EPI WATER

Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

WP4 EX-ANTE Case studies

Droughts and water scarcity – Tagus (Central Spain & Portugal) and Segura (SE Spain) interconnected river basins

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Executive Summary

Introduction

Barely anywhere in the developed world other than in Central and Mediterranean Spain it is more evident that water is a valuable economic asset. Shaped by a poor and uncertain natural supply the need to manage water on a collective basis emerged as an early political and social concern in Spanish history. There are paramount examples of this. On one side, the Water Court created more than a millennium ago by Moorish farmers in Spain to adjudicate water disputes in a non-confrontational way[1]. On the other, the creation of the first river basin district authorities in the world about one hundred years ago as public-private partnerships to coordinate collective investments required to unleash the driving forces of economic growth.

Within that context water management has played a critical role. Directly, if fostering the establishment of competitive agriculture[2] (*circa* 14% of EU-27 gross value added of agriculture at producer prices in 2011, just after France and Italy: EUROSTAT, 2013), the expansion of a modern energy industry, the rapid urbanization and the expansion of a competitive tourism sector (world fourth in visitors; second in income, after the USA: UNWTO, 2012). Likewise, indirectly through the derived demand of services associated to those primary activities and to the production of linked goods and services, water resources are indeed part of the foundations of the entire productive system. As a result of that, their management has always been perceived as central for local and regional economic development.

Yet, the evident success in harnessing the potential of water for economic growth comes along with new significant governance barriers and challenges. Coupled with production and population growth, the demand of water services has soared up and, particularly in the Segura river basin, it is now higher than long-term renewable resources and water scarcity has been worsened throughout time. It is evident that impacts from extreme weather events (i.e. droughts) amplified by climate change will not make this situation get any better unless action is taken.

Nowadays, all economic activities are even more dependent on a reliable water supply and far more vulnerable to precipitation variations. The existing potential for traditional responses to water scarcity, such as new water storage and major diversion works, has been mostly exhausted. Marginal opportunities still remain for new water works but they would need to jump not minor political and

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[1] See http://www.tribunaldelasaguas.com/ingles/el%20tribunal2i.html for further information.

[2] Water planning is actually well known for having a very long tradition in Spain. Yet, it could be argued that water planning in Spain was much more a logical need than just an outcome of political will across the 20th century. One may find references to water policy (more as a sublimated or idealized expression of agricultural policy or even economic policy of the country), back in 1902 (when the first National Plan on Water Works was passed). The 1879 Water Act had already made a significant contribution to water management and the definition of the public domain, but it was not until the early years of the 19th century that water policy acquired a different (i.e. stand-alone) status.

social hurdles due to the perception of water both as a scarce and a valuable resource in different sites. Furthermore, the economic downturn and the associated fiscal consolidation reduce the possibility of publicly supporting new infrastructures, emergency responses to droughts as well as water conflict management through additional subsidies or short-term public expenditure expansion. The role of the State in water management is shifting.

Why vulnerability to scarcity and drought has increased throughout time

This report explores the trends towards increased water scarcity and drought exposure in the Tagus and Segura river basin districts as the joint effect of three relevant driving factors:

- *A challenging meteorology for economic and social development*. Except for the North and several areas in Central Spain, land is in arid and semi-arid regions with lower-than-national-average rainfall and few long-term available resources per unit of land and on a per-capita basis. In addition, what is probably most important: there is high variability between wet and dry years. Private and public responses to these constraints in Spain make water management singular in the European context.
- *Powerful incentives in the economy leading to increased water use in the short term*. As shown in this report, water is the missing factor required to mobilize prevailing comparative advantages for the development of a thriving agriculture and a tourism economy as well as to further advance in the energy, building and manufacturing sectors. Water is not only valuable *per se* but rather for its potential to harness other economic factors – i.e. when rivers run dry the existing hydropower production potential remains useless, and definitely for its capacity to multiply income, employment opportunities and the production of goods and services – i.e. access to water is the critical factor explaining the difference between crop yields and profits in irrigated versus rainfed agriculture. Since economic incentives in place lead to the demand of increasingly unsustainable amounts of water, so does the demand for further public responses for different purposes: to solve local and regional deficits that are difficult to make compatible to each other at a national level; to the use of as much water as possible anywhere; and also to the engagement of further withdrawals of those resources that are not yet under full public control (i.e. groundwater).
- *The relative failure to implement public policy responses to water scarcity that have not been utterly able to coordinate individual decisions of all water users with the overall aims of water policy*. Despite the lack of comprehensive assessments of government responses to water scarcity there is circumstantial but clear and convincing evidence of the limited effect they might have had in curbing scarcity down or reducing drought vulnerability. For example, the performance of water transfers below expectations might be explained more by the increase in water demand than in water supply and might have resulted in an additional factor driving increased water scarcity. Higher restrictions to use surface water are less effective when users have the option

to compensate water deficits through (illegally) overdrafting groundwater[3] and this can lead to a dynamics towards increased water scarcity and lower drought resilience in the future. Making water use more technically efficient might result in lower water returns from irrigated agriculture; water saved at a plot level might well aid to cover structural water deficits with a positive impact over the economy in the short run but have no effect at all in mitigating water depletion. In another example, the proven capacity to develop new water sources, e.g. from advanced water treatment and from desalination plants, has not been complemented by a financial strategy to put all this additional water into use and most users still perceive these resources with good reason as expensive, thus not worth to use on a regular basis. The consequence has been a marked preference for extending the use of already overexploited groundwater sources.

Why EPIs are called to play a critical role in water policy reform

This report is meant to make a critical point: current trends in water use can only be tackled and changed should a proper set of incentives be put in place. EPIs are incentives for individual water users to decide why and how much water to use and are purposely designed in such a way that decisions taken by anyone are compatible with the overall objectives of water policy. The above-mentioned governance failures make evident the need to place incentives at the core of discussions on the best public policy responses to water scarcity.

Precisely for the same reason economic incentives are central elements of any water policy alternative that focuses more on the so-called soft options of water management rather than just on hard (physical capital) solutions. Once the potential for new infrastructures has been developed, available alternatives to match water supply and demand, to reduce water scarcity, to enhance drought resilience and to improve water security must be found in a blend of new alternatives such as water demand management, the increase in the technical efficiency with which water is applied to any economic use and/or the development of non-conventional sources such as regenerated or desalinated water.

This report stresses the importance of thinking in terms of collective action, that is to say in terms of the coordination of public policy and individual decisions to respond to water policy challenges.

Coping with water scarcity and responding to increased water uncertainty requires a coordinated response involving all significant water uses in the economy and all relevant stakeholders. As the analysis in this report makes clear, this kind of 'order' cannot be achieved only through norms or command-and-control instruments. Although these legal standards and regulations are essential, their actual effectiveness depends on many individual decisions that are made in market circumstances that cannot be fully anticipated by the water authority. The use of EPIs as a supplement rather than a

[3] The second most common pressure on EU ecological status (in 16 Member States) stems from over-abstraction of water (EC, 2012a: *Blueprint to Safeguard Europe's Water Resources*, p. 6).

substitute of prescriptive behaviour and public norms can help manage individual incentives so that these decisions are not at odds with the expected environmental outcomes of water policy.

Three water management challenges EPIs may contribute to respond to

Command and control and EPIs for water management are instruments to an end. Its importance should only be judged against its potential and actual contribution to water policy goals. Prices are not right or wrong themselves but rather because of their ability to serve the purposes of: (a) cost recovery, which requires prices to be set at a proper level, and most importantly for this research, (b) by its capacity to change water users' decisions, which in turn entails prices to be of the right kind and be deliberately designed to attain a water policy goal. Along the same line, water use right trading must not be considered good or bad *per se* – the central focus in its design must be to guarantee that water trades individuals might agree on, lead to an effective contribution to water policy goals.

Under these premises the discussion about EPIs calls for a prior definition of what the objectives of water policy are. These objectives have already been defined by the European water policy (remarkably the EU Water Framework Directive). Nevertheless, they need to be stated for the particular context of water issues at stake in this case study (water scarcity and drought) and for the specific setting and study site (Spain as a Mediterranean country and the interconnected Tagus-Segura river basins).

