (Molle, Wester, & Hirsch, 2010).

Likewise, there is a rather uneven distribution of water resources across the basin and among different users. The structure of the water use rights in the SRB is somewhat obsolete from the viewpoint of economic efficiency. On the one hand, traditional irrigated areas have older concessions that take priority over the basin surface waters, with very low supply costs. On the other hand, the most profitable irrigated agriculture is concentrated in regions with lower resource endowments, high water supply costs and more recent and rather insecure rights. On top of this, the value of water is high for many water uses, with sizeable differences across the basin, and there is water transportation infrastructure connecting the main irrigation areas in the basin. All this adds up to very favourable conditions for water trading activity. However, as will be shown, despite being home to the greatest water market activity in continental Spain, the trading volume in the Segura basin has been rather low in practice.

This paper reviews the formal water market experiences in the Segura basin since 1999. Formal water transactions were compiled and classified based on data from the scientific

literature, grey literature, water authorities and interviews with water user associations (WUAs). This study contributes to the ample international literature on water markets, and more specifically to that describing water trading in Spain, by providing a more detailed description and analysis of the water market experiences in the SRB. The paper continues with a description of the water economy in the SRB. Then the formal water market experiences to date are described, including trading between users in the basin and users in other basins and through PWRPOs. The paper concludes by stating a number of hypotheses, inferred from this analysis, as to why this economic instrument is not fully operational.

Water resources and demands in the Segura River basin

The SRB, located in the south-east of the Iberian Peninsula (Figure 1), is one of the most water-stressed regions in the Mediterranean basin. Its Mediterranean climate is characterized by a severe dry summer followed by sporadic intense rains in autumn, and frequent multi-annual droughts. For more information on the physical environment and irrigated agriculture, see Calatrava and Martínez-Granados (2012).

According to the most recent official estimates of water resource availability and demands in the SRB, average annual available renewable resources were 1403 Mm^3/year in 1980–2012, including surface resources, groundwater, external resources from other basins, reuse from the purification of urban and industrial wastewater and return flows from irrigation, and

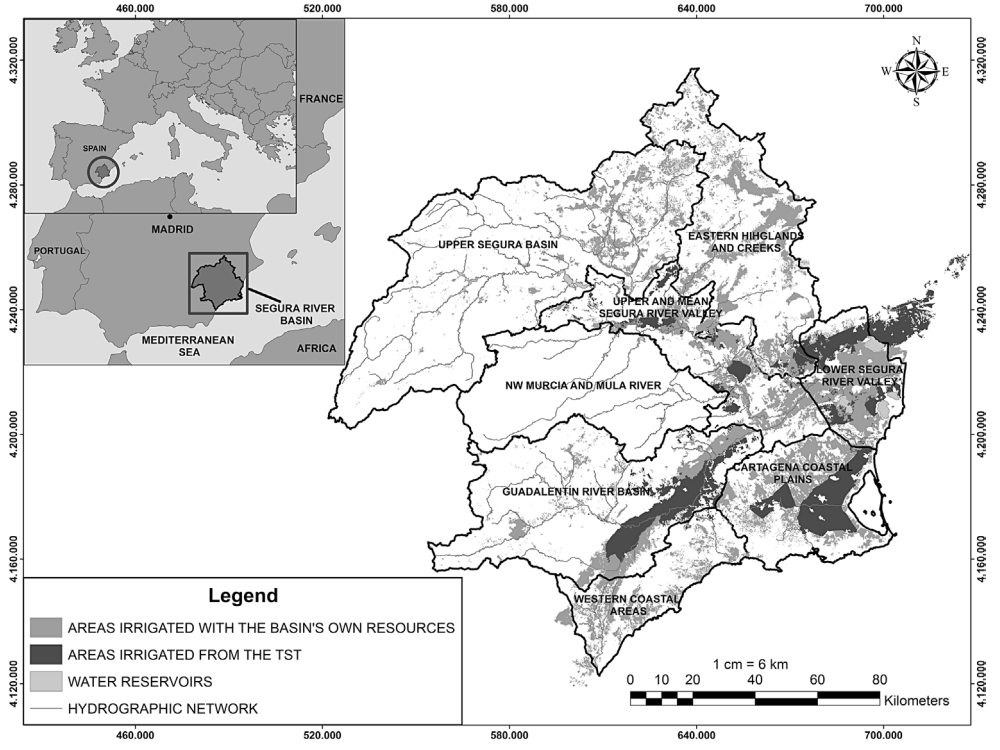

Figure 1. Hydrological and irrigated areas in the Segura basin. Source: Own elaboration with data from the Segura River Basin Authority.
Note: TST = Tagus-Segura Transfer.

desalination (CHS, 2014). Most of the basin's surface water resources come from the Segura River, whose tributaries have low river flows. Aquifers are the most important source of water, especially in coastal areas where there are no rivers. Another major source of water is the Tagus-Segura Transfer (TST), whereby water is transported from the Tagus basin in central Spain along a 300 km channel.

These water resources are not enough to satisfy the water demands in the Segura basin. They amount to approximately 1841 Mm^3/year, of which agriculture accounts for 1546 Mm^3, domestic consumption 236 Mm^3, industrial uses 20 Mm^3 and environmental uses 39 Mm^3. Consequently, the basin has a structural water deficit of approximately 438 Mm^3/year (1841 Mm^3 minus 1403 Mm^3). This deficit is offset by non-renewable groundwater pumping, estimated at 237 Mm^3/year, and by deficit application of water to crops, which are in many cases subject to water-stress conditions, estimated at 201 Mm^3/year.

As domestic and environmental uses have priority by law over other uses, the burden of this water deficit is borne by agriculture. Average renewable resources for irrigation are approximately 1113 Mm^3/year, whereas agricultural water demand is estimated at 1546 Mm^3/year (CHS, 2014). In fact, this disparity between the basin's resources and demands is the result of the huge increase in irrigated area over the last few decades based on very optimistic expectations about the yearly amount of water that would be transferred through the TST, which in practice has supplied about half of the initially planned volumes, and with major inter-annual variations (Rey, Garrido, & Calatrava, 2016b).

The Segura basin is an eminently agricultural region, and, as shown, agriculture is the main water user. Irrigable area in the SRB is 472,000 hectares, 261,000 hectares of which are currently irrigated (CHS, 2014). The irrigated area has doubled over the last 35 years, exacerbating the water scarcity in the basin and generating a severe overdraft problem in many aquifers. A total of 152,000 hectares (darker grey in Figure 1), some of which are not within the SRB boundaries, are served with water from the Tagus basin through the TST (CHS, 2015).