This report conveys the following three water challenges to which EPIs can make an important contribution in the Tagus Segura interconnected river basins (and seemingly in any other water stressed economy).

1. *Recognizing and managing the river basin closure.*

Should the problem not be recognised, the unavoidable transition from financially cheap (if scarce and unreliable) towards expensive (although abundant and dependable) water sources would bring about significant harmful effects over the economy. Dubbing these water sources as cheap or expensive is somewhat limited and misleading and but a recognition of a pricing failure (i.e. the fact that environmental and resource costs are ignored).

2. *Regaining control over groundwater in the river basin.*

Considerable progress has been made through drought management plans. They made drought response anticipated (rather than discretionary and reactive) and planned (rather than *ad-lib*), but failed to tackle the real problem: the lack of control over an important share of available water resources). Actually, this can even be counter-productive, as tighter constraints may lead to more powerful incentives for overabstraction, lower buffer stocks and higher drought risk.

3. *Harnessing the economic potential of water and providing development with higher resilience.*

The absence of a system able to transfer information about the relative abundance or scarcity of water is an actual drawback to allocate or re-allocate water to its most productive uses. Lack of information also includes the willingness to pay (WTP) to have access to additional resources (on the demand side) and about the minimum compensation required (WTA) before being able to give up part of the water use rights available at any time, place and use (on the supply side), thus limiting bargaining and water trades.

Four opportunities to put EPIs into practice

The introduction of EPIs is based upon a plain assumption: individuals are willing to engage in any specific action provided there is an individual benefit to be reaped. Households buy water to satisfy wants and needs for which they are willing to pay more than the current water price; water trading is feasible only if the set price equals at least the seller's opportunity cost of giving water up but is lower than the buyer's WTP… Of course these opportunities, as shown in this report, are influenced by public policy. How could they not? For example, higher administered prices may induce decisions to install more efficient water using devices.

Hence, opportunities to implement innovative EPIs basically consist in situations where there are both private benefits to be gained by those individuals engaged in such decisions and collective gains in terms of water policy objectives if individuals make the kind of decisions expected from them. Should there be just individual benefits, this would not be an actual opportunity for water policy. In turn, were there only collective gains, this might well be a good opportunity for water policy but the most appropriate instrument would never be an EPI.

The opportunities identified in this research are as follows:

1. Managing the entire water 'portfolio'. As it is well known, under river basin district management, water supply as a whole is composed by a range of sources that differ in some important aspects and need to be properly managed: their financial cost, their availability, and their security of supply. For example, for individual users surface water is inexpensive, increasingly scarce and highly unreliable. Yet, given the installed capacity (i.e. infrastructures already in place), desalinated water is abundant, costly and reliable. In addition, groundwater is increasingly scarce, financially expensive and (still) reliable. When left to individual decisions the proper combination of water sources used at any point in time can be inefficient and lead to unsustainable exploitation trends. This is actually happening in the Segura river basin district where, for example, desalinated water is being primarily used as a buffer stock, thus putting the financial sustainability of existing facilities at risk, and groundwater is used on a current basis, increasing its costs and reducing drought resilience as aquifers become increasingly depleted. Conveying each water source a particular role in providing an amount of water at a price and providing more or less security is one important priority that can be used to stimulate changes in water demand in such a way that water demand matches supply ever since and increase water security and cost-recovery ratios in the long run.

2. Taking advantage of the high value of water security. When water supply is lower and increasingly uncertain individuals are willing to pay for water security. They might be willing to transform its productive system in order to save water and reduce its exposure to water shortages. They might also be willing to shift towards crops that are less vulnerable to water deficits or, for example, they might be willing to pay for an insurance covering drought losses or even to buy water in a hypothetical market of water options. This research has found significant evidence about the high value of water security in the Tagus and Segura interconnected river basins. This is an opportunity to put in place an insurance system that, whilst individual welfare is increased, it might also have the potential to reduce water scarcity and improve responses to drought.

3. Taking advantage of the opportunities to reallocate water across uses and locations. The value of water widely differs among uses as well as throughout time and space. Besides these common features, though, economic development and the way water resources have been governed have resulted in even wider asymmetries in the value of water. On the one hand, the perception of water development as the cornerstone to push rural development has led to the construction of bulky infrastructures to use the resource as much as possible. In relatively water-abundant areas this entails expanding the use of often-subsidized water to very marginal lands (partially because the alternative would be to lose the resource). For individual plots relatively low water prices might have resulted in production systems using water intensively, with somewhat low technical efficiency, and not so intensive in the use of physical capital or specialized production factors. On the other hand, in water-stressed areas agricultural systems make a more effective use of water in combination with machinery, specialized labour and production inputs that altogether lead to higher yields and profits. All this is an important opportunity for individual agreements to reallocate water that at the same time, as long as EPIs are properly designed for that purpose, might reduce water scarcity and drought risk.

4. Bridging the technical efficiency gap. There are wide differences in the efficiency with which water is used wherever and for different purposes. Technical analysis of potential water savings if best available technologies (BAT) are used shows that there is still significant leeway for further savings. However, once the efficiency gap has been admitted, it is also important to understand what failure explains why water users do not do their best to bridge this gap and whether water policy may correct it. The only way to harvest the opportunities associated to bridging the efficiency gap is through pairing them with the financial incentives in place.

The three best-suited EPIs to take advantage of prevailing opportunities to cope with water challenges…

1. A pricing system

Further to its contribution to cost recovery, the proposed reform is meant to make pricing a real mechanism to match water supply and demand (contributing to the river basin closure), and assigning each water source a price depending on its role in terms of the supplied quantity and its weight for water security in the short and the longer term. The price of water security is introduced as a financial mechanism to guarantee the existence of buffer stocks and to allow for the recovery of depleted aquifers as well as to reduce water demand on a current basis.

2. A formal insurance for the delivery of water for irrigation

In the absence of formal insuring mechanisms drought responses are mostly made of a set of individual, uncoordinated and reactive responses rather than collective, planned and coordinated actions. In the Segura river basin uncontrolled and outlawed abstractions have traditionally played the role of insuring yields and farmers' income in dry periods and this is actually an important driving factor of water depletion in particular when shortages make water more valuable. These problems could be avoided if the financial sector could provide a proper insurance system to stabilize farmers' income as well as removing existing incentives to deplete groundwater sources.

3. A multi-level water-trading scheme.

Voluntary trade of water use rights can become a significant mechanism to secure the benefits of reallocating water among sectors and places. To be effective, water trading requires making water use more flexible by allowing purchase and sale to be an option instead of the strict use of licensed water entitlements in the amounts, the points of diversion and the specific uses for which they are issued by the water authority. The definition of tradable water rights is a major change in the current institutional setting where, contingent to water availability anytime, individual users are granted with usufructuary rights that, unless a complex authorization process is followed, cannot be used for a different purpose or elsewhere than where authorized by the water authority.

… but only one package of incentives

The three instruments have been chosen for its potential to make a relevant contribution to face current water challenges but its particular role cannot be understood in isolation but rather as an integral part of a package (see *tables ES.1* and *ES.2*) designed as part of a drastic change in water policy.

Table ES.1. Links between EPIs and water policy challenges in the Tagus and Segura interconnected basins

	THIS EPI ...	... MIGHT CONTRIBUTE TO		
		Segura's river basin closure by...	*Regaining control over the resource by...*	*Enhancing economic resilience by...*
EPIs	**PRICING >**	· Adapting water demand and supply. · Guaranteeing additional supplies to cope with temporary shortages. · Promoting the substitution of water sources in order to reduce overexploitation.	· Pricing access to non-conventional water sources in a way that induces farmers to signal their responsible use of groundwater resources under their control.	· Increasing water security for urban uses by reducing shortages of irrigated water, via relaxing the reduction in supply of surface water. · Increasing buffer stocks in the medium term (by excess supply of non-conventional sources in normal periods) and in the longer term (by allowing better conserved aquifers).
	INSURANCE >	· Setting an opportunity cost for groundwater overexploitation and making information about current trends in groundwater available for the water authority.	· Setting up an alternative way to stabilize farmers' income in dry periods through reducing incentives to withdraw already depleted aquifers and providing incentives to signal its responsible use of aquifers. · Creating conditions for a collective control of aquifers (as compensations in dry periods might depend on the proof that no overdraft happened in the irrigation district).	· Reducing the negative outcomes of reduced income over local expenditure and fiscal revenue and acting as an automatic stabilizer of the local economy.
	TRADING >	· Adjusting water demand and supply at every moment in time (accommodating water uncertainty) and space. · Serving as a transmission mechanism for incentives to save water across space and economic uses.	· Providing new incentives to signal the responsible access to aquifers and to avoid trading incentives resulting in further depletion.	· Allowing economic decisions to adapt to a water supply, which is increasingly uncertain and variable throughout time and space, and reducing economic losses in dry periods.

Table ES.2. Synergies between assessed EPIs.

THIS EPI ...	... MIGHT BE DESIGNED TO REINFORCE		
	PRICING	INSURANCE	TRADING
EPIs PRICING >		· Conveying information about the opportunity cost of water, farmers' attitudes towards water security and farmers' willingness to pay to avoid risk.	· Internalizing opportunity costs into the water price thus enlarging the amount of water that can be voluntarily sold at higher water prices and allowing for more competitive trades. · Increasing the volume of resources that can potentially be traded (e.g. non-conventional water sources), and providing additional incentives to save water (that can eventually go to the water market) as for example when higher water prices induce more efficient water use.
EPIs INSURANCE >	· Setting an (explicit) opportunity cost for groundwater overexploitation and making information available for the water authority about current trends in groundwater. · Providing incentives to signalling that can eventually be used to promote metering and marginal pricing in places where these mechanisms are not already in place.		· Reducing the likelihood of moral risk problems associated to substituted water voluntarily traded with uncontrolled groundwater withdrawals. · Facilitating transparency and the availability of amounts of water effectively used.
EPIs TRADING >	· Opening options for identifying the best uses of non-conventional water sources in normal periods and reducing the financial burden of maintaining these facilities available for dry periods. · Conveying information about the opportunity cost of water from alternative sources or locations.	· Providing an alternative to protect against droughts (buying additional water instead of insuring income) and allowing more efficient responses to risk.	

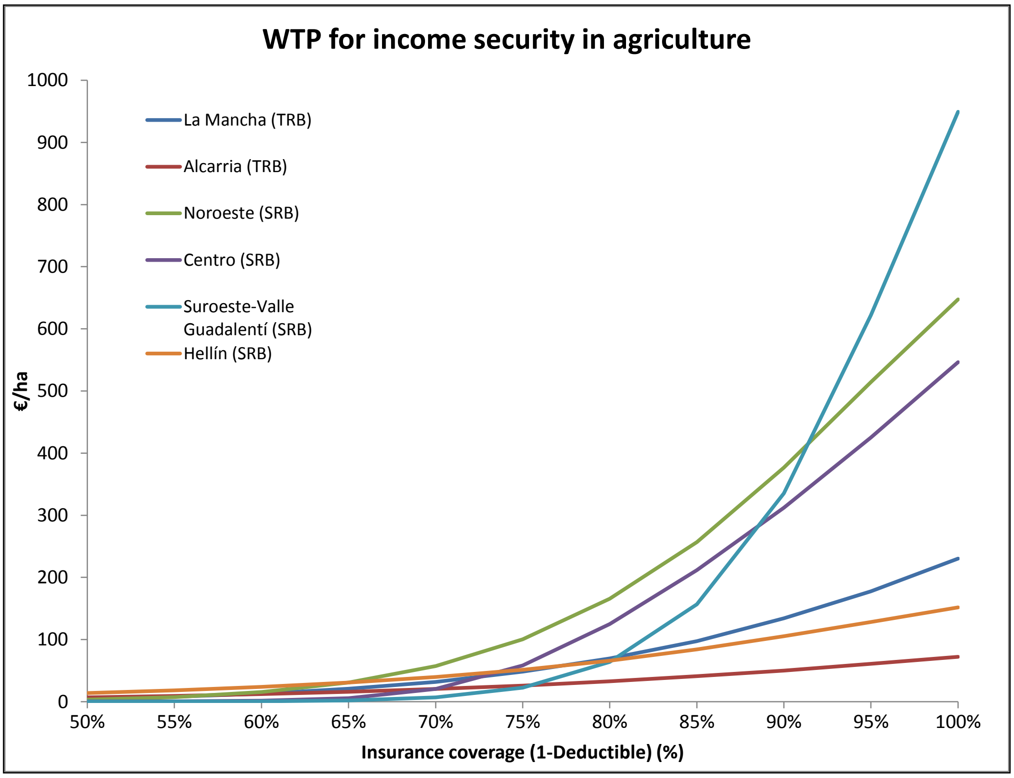
Instrument design and some results

Water prices are re-designed, on the basis of a prospective model for household water demand (HWD), to recover all financial costs implied in the provision of water services. The suggested design is meant to address a crucial issue: how much current water prices would need to be increased so as to guarantee water provision in dry periods. The suggested scheme works as a cost-sharing mechanism among those interested in having a secure water supply.

Our HWD model estimates that charging households for the capital costs of desalination plants would result in an annual price rate of 0.72% during a cost-recovery period of 30 years and would have a negligible effect on household water demand (< 0.7%). Urban water security in turn increases water availability and security in agriculture, which results in income variability, stable employment and positive forward linkages in other economic sectors (i.e. agro-industry). This provides the rationale for sharing costs. Yet, while household demand is often inelastic, irrigated agriculture is more likely to suffer negative impacts from higher water prices. According to our revealed-preference model (RPM), this is not the case in the Segura RBD (i.e. inelastic demand curve up to 0.4 €/m^3). The impact of higher prices is absorbed by the gross margin, with no negative effect on employment. Caveats apply, though, as to spatial heterogeneity and equity concerns.

It is also important to note that the replacement of overexploited groundwater resources with desalinated water would not be feasible, though, which makes the case for other EPIs to be implemented. Capital costs represent *circa* 20% of the production costs of desalination. Nevertheless, high variable costs are still a hindrance.

Drought insurance design is not only based upon a revealed-preference model to simulate farmers' decisions but also a risk assessment model (RAM) to analyse the risk (of delivering different amounts of surface water), the exposure (i.e. losses in ligneous crops stemming from any drought event), and the fair risk premium (i.e. the minimum cost at which such insurance can be provided by risk-neutral insurance companies). The analysis shows that between the fair risk premium and risk-averse farmers' WTP, there is scope for insurance systems to stabilize income and reduce incentives for groundwater overexploitation during dry periods.



Source: Own elaboration

Water use right trades have been designed, as part of a sequential process, on the basis of the analysis of actual opportunities for water transfers, the identification of operational costs implied in those trades (mainly transport costs and water losses due to evapotranspiration and infiltration), and the analysis of third-party effects (specially relevant for the EU Water Policy and the definition of water entitlements in EU Member States).

Even ignoring other transaction costs, results show that opportunities for water trading decay with distance as transport costs increase. Neither transport costs nor third-party effects are very significant when water is traded on a local basis among users of the same kind (i.e. irrigators within the same irrigation district). The potential for local bargaining, in turn, is higher when irrigation profits are more variable.

Transportation fees in the Tagus-Segura Water Transfer are 0.1 €/m^3, while transportation losses are estimated at 10%. Bearing in mind just these two cost categories, the potential for water trading is reduced by 30 hm^3 (10% reduction), along a price increase of 16%. The average technical efficiency in the irrigated areas of the TRBD connected to the Water Transfer is estimated at 39.9%, meaning that 60.1% of water is actually "lost" and either returns to the watercourse or evaporates. Return flows are estimated at 19%. Considering that ratio, the potential for water trading would be reduced by 19.6% (from 240 to 193 hm^3 *per annum*), while prices would be 3.7% higher. Under precautionary principles (return flows at 60%), water-trading potential would fall by 65% and water prices would increase over 40%.