The agricultural sector is very important to the basin's economy in terms of production, employment and exports. The value of agricultural production depends basically on irrigated agriculture, mainly vegetables, citrus, temperate-climate fruits, and grapes. Maestre-Valero, Martínez-Granados, Martínez-Alvarez, and Calatrava (2013) estimate the average value of agricultural production in the SRB at €2002 million/year. This results in a farm profit of €865 million/year and generates annual employment equivalent to 58,500 annual work units. Intensive vegetable production is mostly located in the coastal areas and in the Guadalentín River Valley (bottom part of Figure 1), which are mainly supplied by groundwater resources and the TST. Fruit production is mostly located in the traditional irrigated areas of the Segura River Valley. Farms in traditional irrigated areas tend to be smaller, whereas farms in newly irrigated areas usually have a larger area and more capital. Irrigated vineyards, almond trees and rice predominate in the upper basin and in the north-west and north-east of the Murcia Region (Figure 1) (Calatrava & Martínez-Granados, 2012).

The use value of water in the SRB is among the highest in Spain. In terms of raw water, and for the whole basin, the marginal value of water is €0.52/m^3, while the average value is €0.81/m^3 (Calatrava & Martínez-Granados, 2012). However, there are significant differences in these values from one area to another. The marginal value of water in the different areas of the basin ranges between €0.13/m^3 and €0.97/m^3, whereas the average value ranges between €0.46/m^3 and €1.64/m^3. The use value of water in agriculture is higher in coastal areas (southern areas in Figure 1) and in the irrigated areas that are supplied with water from

the TST (darker grey in Figure 1), because they are home to the most intensive and profitable vegetable and greenhouse farming and tend to be the basin's most modernized and least water-endowed areas (Calatrava & Martínez-Granados, 2012).

According to the Segura River Basin Authority (SRBA) (CHS, 2014), the average tariff paid by agricultural users in the SRB for raw water is €0.14/m^3, whereas WUAs pay an average of €0.17/m^3, considerably more than the average water tariff for all of Spain, which is equivalent to €0.021/m^3 for raw water (Calatrava, García-Valiñas, Garrido, & González-Gómez, 2015). Water tariffs in the SRB differ significantly depending on the source of water. Average tariffs are €0.035/m^3 for surface and treated wastewater, €0.20/m^3 for groundwater and €0.45/m^3 for desalinized seawater. Generally, these average tariffs are very similar across the different areas of the basin, with the exception of groundwater, whose extraction costs range from €0.10/m^3 to €0.47/m^3 (CHS, 2014). On top of the above tariff, farmers also pay distribution costs to the WUAs ranging from €0.04/m^3 to €0.075/m^3, with an average of €0.06/m^3, according to our own estimates based on data from several WUAs in the basin. For urban uses, the average price of water supplied by Mancomunidad de Canales del Taibilla (MCT), the major domestic wholesale water supplier in the SRB, is €0.6433/m^3.

Lease contracts between Segura River basin users

The data on water transactions presented in this paper were obtained from the scientific literature, internal reports of the Sindicato Central de Regantes del Acueducto Tajo-Segura (SCRATS) and MCT, water authorities, and interviews with WUAs. Only annual aggregated data on volumes and range of prices were provided by the SRBA. More disaggregated data were obtained from interviews with 30 WUAs using a semi-structured questionnaire which asked about their participation in water markets (dates, sellers and buyers, volumes traded, prices, transportation costs and losses, difficulties encountered when negotiating and contracting, reasons for the agreement failing or not being authorized). Information was updated with follow-up telephone conversations. The primary data obtained from WUAs served for example to identify the major areas of origin and destination of water transactions, as well as transportation costs and average market prices.

Figure 2 shows the volumes traded under lease contracts authorized by the SRBA from 2000 to 2015, that is, from just after the 1999 Water Law Amendment took effect to the latest period for which comprehensive results are available. The average annual volume for the above period is approximately 4.68 Mm^3/year, or less than 0.5% of the total volume of water used for irrigation in the SRB. This average value is not, however, very representative, as it was only exceeded in five of the 15 years of the above period, and the traded volume was less than 2 Mm^3 in six of the years. With some exceptions, the annual volume traded in each lease contract was less than 0.4 Mm^3 and, in many years, under 0.2 Mm^3, although there have been some transactions for volumes greater than 4 Mm^3 over the last five years. Annual traded volumes in the last five years were greater than the average for the period, suggesting that the trend is upward. But, briefly, annual lease contracts in more recent years can be said to be confined to a couple of one-off operations (3–5 Mm^3) and around 10 smaller operations, for volumes of generally less than 0.25 Mm^3.

Figure 2 also shows the price range of these lease contracts. First, it can be seen that there is a considerable price spread, with minimums of around €0.06/m^3 and maximums of €0.24/m^3 (€0.30/m^3 in the case of urban buyers). This is to be expected in view of the low level of

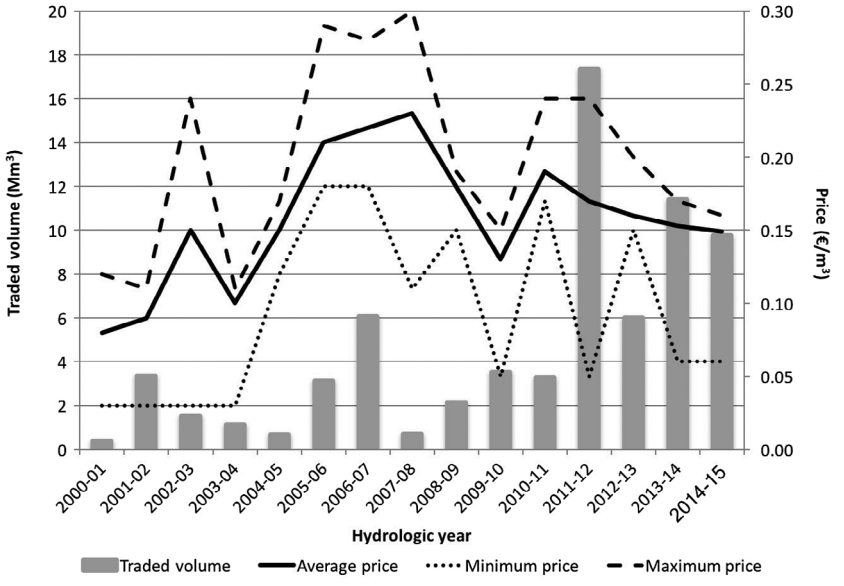

Figure 2. Annual volume of water traded between users of the Segura River basin and price interval (volumes in Mm^3; prices in €/m^3; 2000–15). Source: Own elaboration with information supplied by the Segura River Basin Authority, SCRATS (2015) and buyers. Prices are at source, not including VAT or transportation costs.

competition in this market. Second, although there were sizeable price fluctuations, prices were higher in drought years. Third, the prices, especially minimums, were lower towards the beginning of the period (2000–04). Finally, a slightly downward trend in recent years can be observed. Note that, unless otherwise indicated, all prices given in this paper are prices at the source and do not include VAT and transportation costs, which can increase the final price significantly.

The unusually high volume traded in the 2011–12 hydrologic year is due to the unusually abundant surface water resources in the Segura basin in the above period. This occasionally provided for a few formal lease contracts that were signed pursuant to the 1953 Decree (Law 25/04/1953), which prescribes irrigation water uses in the SRB and establishes the beneficiaries of surface resources, in terms of water endowments and irrigable areas. Water allocation resulting from this decree is clearly asymmetric, with traditional irrigated areas taking priority over the others and the newer ones having less secure water rights. In exceptionally wet years, more surface water is allocated to areas that usually receive hardly any resources from this source. This occasionally generates a small resource surplus that encourages trading. These contracts primarily targeted WUAs in the south-west coastal areas of the basin. In fact, a considerable share of the resources traded since 2009 was purchased by WUAs in this area. Some of these agreements were repeated in the following year.

Simply speaking, the water traded is mainly sourced from the river basin headwaters (Upper Segura basin) and the Upper and Middle Segura River Valley (Figure 1). The destinations of the purchased volumes are mainly in the irrigable areas of the TST (dark grey in Figure 1) and in the south-west of the basin (Upper Guadalentín basin and western coastal areas). On historical grounds, WUAs in these last areas do not have access to resources from

the TST either, even though they are home to some of the most profitable horticulture in the basin. Indeed, these and other WUAs also holding less secure rights are the key actors, together with SCRATS, in lease contracts. This does not preclude other trading, albeit generally of smaller volumes, having taken place over shorter distances in other regions of the basin (e.g. in the Eastern Highlands, Mula River and Lower Segura Valley).

Some intra-basin trading agreements have been disputed. HUERMUR (Asociación para la Conservación de la Huerta Murciana, or Association for the Conservation of the Murcia Huerta) lodged an appeal with the SRBA against the 5 Mm^3/year water leases from the Landowners Board of the Murcia Huerta (Junta de Hacendados de la Huerta de Murcia), a traditional WUA in the Segura Valley, to the Águilas and Mazarrón WUAs in 2014 and 2015; the appeal was rejected.

In 2015, greater opposition met SCRATS in its attempt to purchase up to 20 Mm^3 from several traditional WUAs in the Lower Segura Valley. These WUAs have consistently opposed water transfers from the Segura Valley to other areas of the basin. In the end, SCRATS only managed to reach an agreement with the Orihuela Water Court WUA (Juzgado Privativo de Aguas de Orihuela) for the purchase of 10 Mm^3 at a price of €0.06/m^3, an agreement which was not authorized by the SRBA because the lack of metering systems did not allow verifying that the leased volumes were no longer used in the selling area. Note that the previously mentioned large lease contract (5 Mm^3 at a net price of €0.16/m^3) between the Landowners Board of the Murcia Huerta and the Águilas and Mazarrón WUAs (in the western coastal areas) was rejected several times by the basin authority on the grounds of the physical impossibility of measuring the volumes consumed by the selling WUA. Once a system of volume meters was installed in the latter, that trading agreement was authorized in 2014 and 2015.

More recently, in 2016 SCRATS reached an agreement to purchase 30 Mm^3 from the traditional irrigated areas of the Middle Segura Valley. This agreement met such strong opposition from several WUAs and municipalities in the Lower Segura Valley, supported by the Regional Government of Valencia, that the SRBA only authorized it under the conditions of no monetary compensation taking place and water being given back to the original users in the future once the drought has ended.

Lease contracts with users in other basins

The 2005–08 drought

There are two major cases of inter-basin lease contract agreements in the Segura basin. One involved the MCT, the major domestic wholesale water supplier in the SRB, and the other involved SCRATS, as the official representative of the 59 WUAs with entitlements to use water from the TST for irrigation purposes.

The logic of water market operation, involving the transfer of water resources from lower- to higher-value uses, suggests that urban users take precedence in water purchases. This is often the case in many regions in the south-west US (Hadjigeorgalis, 2009). In Spain, however, the fact that domestic uses have priority over other possible uses has in practice limited the resource to water purchases by urban suppliers. Although there have been some one-off intra-basin water trading agreements between farmers and urban suppliers in the Tagus, Segura and Júcar basins, some even prior to the 1999 Water Law Amendment (Law 46/1999),

most of the formal trading of water in Spain has taken place between agricultural users (Palomo-Hierro, Gómez-Limón, & Riesgo, 2015). In the case of the Segura basin, the MCT has been the most active water purchasing urban water supply organization in Spain (Table 1).

During the 2005–08 drought, the MCT entered into three agreements (in 2006, 2007 and 2008, respectively) with the Las Aves Channel (Canal de Las Aves) WUA in Aranjuez (Madrid), under the provisions of RDL 15/2005 (Law 15/2005). This agreement covered the transfer of a maximum of 40 Mm^3 per year. However, the real aim of these agreements was to build up a strategic reserve in the headwaters of the Tagus River to assure supply and prevent the levels of the Entrepeñas and Buendía reservoirs, which feed the TST, from dropping below the critical threshold, under which, by law, resources cannot be transferred to the Segura (Calatrava & Gómez-Ramos, 2009). In fact, a sizeable part of the resources purchased through these three agreements was not finally transferred to the SRB. The MCT purchased a total of 108.5 Mm^3, but only 47.78 Mm^3 (2.34 Mm^3 in 2006, 8.5 Mm^3 in 2007 and 36.94 Mm^3 in 2008) was actually transferred (CHS, 2007, 2008, 2009). The total cost of the purchases (€30.33 million, equivalent to €0.2795/m^3 for all three agreements) was offset by a waiver of the TST tariff during the drought period for both the ordinary transfer volumes (€27.98 million) and the purchased volumes (€4.1 million).