Adapting institutions to enable EPIs and make them effective, implementable and politically acceptable

EPIs are part of an integral change in the institutions governing water and, as a result of that, in water policy itself. Hence EPIs cannot be assessed in the absence of explicit links with the institutional setting under which these innovative instruments are meant to operate.

Well-designed EPIs might fail to reconcile individual decisions and the collective goals of water policy. This failure might be explained by very different reasons. A chief one indeed is the non-appropriate consideration of enabling conditions for these EPIs to be implementable and efficient.

As above, though, there are other reasons that might explain that potential failure: the design itself of EPIs and their delivery mechanisms is essential to improve their effectiveness and reduce their implementation costs.

Institutional change and the potential effectiveness of these innovative EPIs are also highly contingent on their social acceptability which, for the sake of this assessment, depends in turn on a shared perception of a meaningful break-up with respect to current practice and also on the plausibility of these EPIs delivering the expected environmental outcomes within a range of affordable costs and in an equitable manner.

Within a transaction-cost perspective, it seems evident that water policy reform will only occur when its transaction costs are lower than the opportunity costs (or foregone benefits) of maintaining the *status quo*.

Unlike traditional water policy alternatives, intensive in infrastructures and direct costs, EPIs are part of a different fashion of water policy options whose cost-effectiveness can be obtained through:

- Improving their design (in order to reduce direct transaction costs while guaranteeing their effectiveness).
- Identifying and sequencing their implementation strategy (so as to minimize institutional transaction costs).
- Designing the best strategies to minimize the burden of institutional lock-in (so as to enhance EPIs' performance as well as their social and political acceptability).
- Improving the joint contribution of the whole package of incentives (i.e. innovative EPIs) to cope with water policy challenges, via decisions in the design phase.

Is this only a Southern European issue? A few words on transferability

There is widespread evidence in the European Union that scarcity and droughts are not anymore a Southern European challenge (as also evidenced in Lago *et al.*, 2013, in Ecologic's input for this case study). Further to scarcity, droughts have sorely increased in number and intensity throughout the EU. There have been recent drought events or threats in Portugal, Spain, southern France, Greece, Cyprus, Italy (including in some northern basins, reflected in this case study through the insights of the Po River mirror case study, developed by FEEM: Carrera *et al.*, 2013), Hungary, and southeastern England (see the mirror case study developed by MU-FHRC for the purposes of this WP4 report: Green, 2013)… The European Drought Observatory even reported drought conditions in Germany or the North Atlantic Faroe Islands, the self-governing region of Denmark.

The EC has responded to this increasingly challenging problem in different ways. Through its "EU 2020 – A strategy for smart, sustainable and inclusive growth" [COM(2010) 2020 final], the EU established a number of strategic priorities regarding resource efficiency for sustainable economic growth (reinforced by the "Roadmap to a Resource Efficient Europe [COM(2011) 571]). Challenges from water scarcity and drought were in turn previously recognised in the Communication "Addressing the challenge of water scarcity and droughts" from the EC [COM (2007) 414] and their annual Follow-up Reports, partially on the basis of which the EC's Water Scarcity and Drought policy was reviewed in 2012.

That review is part of the "Blueprint for Safeguarding European Waters" [COM(2012) 673]. To some extent, the Blueprint represents an effort to (*inter alia*) more resolutely integrate water quantity issues into the overall policy framework. The recent "EU Strategy on adaptation to climate change" [COM(2013) 216 final], although not specifically addressing water reuse, consolidates some of these policy initiatives, by placing them into a wider context.

The three innovative EPIs assessed in this report do fit this policy context and therefore could be transferred with some caveats to other geographical areas (this will be furthered explored in WP5 of this project). In addition, the discussion included in this report is meant to feed into some of the ongoing reflections of the EC regarding water policy reform and the use of economic policy instruments. There is widespread evidence in the world of similar instruments. Innovative does not mean new; yet, none of these instruments has been yet applied neither in the Spanish nor the EU context as such.

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Case study final report

1 Introduction – setting the scene: water scarcity and drought risk in the Tagus and Segura interconnected river basins

1.1 Brief description of the study area

Tagus (TRB) is the largest river basin in the Iberian Peninsula (which includes Central Portugal and Central Spain). Its Spanish section ranges 55,781 km^2 (while the Portuguese section, in turn, spreads over 25,666 km^2) and its population of 7.2 million inhabitants is highly concentrated in Greater Madrid (TRBA, 2013). Average consumptive water use amounts to 2,893 million m^3/year (*ibid*.), mainly from surface water sources over an average natural renewable resource availability of 10,214 million m^3/year[4]. Despite significant local scarcity problems (essentially in the Upper Tagus) and high variability in water resources, severe scarcity is not pervasive and drought vulnerability is still relatively moderate in the river basin district.

By contrast, the Segura river basin (hereafter SRB), in Southeastern Spain (see Map 1.1.), with a smaller area (19,025 km^2, excluding coastal waters) and lower population (1.98 million inhabitants in 2010, increasing in peak seasons up to 2.1 millions, depending on tourist inflows) shows a growing demand for water. In 2010, water demand hit 1,760 hm^3 *per annum* (SRBA, 2013a), while average renewable rainfall and runoff over the last 40 years is estimated to be only 848 hm^3/year (704 hm^3/year when considering the period 1980/81-2005/06) (SRBA, 2013).

Shortage of renewable resources is partially compensated via water transfers from relatively more abundant watersheds such as in the interbasin major diversion project from the Tagus itself that, nevertheless, since its opening in 1979, has been always below the planned and announced level of over 600 hm^3. The resulting deficit is mostly covered through the overexploitation of groundwater sources (a buffer stock), re-used water, and alternative resources from desalination.

[4] Average for the series 1940/41 -2005/06.

Map 1.1. Tagus (in orange – Spanish section – and yellow – Portuguese section) and Segura (in green)

Source: Own elaboration.

SRB's agricultural sector accounts for 86.4% of total water demand in the river basin, and against any yardstick but water management it can be considered a model of competitiveness and productivity. This river basin has many advantages for the development of a wealthy irrigated agriculture such as a comparatively high number of full sun hours per day, abundant arable land, cheap labour force, supplementary inputs, know-how, and location close to high-demand markets (Andreu *et al*., 2011; SRBA, 2010, 2008)[5]. Scant water resources have thus become the limiting production factor. Agriculture has turned into a relevant sector that, on average, represents 4.8% of GDP and 8.9% of total employment in the SRB (as compared to national averages of 2.3% and 4% respectively), with shares that reach 11.5% of GDP and 18% of employment in the most productive areas of the province (NUTS 2) of Almería.

Most of the water demand in the TRB also comes from agriculture (67.71%) (TRBA, 2013), though this sector is by far less significant for local GDP (1.3%) and employment (2.6%) than in the SRB.

[5] Regarding agriculture these advantages stem, as above, from a relative abundance of arable land (Spain has 261,000 km^2 of agricultural land, the largest in the EU only after France; this represents 52.9% of the total area, as compared to the EU average of 43%) (Eurostat, 2013), abundance of sun hours (Spain has on average 2,910 sunshine hours per year, while national averages of other MS – with the exception of Portugal, are below 2,500) (FAO, 2013) and moderate labour cost (due both to the local labour cost and an elastic labour supply fed for many years from immigration, average gross annual earnings in Spain are 26,568, only slightly above the EU-27 average of 25,942 and well below the Eurozone average of 30,462) (Eurostat, 2013).

On the other hand, urban water demand has a relevant and increasing share (27.2%)[6] (TRBA, 2010). This is the result of the expansion of the largest metropolitan area in the Iberian Peninsula: Greater Madrid (more than 6 million inhabitants and 76% of the TRB total population), located upstream.