After these large transactions, and some one-off small lease contracts signed in the midst of the drought state of emergency in 2006 and 2007 with farmers in the headwaters of the Segura basin, the MCT started receiving desalinized seawater resources from the newly operating desalination plants at San Pedro del Pinatar and Alicante and has not had to resort to any more water purchases. More recently, late in 2015, the drought state of emergency forced the MCT to negotiate possible lease contracts with water right holders in the Segura basin to maintain supply reliability for some municipalities, but the MCT does not foresee having to resort to inter-basin trading again.

From 2006 to 2009, during the same drought, SCRATS made four successive and almost identical lease contract agreements with the Estremera Channel (Canal de Estremera) WUA in the Upper Tagus basin. In each of the agreements, the volume to be transferred was established at 31.05 Mm^3, metered at the source (Claver, 2013). The selling WUA therefore

Table 1. Lease contracts between Segura River basin and Tagus River basin users.

Buyer in Segura	Transferor in Tagus	Water year	Volume (Mm^3)	Price (€/m^3)	Settlement (€)
MCT (Urban)	Las Aves Channel WUA	2005–06	35.52	0.2885*	10,247,520
		2006–07	36.03	0.2364	8,517,492
		2007–08	36.94	0.3130	11,562,220
SCRATS (agricultural users)	Estremera Channel WUA	2005–06	31.05	0.1856	5,761,700
		2006–07	31.05	0.1881	5,839,480
		2007–08	31.05	0.192	5,962,097
		2008–09	31.05	0.192	5,962,097
		2013–14	5.56	0.06	333,600
		2014–15	7.7	0.06	462,000
		2015–16	8.973	0.085	762,705
	La Poveda WUA	2013–14	1.42	0.06	85,200
		2014–15	1.42	0.06	85,200
		2015–16	1.42	0.085	120,700

Source: Own elaboration based on Claver (2013), SCRATS (2009, 2015, 2016), annual reports from MCT (2007, 2008, 2009), and additional data supplied by buyers. Volumes measured at source (the final on-site volume after accounting for transport losses is reduced by 10%). Prices at source include neither VAT nor the respective Tagus-Segura Transfer tariff.

*The settlement for loss of earnings established in the 2006 agreement was €0.20/m^3, plus €0.0885/m^3 to compensate farmers who had already sustained some cultivation costs when the agreement was signed.

waived all rights to its concession for the period established in each of the lease contracts, during which it improved and modernized its entire irrigable area. The agreed financial settlement for the first year was €0.1856/m^3, subject to annual price increases equal to 50% of the Consumer Purchase Index, with the exception of the fourth agreement, where the price was not updated at all (Table 1). However, in practice these prices were much higher, as the settlements stipulated in the lease contracts refer to volume at the source. On this ground, once the losses of 10% applicable to the volumes transferred via the TST had been discounted, and the fees applicable to these operations had been added, the price of water delivered at the destination was over €0.22/m^3 in the last two agreements. These costs do not include the fees that farmers have to pay to their respective WUAs.

The trading agreements between SCRATS and the Estremera Channel WUA during the 2005–08 drought mitigated the water shortages in the irrigable areas served by the TST and were beneficial to both parties. Calatrava and Gómez-Limón (2016) estimated the gross earnings from this multi-year agreement at €89.9 million for TST users and €17.8 million for Estremera Channel WUA farmers. This is equivalent to an increase of 12% for the purchasing regions and of over 310% for the selling WUA. The latter used the collected revenue to fund their infrastructure modernization plan. However, these agreements also caused protests by water users along the Middle Tagus (Garrido, Rey et al., 2013). As discussed later, when the drought situation recurred in 2014, this agreement was revived, albeit under different conditions.

The Spanish Ministry of the Environment openly backed these two multi-annual inter-basin transfer agreements. It allowed very large traded water endowments, specifically, the gross maximum endowments granted in each selling WUA's water use right. And both agreements benefited from TST tariff waivers, equivalent to €0.085774/m^3 out of a total tariff of €0.09963/m^3, justified by the Spanish government on the grounds of the ongoing extreme drought conditions (Garrido, Rey et al., 2013). In fact, as these waivers were applied both to the volumes covered by the lease contracts and to the ordinary volumes transferred from the Tagus, they amounted to more than the water purchase cost (Hernández-Mora & Del Moral, 2015).

Although both selling WUAs are in the Community of Madrid, these lease contracts met with strong opposition from the Regional Government of Castile-La Mancha, a declared enemy of the TST, which unsuccessfully lodged successive court appeals against the 2007, 2008 and 2009 lease contracts. Clearly, these trading agreements were controversial and had a significant political cost. The evidence for possible environmental costs is not so strong, as the Spanish legislation requires a previous environmental impact assessment in the event of transfers greater than 100 Mm^3, but not for temporary transfers of rights (Claver, 2013). The Spanish government (Yagüe, 2008) and SCRATS (Claver, 2013) maintain that these inter-basin lease contracts did not cause environmental problems, as the affected stretch of the Tagus River did not drop below the legal minimum environmental flow of 6 m^3/s. But Hernández-Mora (2013) reports that the impacts were severe, as the flow at Aranjuez dropped below this minimum on several occasions.

The 2014–17 drought

It was not until a new drought started in 2014 that the Spanish Ministry of the Environment again authorized the signing of lease contracts between users in different basins. In 2011, between the two droughts, SCRATS had signed an agreement with the Illana-Leganiel WUA

in the Upper Tagus for a total or partial transfer of its endowment (10.24 Mm^3) over a 10-year period (SCRATS, 2012). The financial settlement described in the agreement had two components: a fixed annual payment equivalent to the regulation levy of the above WUA (€13,000–17,000 depending on the year; see Calatrava et al., 2015, for a description of the general water pricing model in Spain), and a variable payment for water of €0.06/m^3 if the transfer were authorized. This agreement is quite similar to a water option contract, as the selling WUA undertakes to transfer the volume stipulated in the contract if there is a drought, and it is required to do so by SCRATS, and inter-basin water trading is allowed by law. But when the above circumstances materialized in 2014, 2015 and 2016, the Spanish government refused to authorize this operation, because the selling WUA had not used its water resources in the preceding years, which is a prerequisite for any lease contract (SCRATS, 2015).

In the recent drought, SCRATS has signed new agreements with the Estremera Channel WUA in 2014, 2015 and 2016 (Table 1). In this case, the Spanish government authorized the transfer of 5.56 Mm^3, 7.7 Mm^3 and 8.9 Mm^3 in 2014, 2015 and 2016, respectively (out of the requested 9 Mm^3, 9 Mm^3 and 10 Mm^3). The grounds for these partial rejections were that the real consumption certified by this WUA in 2013, 2014 and 2015 was less than the volume applied for (SCRATS, 2015, 2016). In these same years, SCRATS signed three lease contracts with La Poveda WUA, also in Madrid. They were authorized for a volume of 1.4 Mm^3/year. In both cases, the agreed settlement was €0.06/m^3 in the first two contracts and €0.085/m^3 in the last one (Table 1). Note that, in contrast with the last drought, these new agreements did not benefit from the TST tariff waiver, and thus the prices specified in Table 1 are subject to an additional charge of €0.0984/m^3 (plus VAT).

As previously seen, the trade volumes have been significantly smaller than in the previous drought, partly because the Spanish government is following a more strict implementation of the applicable legislation. The agreed settlement is also significantly smaller, mostly because no waiver of the TST tariff is being applied this time. To obtain additional resources from other basins, in 2016 SCRATS negotiated a large purchase of water from farmers in the neighbouring Júcar basin, but the agreement was not authorized.

Public water rights purchase offers

Although the WUREC of the Segura basin was created in 2004, it was not until 2007 that the SRBA first issued a PWRPO, with the aim of first satisfying urban demand and second setting up a strategic reserve in the headwaters of the basin to guarantee environmental flows in the Segura and Mundo Rivers (Calatrava & Gómez-Ramos, 2009). Holders of consumptive use rights in the basin headwaters were entitled to participate, subject to the condition that the resources covered by the use rights had been used in at least one of the irrigation seasons prior to the PWRPO.

The PWRPO had a budget of €700,000, and the maximum price to be paid was €0.18/m^3. The SRBA sustained the costs of transporting water from the catchment areas. Finally, 41 offers by smallholders, totalling 371.5 hectares, were accepted. The purchased volume was 2.93 Mm^3, at an average price of €0.168/m^3 and with a budgeted cost of €495,000. All the purchased flows were used to maintain ecological river flows (Garrido, Rey et al., 2013). The PWRPO was repeated in 2008 under identical terms and with similar outcomes (Calatrava & Gómez-Ramos, 2009).

As in the Guadiana and Júcar basins, the Segura PWRPO was only moderately successful, as the originally established budget was not used up, because there were not enough

suppliers that met the requirements (Garrido, Rey et al., 2013; Rey et al., 2014). Apart from the possible mistrust of water markets among irrigation farmers (Yagüe, 2008), another reason could also be that the bid price was not very attractive, as it was only slightly above the marginal value of water in the area studied by Calatrava and Martínez-Granados (2012). In practice, many of the rice-growers that participated did so because there was not enough water available to complete their crop cycles. In the end, the Segura WUREC did not operate as a purchaser of water to be sold on to other users, which was its initial objective, and it has not operated again since then.

Overall water trading

Figure 3 shows the total annual volumes traded in the SRB, including both intra- and inter-basin markets and PWRPOs. Total volume traded from 2000 to 2015 is about 325 Mm^3, with inter-basin operations accounting for 76.5%. It can be observed that the total annual volumes traded during the 2005–08 drought were above 70 Mm^3, with average prices close to €0.25/m^3.

In the current drought cycle, starting in 2013–14, average water exchanges amount to about 19 Mm^3/year, with prices slightly above €0.15/m^3. In the absence of official data from the SRBA for 2016, the provisional information gathered in this study suggests similar figures. An interesting result is that, since 2013–14, intra-basin lease contracts are providing similar or even greater volumes than inter-basin ones.

Another relevant fact is that average water market prices in the current drought period are similar to the average water tariffs paid in the basin, and below exchange prices agreed

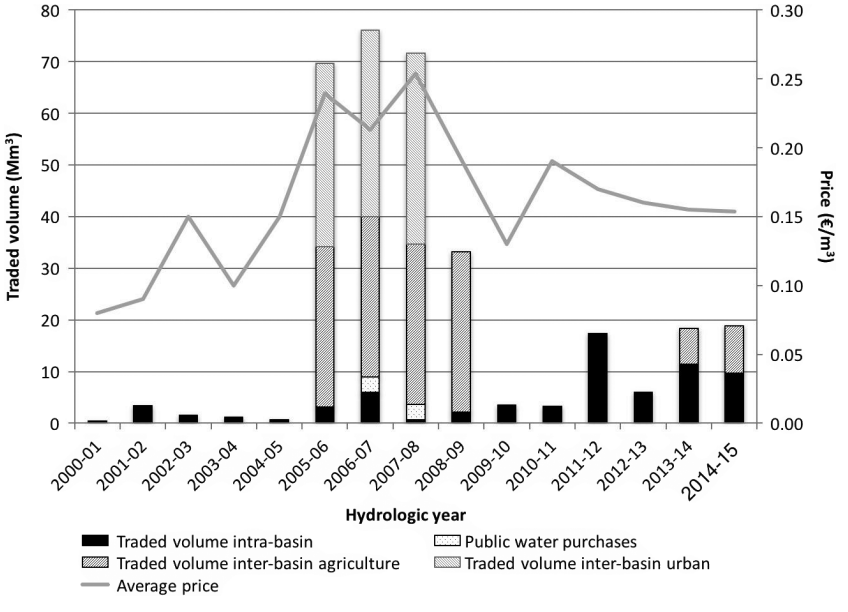

Figure 3. Annual volume of water purchased by users in the Segura River basin and average price paid (volumes in Mm^3; prices in €/m^3; 2000–15). Source: Own elaboration with information supplied by the Segura River Basin Authority, SCRATS (2015) and buyers. Prices are at source, not including VAT or transportation costs.

in the 2005–08 drought. In addition, these prices are, on average, a third of those paid for desalinated water, which is currently providing greater volumes to SRB farmers than water markets (Martínez-Alvarez et al., 2017).