In the region of Madrid population has grown by almost 1.5 million people within the last 15 years, from 5,022,289 inhabitants in 1996 to 6,498,560 inhabitants in 2012, at an annual average rate of 1.73%, which has slowed down its pace in the last few years, as a result of the economic downturn (0.14% in 2012). Population density has also risen from 626 to 810 inhabitants/km^2. The socio-economic appeal of Madrid is explained by its fast economic growth at an annual average of 3.28% until the end of 2007 (a few months before the current crisis became evident). Even accounting for three years of economic decline, GDP per capita had a positive growth rate and increased from EUR 19,755 in 1996 to EUR 23,636 in 2010 (INE, 2011). The main engine of growth up to 2007 was the building sector but the service sector also grew during those 'halcyon days' and is actually still rising above the national average, with a current share of *circa* four fifths of regional GDP.

1.2 Water scarcity in the Segura RB

The Segura River Basin, as it has been pointed out, is a meaningful case of a water scarce region in Europe (EEA, 2009). Against any available standard water is scarce in this basin. Although relatively small and not too densely populated (slightly more than 103 inhabitants per km^2) (SRBA, 2013) water demand is relatively high when it comes to its area (more than 100 billion m^3 per km^2 and year) or its permanent population (more than 1,000 m^3 per inhabitant and year).

The Water Exploitation Index (WEI)[7] is calculated as the ratio of total freshwater abstraction over total renewable resources. Average water demand per year in the SRB is between 2.1 and 2.5 larger than renewable long-term resources available. According to the EEA (2009) this index was at 1.27 in 2003, showing a meaningful trend towards greater water scarcity levels within the last 20 years. Previous studies (Martínez-Fernández and Esteve-Selma, 2002) estimated that water consumption was already 2.25 times greater than available water resources nearly a decade ago (Gómez and Pérez, 2012).

Water scarcity in the Segura will be further explored in *Chapter 2*.

[6] Besides, industries not connected to the network (2.17%) and consumptive water use by the energy sector (2.90%) represent the remainder of water demands.

[7] The water exploitation index is calculated as the ratio of total freshwater abstraction over total renewable resources. The following threshold ranges are used to indicate levels of water stress: (a) non-stressed < 0.10; (b) low stress 0.10 to < 0.20; (c) stressed 0.20 to < 0.40; and (d) severe water stress ≥ 0.40.

BOX 1.1. What do we mean by water scarcity?

Scarcity is a polysemic concept, which is widely used without making its particular meaning explicit. It does not lack a definition but common wisdom is not always linked to scientific rigour. It may appear a simple concept but it seems evident that it can also be difficult to apply to complex natural and human systems (Jaeger *et al.*, 2013).

A distinction needs to be made between general and relative scarcity. In the former water is considered scarce when being insufficient with respect to some objective; in the latter, water is considered scarce when its use for any one purpose requires forgoing its use for another.

Technical definitions of scarcity fall into the first category. For example, water is dubbed scarce if being insufficient to cover current evapotranspiration requirements of existing farms or the drinking water needs of a certain population or the sum of both.

Economic definitions of scarcity fall under the second category. Water, whether in the environment or for its use in a certain activity, is always (economically) scarce because it has an alternative use either for the production of other market goods or left in its source to yield environmental services. From an economic viewpoint, what is important is not whether water is scarce or not but how scarce it is. Scarcity is thus measured by the opportunity cost of either using the same water in the best available alternative (resource cost) or leaving it in the water environment (environmental cost).

Both definitions are not incompatible with each other and need to be jointly used. The former (technical) is critical for the sustainability of current and prospective water uses; the latter (economic) is required to find the best ways to foster economic progress within the limits of available water resources.

Sometimes one may use the technical sense to say that water is structurally scarce: this happens when average long-term water resources are not sufficient to meet current demands of water services as well as to maintain the good status of water providing ecosystems. Scarcity indexes such as the WEI (Water Exploitation Index) measure this kind of scarcity by comparing current uses with long-term (or average) available water resources. Aggregate scarcity indices, though, are straightforward to compute but sometimes do not adequately represent temporal and spatial variations in water scarcity.

Following Jaeger *et al.* (*ibid.*), it is important to recognise that water scarcity is fundamentally a normative, anthropocentric concept, which ought to be distinguished from the related, purely descriptive, notion of water deficit.

Source. Own elaboration.

1.3 Water scarcity in the Upper Tagus RB

In Madrid, socio-economic drivers such as population growth, a lack of planning in the past, and economic development patterns (housing as a critical sector, subsidised agriculture, etc.), amongst other things, may explain the threat of water shortages. Intense industrialization during the 1990s and the prolific development of real estate resulted in a non-negligible increase of water demand. Some concessions to market forces became necessary to facilitate transfers among uses and reallocate already used waters, without increasing total water withdrawals.

Average water demand in the Spanish section of the basin amounts to 2,893 hm^3/year and is expected to steadily increase up to 3,044 in 2015 and 3,251 in 2027. Although water demand is still a share of renewable resources produced in the basin (a Water Exploitation Index of 0.28 still denotes an overall moderate overexploitation), there are significant pressures in the headwaters.

Water supply is mostly generated in downstream areas (the Tiétar and Alagón sub-basins represent 15% of the TRB area and 33% of runoff), while runoff in the middle and some of the upper stretches of the TRB is reportedly low (Tajuña, Henares and Middle-Tagus sub-basins represent 22% of the area and only 6% of runoff) (TRBA, 2010). As a consequence, drought risk is especially high in the middle stretches of the TRB, comprising some relevant cities (Aranjuez – 56,877 inhabitants, Toledo – 84,019, and Talavera de la Reina – 88,755), industrial activities, and irrigated areas (INE, 2012).

Headwater reserves in the Tagus have decreased since 1980 as compared to the previous period. From 1958-59 to 1979-80 the yearly average volume (as measured in streaming flow at gauging stations), was 1,457 hm^3/year. From 1981-82 to 2005-06 that average volume fell to 773 hm^3/year. This means that headwater resources have dropped by 47% with a tipping point in the trend in 1980. Upper Tagus, with only 15% of the area, must supply 88.5% of water demand for urban and industrial uses in the whole Spanish section of the Tagus basin. In the Upper Tagus (up to Talavera), 45% of water resources are available and 85% of consumption, which implies average flows below 2 m^3/s in July for several years, quality concerns, and degradation of the riverbed and banks.

In the Draft River Basin Management Plan (TRBA, 2013), the WEI has been calculated using average natural resources in different points of the basin, with time series for the period 1980/81-2005/06, as this has been considered more representative than a calculation on a yearly basis. Water uses have been estimated as the difference between average natural resources and the average gauged water in the same point. The highest values of the index were logged upstream, reaching its maximum value in Aranjuez (0.71) and Toledo (0.56). Henares (0.43) and Jarama (0.44-0.50) rivers also have values where the river might pose difficulties in sustaining aquatic ecosystems (over 40%).

There is no single driving factor behind water demand increase and water scarcity in the TRB, though. Water demand increase over the last years in the TRB has been largely driven by economic and population growth in the Region of Madrid.

Between 2001 and 2005, main dwellings in the TRB grew at 10.21%, as compared to 2.2% in Madrid and 2.15% in the TRB in the decade 1991-2011. Regarding second dwelling units, for 2001-2005 they grew at 10.68% in the basin district, a sharp increase if compared to the previous decade (4.75% in Madrid, 3.63% in the TRB).