Possible grounds for the limited success of formal trading

Based on this analysis of the formal market experiences in the SRB, which is obviously incomplete considering how limited some sources of information are, some hypotheses may be put forward on the possible reasons behind the limited impact of formal markets in that basin. As mentioned, the priority that domestic users have over other users means that the parties to the lease contracts are mainly agricultural users. Therefore, the following discussion will largely refer to farmers.

Several studies have pointed at some of the reasons for the limited functioning of water markets in Spain (Ariño & Sastre, 2009; Garrido, Calatrava, & Rey, 2013; Garrido, Maestu et al., 2013; Garrido, Rey et al., 2013; Palomo-Hierro et al., 2015; Rey et al., 2014). Many of the barriers to trade highlighted by these authors are similar to those found in Chile, the US or Australia: spatial restrictions, high transaction costs, rigid legislation, slow administrative procedures, difficulties in finding trading partners, and price dispersion (Rey et al., 2014). However, water markets in these countries are more flexible and active (Grafton, Libecap, McGlennon, Landry, & O'Brien, 2011), suggesting that barriers to trade could be more restricting in Spain. Most of the barriers in the SRB are common to the rest of Spain, but some are more specific to the particular characteristics of the water economy of this basin.

Garrido, Rey et al. (2013), following Ariño and Sastre (2009), differentiate between legal barriers, environmental barriers and institutional barriers. Legal barriers result from both the particular nature of water rights in Spain and the market regulatory framework. Unlike in Australia or Chile, the 1985 Spanish Water Act considers water resources as a public good, and consequently they are allocated, with some exceptions, through public water concessions. The water volumes allocated to concessions are established annually by water authorities based on water availability, similarly to Australia. A major problem for the functioning of water markets is precisely the absence of clear public criteria to establish those annual volumes, especially for agricultural users (Garrido, Calatrava et al., 2013), as well as the resulting uncertainties regarding water availability (Giannoccaro, Castillo, & Berbel, 2016).

Regulatory barriers to water trade aim to maintain the public nature of water rights, to prevent speculation and to protect third parties' rights (Ariño & Sastre, 2009; Rey et al., 2014). The most relevant restrictions relate to the direction, volumes and spatial extent of the exchanges. Specifically, water cannot be sold from consumptive to non-consumptive users or vice versa, or from higher-priority to lower-priority users or to non-right-holders, and the volume that can be sold is restricted to the real water consumption of the selling right-holder.

Spatial restrictions on water trading exist in the US and Australia. For instance, inter-basin exchanges are forbidden in Australia (Grafton et al., 2011), and some states even restrict the volumes that can be sold out of irrigation districts and/or agriculture (Bjornlund et al., 2013). In the US, some states allow inter-basin exchanges while others apply strict regulations to limit the spatial extent of trading (Grafton et al., 2011). In Spain, inter-basin trading is restricted to drought periods and requires the authorization of the Spanish government, while inter-regional trading within a basin is not explicitly restricted.

Environmental barriers result from minimum environmental flows, sustainable extraction rates, etc., established by water authorities for the protection of aquatic ecosystems (Ariño & Sastre, 2009; Rey et al., 2014). Potential impacts on these can result in a water right lease contract not being authorized. In addition, water authorities usually require that a share of the exchanged volume be left in the watercourses of the area of origin (Garrido, Rey et al., 2013). Australia also has specific provisions to limit the environmental impact of water trading, while the US and Chile do not (Grafton et al., 2011).

To reduce these barriers, some studies propose to remove restrictions on trade based on the hierarchy of use priorities, except for domestic and environmental uses, and allow non-right holders to purchase water (Garrido, Calatrava et al., 2013; Palomo-Hierro et al., 2015; Rey et al., 2014), as established in the Andalusian Water Law (Law 9/2010), which is only applicable in the Mediterranean coastal basins of this region (Paneque & Beltrán, 2015). Conservationist associations do not agree with such proposals. There is also a need to establish clearer criteria regarding how water is allocated annually, including to the environment. In addition, inter-basin trading should be allowed permanently, subject to clear and strict public rules, and not only during droughts, as proposed by Rey et al. (2016b).

Of the above regulatory and environmental barriers, which are common to all of Spain, the major limitation on trading in the SRB is that inter-basin lease contracts are restricted to drought periods. Institutional barriers, like some of the ones mentioned below, have greater relevance.

First, it must be taken into account that not all water resources in the SRB are tradable. On the one hand, trading of resources from the TST, which account for about 18% of the basin resources and 2% of the rights, is banned by SCRATS. On the other hand, groundwater resources are of considerable importance to the basin's water economy, accounting for about 80% of the rights and a third of the average water use. Although there has been some formal and informal groundwater trading between different hydrological areas of the basin, in practice these are usually limited to the area above the aquifer, where the differences in the value of the water, and thus the potential for trade, are smaller. Besides, some of the basin areas in which groundwater resources are the major source of supply are not connected with the rest of the basin. It can also be assumed that its high price would exclude desalinized water from the market, as the cost of purchasing desalinized water to the producing plants is greater than the average water market prices. All the above notably reduces the volumes available for trading.

Another significant institutional barrier is that most surface resources in Spain are allocated to WUAs rather than to individual or private users (Rey et al., 2014). The water allocated to a farmer belonging to a WUA is part of a concession granted to the WUA as a whole. This is a significant barrier to market participation, as WUAs make communal decisions by voting and are less willing to be party to lease contracts, especially if it means selling their entire endowment. Likewise, WUAs in the SRB hold a substantial share of volumes tied to groundwater concessions.

Another possibly relevant point is the importance of ligneous crops in the SRB, which is likely to reduce the potential number of water sellers, especially in periods of scarcity. Farmers growing annual crops whose water endowment is insufficient have the option of either reducing their crop area or not growing any crops at all and selling their endowment (Wheeler, Loch, Zuo, & Bjornlund, 2013). The Upper Segura Valley rice growers, who sold their water endowments through the 2007 and 2008 PWRPOs, are one example. On the

other hand, fruit producers would use their water endowments to guarantee the survival of their plantations, even if these were insufficient to achieve a profitable level of production. This means that they would be less willing to transfer their water (Bjornlund, 2006).

Another factor to be taken into account is that, even though the willingness to pay for water is generally high, buyers are liable for considerable costs for water transport and losses, water distribution and taxes on top of the agreed prices. Transportation costs are approximately €0.05/m^3 for intra-basin transfers and €0.09/m^3 for inter-basin transfers (fees for using infrastructure), plus water losses ranging between 10% and 25%. Distribution costs within WUAs range from €0.04/m^3 to €0.075/m^3, with an average of €0.06/m^3. The final price paid by users is thus considerably higher than the price agreed in the contracts and, in some exceptional cases, comes close to the price of desalinized seawater.