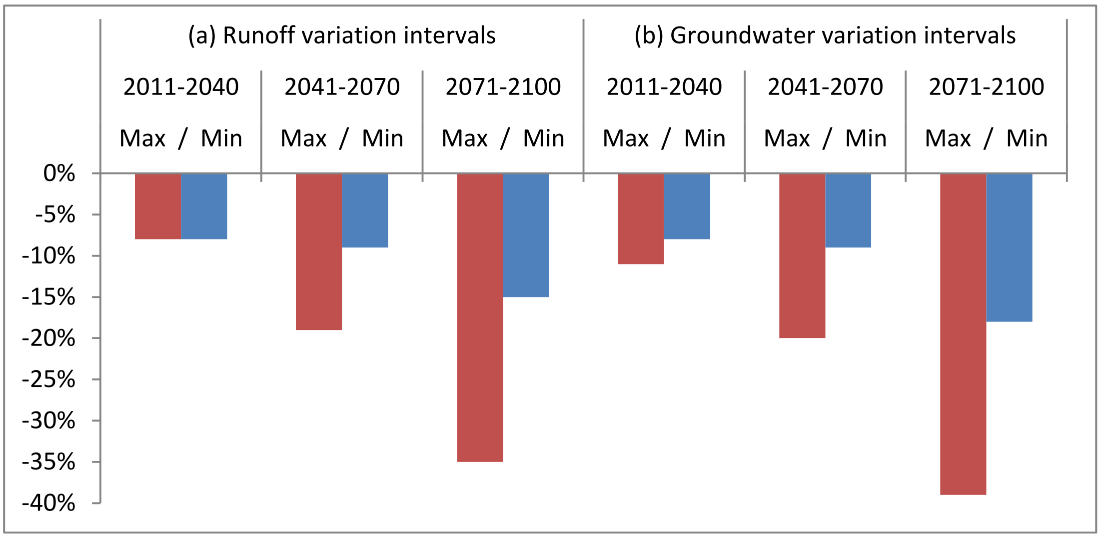
Economic activity, mostly manufacturing and services, grew at an average rate of 4.3% during 1995-2007. This resulted in a significant population growth, which averaged an annual rate of 2.04% (INE, 2012). Accordingly, urban water demand (29.7% of total water demand in 2005) hit a 35.6% share in 2010 (TRBA, 2010). Official water demand forecasts were based upon this juncture, and thus estimated an annual urban water demand increase of 2.9% until 2015 and 2% for the period 2015-2027 (TRBA, 2010). However, the current economic crisis has ceased this trend. GDP growth in the Region of Madrid was sluggish or even negative from 2008 to 2011 (1%, -2.7%, 0.1% and 0.9%, respectively) (INE, 2012). In addition, macroeconomic forecasts show a negative GDP growth in Spain for years 2012 (from -1.4% to -1.8%) and 2013 (from -1.4% to -1.6%), at best a slow recovery or stagnation thereafter (EC, 2012b; IMF, 2012; FUNCAS, 2012; BBVA, 2012).

Irrigated agriculture is still the main water user in the watershed (64.4% of total consumption). Its area (237,000 ha) is expected to change very slightly in the incoming years, resulting in a demand upturn of 4.7% until 2027 (TRBA, 2010).

On other hand, climate change is expected to have a relevant and negative impact over water availability. Figure 1-1 shows the expected runoff and groundwater variation intervals along this century according to official estimates (MARM, 2011). Figure 1-2 includes the same information for the SRB.

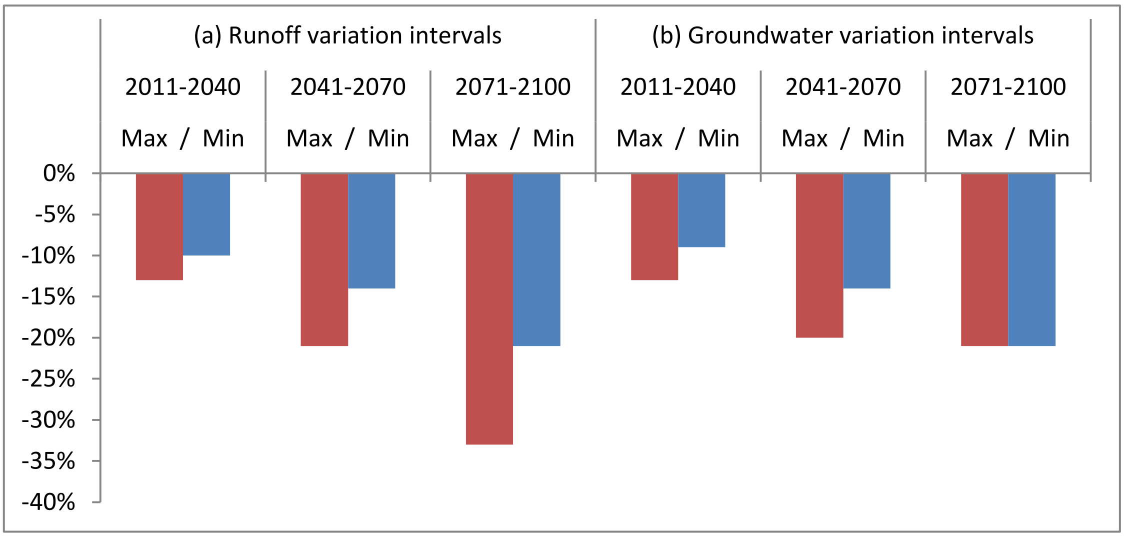
As above, the Tagus RBA estimates a reduction of almost 50% of water resources in Upper Tagus since 1980 as compared to the previous two decades. Downstream Madrid, because of low flow levels and wastewater from the conurbation of Madrid, the ecological status of the river is poor (high levels of conductivity). In order to comply with the WFD demands, the new RBMP – yet to be submitted to the EC when drafting this report, would be willing to implement both an environmental flow in the most affected sectors of the river (Aranjuez, Toledo and Talavera de la Reina) and foster wastewater treatment in Greater Madrid. E-flows in Aranjuez would increase from 6 m^3/s (as established in the current plan of 1999) to 10.86 m^3/s, in Toledo from 10 m^3/s to 14.10 m^3/s, and in Talavera it would be 15.92 m^3/s. These new e-flows and the reduction in available resources would result in the decrease of the “water surplus” transferrable to the Segura river basin.

Figure 1-1. Climate change and water availability forecasts (2040, 2070, and 2100) in the TRB: (a) runoff and (b) groundwater



Source: MARM (2011)

Figure 1-2. Climate change and water availability forecasts (2040, 2070, and 2100) in the SRB: (a) runoff and (b) groundwater



Source: MARM (2011)

1.4 Comparison between Tagus and Segura trends

The Draft Management Plan for Tagus River Basin (TRBA, 2013) foresees an improvement in the WEI after the implementation of the Programme of Measures designed as part of the planning exercise. Its value in Aranjuez would decrease from its current value of 0.71 to 0.56 after 2021.

Since the mid 1970s, Madrid and its metropolitan area, have been able to cope with a growing and more affluent population, as above, as well as with the increasing demand of a rapidly growing economy (an average rate of 3.28%, between 1996 and 2010) without building any new major water infrastructures and without engaging in massive groundwater abstractions (see Table 1.1 andTable 1.2). Within the last three decades water management in Madrid provides a clear example of a gradual adaptation towards a more efficient use of infrastructures, together with incentives and pricing schemes designed to swiftly adjust water demand. However, in the two decades before the current downturn, the combination of intense population change, economic expansion, and rapid and extensive urban sprawl pushed to the limit the capacity to manage an increasing water demand within the range of available resources and current water regulation infrastructures.

Table 1.1. Reservoirs managed by the Canal de Isabel II (water utility) classified by sub-basin

Name	Construction (date)	Volume (hm^3)
Cuenca del Lozoya		589.0
El Villar	1879	22.4
Puentes Viejas	1939	53.0
Riosequillo	1958	50.0
Pinilla	1967	38.1
El Atazar	1972	425.3
Cuenca del Jarama		55.7
El Vado	1960	55.7
Cuenca del Guadalix		40.9
Pedrezuela	1968	40.9
Cuenca del Manzanares		102.0
Manzanares el Real[1]	1912-1971	91.2
Navacerrada	1969	11.0
Cuenca del Guadarrama		132.0
Navalmedio	1969	0.7
La Jarosa	1969	7.2
Valmayor	1976	124.4
Cuenca del Alberche		26.0
Los Morales	1988	2.3
La Aceña	1991	23.7
Total		945.6

Source: Canal de Isabel II, 2011

Groundwater sources meet only a marginal share of urban water demand (on average, 20 hm^3 between 1995 and 2006) and are used as buffer stocks during drought periods when withdrawals can soar up to 48 hm^3, and never accounting for more than 7% of water resources (TRBA, 2010). Renewable resources in the four aquifers used to supply water demand in Madrid (120 hm^3) are mostly in poor quantitative and qualitative status as a result of depletion and pollution (mainly from agriculture), with just 35 hm^3 in fair conditions.

Table 1.2. *Groundwater resources, Madrid Region, qualitative and quantitative state*

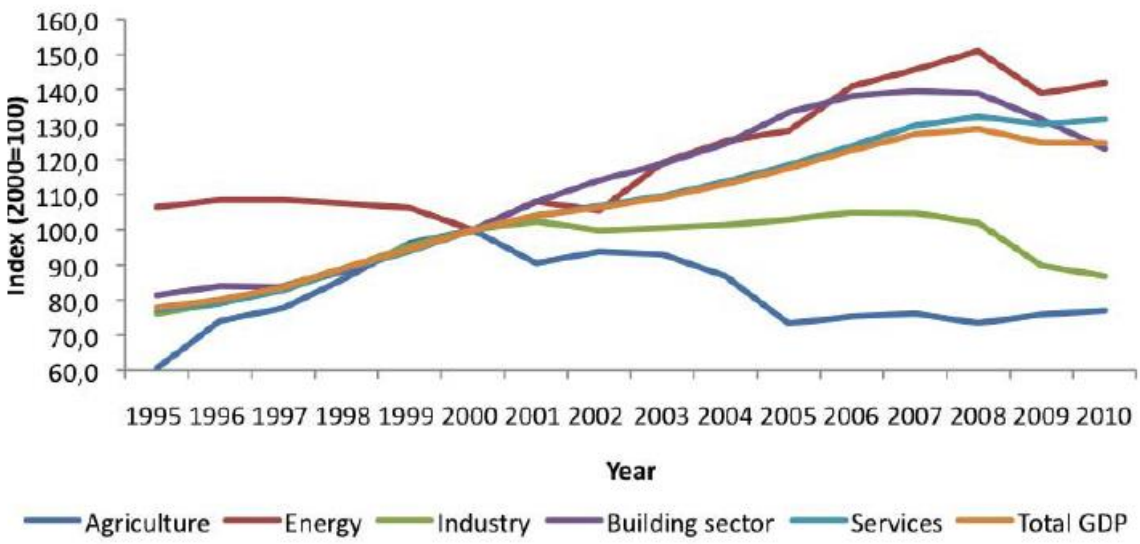
Name	Renewable resources (hm^3)	Quantitative state	Qualitative state
Torrelaguna	8.84	Fair	Fair
Madrid: Manzanares-Jarama	32.3	Poor	Poor
Madrid: Guadarrama-Manzanares	50.8	Poor	Poor
Madrid: Aldea del Fresno-Manzanares	27.3	Fair	Fair

Source: Own elaboration from Tagus River Basin Authority (CHT), 2010

As it can be inferred, Madrid has been able to guarantee a rapidly increasing water demand mostly with the same infrastructures to manage surface water and with degraded marginal supply from groundwater sources. Efficiency gains and management improvements have been critical to meet water demands so far.

Agriculture, albeit the main water user, has never been an important source of economic growth in Madrid and its contribution to the overall added value is declining, representing less than 0.6% of GDP (see Figure 1-3). The second water user, the manufacturing industry, has being shrinking for more than a decade and its output is nowadays 10% lower than in 2000; the share of the overall regional production has been consequently declining (from nearly 15% in 1995) to less than 9% in 2010 (INE, 2011).

Figure 1-3. Total GDP growth and sectoral evolution (1995-2010), chained indices (2000: 100), Madrid region



Source: Own elaboration from INE (2010)

In the Segura RB, GDP and population growth have increased the urbanized area (as a share of total area) and water demand during recent years. However, the overwhelming weight of agriculture in terms of water consumption (86.4%) and its booming expansion in the last decades make this sector the main driver behind water demands. Actually, the issuance of additional water rights for irrigation in the SRB was already banned in 1986. However, between 1990 and 2000 the irrigated area grew at an average rate of 6,500 ha/year, and currently only 155,313 ha out of the 225,356 ha under irrigation in the Region of Murcia (71.4% of the total irrigated land in the SRB) have formal water entitlements (IDR-UCLM, 2005). This process has been the combined outcome of high expectations regarding profits in irrigated agriculture and tolerance with offenders (i.e. illegal withdrawals).

As above, more recently some planning and efficiency improvement policies have been implemented to restrict water demand for irrigation. This is the case of Irrigation Modernization Plans, which increased irrigation efficiency, and the Drought Management Plan (DMP) of the SRB, which defined specific thresholds of possible drought situations and set water constraints that will be binding in each of those cases.

In both basins, the lack of properly defined and enforced e-flows has contributed to the overexploitation of surface resources even during dry years (TRBA, 2010, SRBA, 2010).

1.5 Drought risk seems to have grown over time

As water becomes scarcer the exposure to drought risk of all water dependent economic activities (in the SRB and elsewhere) increases and the capacity of water management systems to provide security and resilience is put under more pressure. In this report, we show concern about exposure to drought risk rather than to drought itself (and then to hydrological rather than meteorological droughts – see *section 2.2*).

Drought events in Spain have been more frequent after 1970 (Iglesias *et al*., 2011) with economic and social damage increasing year after year (see Table 1.3, with estimates from the *Drought R&SPI EU FP7* project) [8].

[8] During Spain's most recent lengthy drought (2005-2008), the Central Government issued a set of emergency decrees to mitigate the impact of drought in affected regions. The overall estimated budget for those emergency decrees was over EUR 4,173 million and the main beneficiary was irrigated agriculture. An important share of measures was infrastructure aimed at permanently increasing water use efficiency and/or water availability (i.e. modernization of irrigation systems, construction of storage reservoirs or desalination plants) and therefore their costs should not be directly linked to *emergency* mitigation of drought. Measures aimed at directly tackling drought impacts were mostly administrative provisions to mitigate economic losses in agriculture.

Table 1.3. Some costs of drought emergency measures in Spain

Type of administrative measures	Sector	Years	Estimated budget or final cost
Exemptions from paying water use tariffs	Irrigated Agriculture	2006, 2007, 2008, 2009	?
Exemptions from paying fees for the utilization of some public water infrastructure	Irrigated Agriculture	2006, 2007, 2008, 2009	?
Reductions in the tariff for electricity supply for irrigation	Irrigated Agriculture	2006	?
Compensations for restrictions to irrigated agriculture in the Jucar basin	Irrigated Agriculture	2006	0.48 M€ (final cost)
Lease of irrigation water rights to ensure minimum in-stream flow in the Jucar river	Irrigated Agriculture	2007, 2008	18 M€ (final cost)
Reductions in the fees to be paid to the national health system	Agriculture Stockbreeding	2005	?
Public loans to banks, to foster loans to farmers and stock breeders affected by drought	Agriculture Stockbreeding	2005	750 M€ (estimated)
Special fiscal reductions for agricultural activities	Agriculture	2005	?

Source: Drought R&SPI project, http://www.eu-drought.org/

BOX 1.2. What is actually a drought?

While scarcity (in its technical sense) is a structural problem, water shortages, droughts and floods are only temporary problems that can be managed (provided water is not structurally scarce). Following EC (2008), droughts represent a relevant temporary decrease of the average water availability and are considered natural phenomena. There are two types of droughts. In fact, when rainfall is variable, one of the critical roles of water management consists in providing water security by avoiding that a lack of rainfall (a meteorological drought) results in water shortages (hydrological droughts) and subsequent losses. While meteorological droughts are states of Nature (mostly beyond ordinary human control), hydrological droughts are the outcomes of these states of Nature when managed by society.

Discussions around drought management tend to focus on hydrological droughts rather than on meteorological ones. In other words, emphasis lies on the options and the ability of existing institutions to protect the people and their economic activities against the vagaries of rainfall. Of course, low rainfall has important economic consequences (as evident in the environment and for rain-fed agriculture) but, unlike irrigated agriculture, managing better available water cannot reduce them. This is the reason why in this report we will use the term drought in its hydrological rather than meteorological meaning.

All indices used since 2007 in Europe to measure drought severity (and to boost the required institutional responses) are based upon the status of water bodies (such as streams, reservoirs or aquifers) rather than in the amount of rainfall. They measure hydrological rather than meteorological droughts. At the end of the day, drought is something we measure (a penalty kick is when the referee calls a foul and blows the whistle).