But the transaction costs are not confined to transportation. While the costs of finding buyers and sellers and negotiating the contracts do not appear to be significant, the political costs are notable. The major institutional barriers to water trading in most countries derive from the opposition of different stakeholders, including those in the areas of origin and environmental organizations. (Garrido, Maestu et al., 2013; Garrido, Rey et al., 2013). The major issue for the SRB is the Regional Government of Castile-La Mancha's open opposition to any trading involving users in its region in lease contracts with users in other regions, even within the same river basin. All the consulted WUAs from Murcia and Almeria interested in purchasing resources mentioned that it was far from easy to enter into agreements with users in that region, not only in the Tagus but also on the Castile-La Mancha side of the Segura basin. However, Castile-La Mancha is not water trading's only opponent.

Besides the resistance from environmental NGOs, it is striking that the biggest opposition to lease contracts among SRB users comes from the traditional irrigated areas of the Middle and the Lower Segura Valley, which have priority access to the basin's surface water resources and could act as sellers without having to significantly cut back their farming activity. This is partly due to strategic action on the part of these users, who fear that their concessions will be questioned and revised downwards if they transfer their resources (Garrido, Rey et al., 2013). Nor must we overlook the traditional rivalry between Alicante's Lower Valley farmers and Murcia's irrigators, as well as between traditional and newly irrigated areas, which obviously flares up during periods of scarcity (Herin, 1972). Scarcity itself is also a major source of transaction costs, as it increases the probability of any water market's operation being conflictive (Colby, 1990).

The above leads to another relevant issue, namely the reluctance of Spanish farmers to sell water (Giannoccaro et al., 2016; Ortiz & Ceña, 2001), especially out of the agricultural sector (Garrido, Rey et al., 2013). Some authors explain this by noting that farmers worry that leasing their rights might weaken those rights (Albiac, Hanemann, Calatrava, Uche, & Tapia, 2006; Palomo-Hierro et al., 2015), a problem also found in the US and Australia (Bjornlund & McKay, 2002; Howitt, 1994). However, the water lease experiences during the last 15 years seem to have reduced the distrust of water markets among farmers in the SRB. This is also supported by the results found by Giannoccaro, Castillo, and Berbel (2015), and Giannoccaro et al. (2016) in the neighbouring Guadalquivir and Almanzora basins.

Another common barrier to water trade is the slow administrative procedures for authorizing lease contracts, which deter market participation. This is an especially acute problem in some US states (Colby, 1990; Grafton et al., 2011). In the case of Spain, not only are the procedures slow but their outcome is often uncertain due to the lack of a clear definition of

the circumstances under which applications for lease contracts are authorized, for both intra- and inter-basin lease contracts (Rey et al., 2014). This is a factor highlighted as negative by many WUAs in the SRB interested in purchasing resources. However, a distinction has to be made between levels. At the national level, the Spanish government clearly encouraged water trading during the 2005–08 drought and later introduced reforms to flexibilize trading conditions, which, nevertheless, have sparked some criticism (Hernández-Mora & Del Moral, 2015). However, in the last two years the Spanish government seems to be shifting its position on inter-basin water trading. In fact, the 2016 contracts between SCRATS and the Estremera Channel and La Poveda WUAs had trouble getting authorized, and there are currently (September 2017) serious doubts about whether these same operations will be authorized this year.

At the SRB level, and in relation to lease contracts within the SRB, in our view, it is not feasible to objectively analyze the role of the SRBA beyond examining its enforcement of the applicable law. The available information shows that the percentage of rejected applications is shrinking. This is more likely to be because the potential participants have learned the applicable criteria than because the authorities have become less strict. As no environmental impact assessment is required by law, the role of the authorities is confined to the inspection of administrative and technical issues such as whether the applicants are concession holders, their order of priority, the volumes that really are eligible for transfer, and the feasibility of monitoring trading in practice. As mentioned, some large lease contracts have been rejected on the grounds of the physical impossibility of measuring the volumes consumed by the transferors. Applications that were likely to have an impact on third parties have also been rejected. In any case, there is no objective information to suggest that the applications were processed or agreements authorized negligently or unlawfully, although some rejected applications were later authorized by the courts. However, authorizations are unquestionably somewhat discretionary.

Although Law 46/1999 stipulates the criteria that should be taken into account, they are rather nonspecific, giving the authorities some leeway. Specifically, the criteria for not authorizing a water rights lease contract are that the agreement would have a negative effect on the basin's water use system, the rights of third parties, environmental flows, the status or conservation of water ecosystems, or any other breach of law (Embid, 2016). This obviously raises doubts about the outcome of the applications, bearing in mind that reports, albeit not binding, are required from the national or regional bodies responsible for agriculture. This again leaves some leeway for political intervention. All this may discourage users from submitting applications.

To help overcome some of the mentioned institutional barriers, water authorities should clearly define the criteria governing the authorization of lease contracts. This would reduce uncertainties about the outcome of applications and provide legal security to market participants in terms of maintaining their water rights. In this respect, Garrido, Calatrava et al. (2013) propose the further development of procedures providing for more automated, protocol-based and exhaustive market control proportional to the volume of the trade, the distance between buyers and sellers, and the technical complexity of the transaction. This should make the trading applications and authorizations easier to process for both the authorities and the parties to the lease contract, reducing transaction costs. In the case of the SRB, it is important that clear criteria also be established for inter-basin lease contracts, to limit political interference.

These and other relevant barriers to trade create market thinness and lack of competition, resulting in monopsony and monopoly behaviours (Garrido, Maestu et al., 2013). In the case of the Segura, this is especially acute in inter-basin agreements, where the number of potential market participants is very small. Ample consensus exists in asking for greater market transparency (Garrido, Rey et al., 2013, Garrido, Calatrava et al., 2013; Montilla-López, Gutiérrez-Martín, & Gómez-Limón, 2016; Palomo-Hierro et al., 2015; Rey et al., 2014). One of the strengths of the water markets in Australia is the availability of information on prices and volumes, which encourages market participation and reduces price dispersion. Spanish water authorities should publish annual information on lease contracts (prices, volumes, participants, motives for rejection, etc.). This is a key issue for the SRB, where no public data on market activity are published and significant price dispersion has been found.

The Spanish government should also foster more innovative trading mechanisms. For instance, water supply option contracts could avoid some barriers to trade by reducing uncertainties and transaction costs (Garrido, Calatrava et al., 2013; Rey et al., 2014). Similarly, water banks (WURECs) would facilitate water trading by reducing transaction costs and increasing market participation (Montilla-López et al., 2016), while allowing better public monitoring of operations (Garrido, Rey et al., 2013) and increased market transparency (Palomo-Hierro et al., 2015). They could also help reduce political interference, especially in the SRB.

Finally, barriers to trade result from the role of formal water markets being taken by alternatives that are worthy of note. First, there are subrogated water markets operating through the sale and lease markets for land with irrigation rights. In the Segura, agricultural profitability is closely linked with water availability. However, rather than reducing the potential of water markets, in many cases these markets would be acting as substitutes, due to the strong linkage between land and water and the constraints on the transfer (and sale) of water rights. That is, these markets may play the role of water markets, but they are not the reason why the water markets are not functioning.

Another part of the unsatisfied demand for water purchases is covered by what are known as informal water markets. These are markets that are not covered by the provisions of Law 46/1999 (De Stefano & Hernández-Mora, 2016). Informal trading includes exchanges between members of the same WUA. However, most WUAs in the SRB, especially those in areas with smaller endowments, expressly prohibit their members from trading the water that they supply, and unused volumes must be returned to the WUA for reallocation. Most of the informal trading refers to groundwater resources from private rights. As in the Júcar basin, there is a parallel, albeit mainly local, water economy in many areas of the SRB that relies on private groundwater resources, and that is very hard to quantify. These informal markets for the lease of private groundwater rights are mainly active during times of scarcity.

Last, one feature of irrigation in the Segura basin is that many water users resort to several different water sources. The structural shortage has led to the gradual development of very diverse sources, some of which are mobilized in drought periods (Rey, Calatrava, & Garrido, 2016a). In many areas, aquifers are a strategic water source at times of scarcity (drought wells). The diversification of sources and a greater tendency to resort to groundwater are, on top of water purchases, ways of supplementing the available water during droughts and fulfilling part of what should, in theory, be the function of water markets.

Conclusions

Based on the presented analysis of the formal water markets operating in the Segura basin since 2000, it can be stated that they have been less active than might be expected in view of the hydrological conditions and the characteristics of the water economy in the basin. Also, they have been almost exclusively confined to the field of agriculture. The water market activity and impact have been limited and uneven, with a relatively small number of lease contracts each year. The sources of most of the volumes traded from 2000 to 2015 (249 out of 325 Mm^3) were agreements with users outside the SRB.

Whereas nationally the activity of water markets has been sporadic and has focused on inter-basin trading during droughts, the trading between SRB users reveals that, on the one hand, the trend in the traded volumes is slightly upward, and, on the other, activity is greater in the years of higher water availability. The potential of water trading within the SRB is not, therefore, confined to sporadic conditions of increased scarcity. Likewise, there is a demand for trading with Tagus basin users in ordinary years, which does not necessarily depend on there being a drought scenario. Briefly, on top of other legal, institutional and economic restrictions, the structural scarcity in the basin is another reason for the shortage of water sellers and the low level of market activity.

Another key aspect is the prices agreed in the trades. The presented data show a considerable price spread, with higher prices during droughts, and a slightly downward trend in recent years. It is also surprising that prices are not directly related to the average value of the resource at the water source or destination, but appear to depend more on either party's negotiating skills. This large price spread, together with the relatively small number of water transactions, suggests that there is a thin market, typical of scenarios where the number of potential market participants is small as a result of the limited spatial extent of the market, due, for example, to physical or legal constraints (Tisdell, 2011). This discourages competition and causes the dispersion of prices, which are no longer a good indicator of resource scarcity.

In the case of the PWRPOs, the Segura experience is similar to that of other basins, as not all of the purchase offer budget was used up. The values of water in the selling regions on the Castile-La Mancha side of the basin suggest that, rather than being a problem of low offer prices, this was the result of other strategic and/or collusive behaviours or of irrigation farmers being pressed into not participating in the offers (Calatrava & Gómez-Ramos, 2009).

A positive aspect is that the resources have been reallocated to higher-value uses, thus generating ample gains in welfare for trading partners, which may outweigh the possible negative environmental impacts. But these impacts have not been quantified. In this respect, from the traded volumes and the fact that some applications have been rejected, it can be inferred that the possible environmental impacts have been insignificant at the basin level. There have even been environmental benefits from the PWRPOs, which, as in the rest of Spain and like the public water banks of California, Australia and Canada, have been used exclusively to achieve environmental goals (Docker & Robinson, 2014; Loomis et al., 2003). The environmental impacts may have been greater in the case of inter-basin leases, although opinions on this point are contradictory. In any case, one of the most obvious weaknesses of the water market legislation in Spain is its failure to consider either positive or negative environmental issues (Calatrava & Gómez-Ramos, 2009) beyond the environmental impact of specific and sporadic trading, which is unlikely to be irreversible (Garrido, Calatrava et al.,

2013). A negative aspect is that the increasing opposition of some stakeholders results in political interference and conflicts between different users and regions.

Despite the important role played by the authorities in promoting inter-basin trading during droughts (Garrido, Maestu et al., 2013) and the successive legal reforms aimed at extending trading opportunities (Hernández-Mora & Del Moral, 2015), they have not clearly committed to harnessing the potential of water markets by reforming the regulatory framework, unambiguously defining both tradable volumes and criteria for authorizing exchanges, increasing market transparency and setting up water exchange centres. Water banks should serve not only to purchase rights for environmental purposes but also as a way of facilitating trading by concentrating supply, reducing transaction costs and promoting more user participation, something which many of the less endowed Segura WUAs have been demanding for years.

Despite the mixed picture, in our view, the trading experiences have been positive, as they have managed to prevent a lot of damage in some areas, even to the environment in the case of PWRPAs. Lease contracts are not, however, the answer to the structural problem of scarcity in the SRB. Although, given the unequal distribution of water resources in the basin, water trading is an instrument with potential, it is only one of many options, and is in no case a substitute for water authority action. Moreover, its limited practical impact raises doubts about its current real potential in drought periods, where other actions, like the mobilization of strategic groundwater resources and even, despite its higher cost, desalination, have delivered greater volumes to the less water-endowed and more vulnerable areas.

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