Source. Own elaboration.

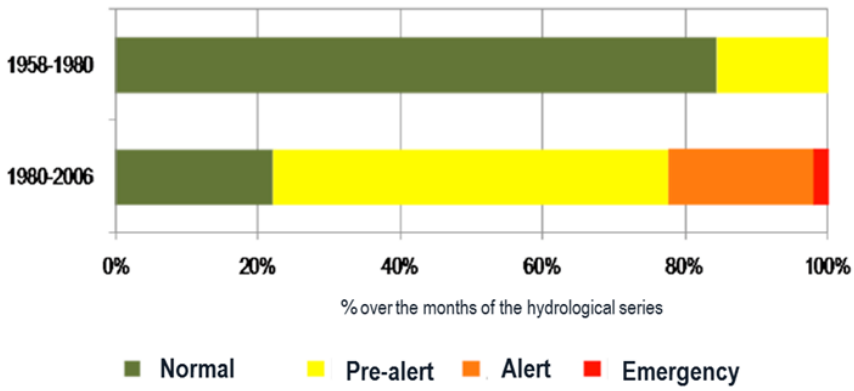
As a part of natural variability, the precipitation and thus the availability of water resources throughout time and space vary within bounds determined by given climate conditions. Droughts are indeed extreme events at the lower bound of climate variability.

The high financial costs of traditional policies to tackle scarcity and drought – even higher times of recession and within the [physical] limits of water supply have forced water authorities to alter their policy action. In the EU, some important legal restrictions over agricultural water demand have been recently approved to address the problem of recurrent droughts.

This is the case of the Drought Management Plans (DMPs), inspired in the drought contingency plans implemented in the US since the 1980s and thus following similar rules (NDMC, 2010). Basically, the DMPs define the precise thresholds of likely drought events and set water constraints that would come into force in each of these cases, with the aim of guaranteeing priority uses. Drought thresholds are obtained from the historical assessment of water supply (see Figure 1-4 for the TRB, which shows that normality is becoming exceptional!), while the extent of water constraints varies from one basin to another and largely depends on the ratio between water demand and supply, being more restrictive in the most exploited basins (EC, 2008). As a result, the declaration of a drought will automatically reduce, in a predictable amount, the quantity of water delivered to the irrigation system from publicly controlled water sources.

Although relatively new and voluntary, DMPs have rapidly spread across EU southern countries, such as France, Italy, Portugal and Spain[9]. In particular, Spain has pioneered the adoption of DMPs and currently every multi-regional river basin in the country has already approved its DMP. This is particularly shocking if we consider that there are no assessments available on the potential impact of DMPs on economic activities exposed to water binding restrictions. As a result, the effects of DMPs over water availability in sectors such as agriculture are basically unknown.

Figure 1-4. Hydrological drought thresholds in the TRB (1958 – 2006) – occurrence of different states



Hydrological situation applying the drought thresholds in alert and drought situations
Source: TRBA, 2011

[9] Unlike other water management instruments such as River Basin Management Plans, DMPs are not prescriptive, although they are already available in several Southern European basins such as Spain, Italy, Portugal and France, but also in Finland, the Netherlands and the UK.

1.6 Structure of the report

This report has been structured in such a way that the reader can follow a storyline. Much of the methodological content has been attached in technical annexes (prospective model for household water demand, revealed preference model, risk assessment model, agent-based model for assessing water trading). In addition, a comprehensive annex includes inputs from some of our peer fellows in this project. Whereas the executive summary is meant to be a stand-alone document, none of the chapters is disconnected from each other. Chapter 1, as the reader has just seen, includes a description of the study site (the interconnected basins of Tagus and Segura) but also a characterization of scarcity and drought in both basin districts. Chapter 2 provides in-detail evidence on the three main drivers of structural scarcity and drought as part of baseline trends, including and analysis of conventional policy responses, thus providing a rationale for the innovative character of the assessed EPIs. Chapter 3 presents the EPIs and match them with water policy opportunities. This chapter has a strong methodological content (especially in section 3.5) and is central to understand how the assessment has been performed and the fact that three EPIs are proposed but as part of a single set of economic incentives. EPIs are not assessed in isolation Chapter 4 analyses water policy challenges to which EPIs would respond. Chapter 5, in addition, deals with the specific design of the EPIs from a technical perspective, as well as providing the outcomes of the *ex-ante* assessment. Chapter 6 adopts a transaction cost perspective for the assessment of further outcomes, dealing with some relevant policy issues: sequencing of water policy reform, institutional lock-in, packaging incentives (as in Chapter 3), the policy mix (EPIs and conventional policy responses. Finally, Chapter 7 includes some key lessons and findings.

2 Baseline scenarios or conveying the problem – Why does this happen? How did we get here?

2.1 Decoupling economic development from water use: a pending issue

Throughout history Spain has been able to harness the potential of water for economic development mostly for agriculture, energy, tourism and urban development. The other side of the coin is that the most competitive areas of the economy (and those that are more resilient to the current economic crisis such as agriculture and tourism) are heavily dependent on the provision of water services.

Freshwater sources are intensively used, especially in the most water scarce areas (such as SRB) where population and the most water intensive activities tend to concentrate (agriculture, tourism). This has resulted in water abstractions and discharges that are already in excess over the sustainable capacity of natural sources and infrastructures to satisfy current demand even in normal years. Available evidence about climate change shows that water endowments might decrease in the near future (see above: Figure 1-1 and Figure 1-2).

In the past the main strategy has consisted in coordinating the public effort required to encompass economic growth by supplying water services demanded as a result of progress in the many areas of the economy including population change, urban sprawl, irrigation development, manufacturing activities, etc. Regarding economic goals the main objective of water policy consisted in finding inexpensive and reliable means to meet water demands. However, in line with the WFD, this supply-oriented *modus operandi* is currently in its transition to a new one aimed at making all water services used by the economy consistent with the preservation and adequate protection of the status of water bodies. This means that, rather than an engine for the expansion of the economy, water policy must be designed to decouple growth from increases in water services demand, to revert scarcity trends, and to coordinate all economic uses of water within the range of the ability of water bodies to sustainably provide them.

The simultaneous economic progress has made evident the need to enhance policy coordination, on one hand, and to overcome the subsidiary role of water management as an add-on instrument of sectoral and regional expansions towards a real mainstreaming element of economic policy on the other. Decoupling economic growth from increased water demand remains an important challenge; particularly in river basins such as Segura where overall water uses exceed the renewable long-term resources available. Success in managing water at a river basin level in order to support economic development has led to a still unfinished changeover towards giving more emphasis to water demand management, instead of supply coverage.

2.2 Water scarcity was earlier recognized as a problem (a long time ago)

Water scarcity and droughts in the SRB are far from being new. Noticeably, the current situation of water scarcity and overexploitation goes back at least to the 1940s, when development projects and policies fostered the extensive use of Mediterranean aquifers. Since then, overriding supply-side policies have tried to keep pace with increasing water demands from the simultaneous developments of agriculture, manufacturing, tourism, and urbanization without a proper consideration as to the ability of water-related ecosystems to guarantee a sustainable provision of this critical resource.

As the resource was scarcer (see *Chapter 1*), water policy became in turn reactive and new infrastructures as well as water efficiency programmes intended to increase water availability were approved.

There are legal texts providing evidence of scarcity in the SRB such as the decree 3221/1966, about water law enforcement, setting the urgent need of reinforcing in the basin district general measures for water law implementation, due to the fact that water resources were almost exhausted. Currently, the estimated overexploitation in the water bodies of the SRB is almost at 285 hm^3 *per annum* (SRBA, 2013).

What is maybe more important, when current demands cannot be handled by publicly controlled sources, farmers have powerful incentives to switch to the more dependable and mostly uncontrolled groundwater sources. Uncertainty, coupled with the legacies of past management actions, often leaves decision-makers few options other than to reinforce the current path-dependency (Anderies *et al*., 2006). The resulting overexploitation of aquifers does actually reduce the robustness and resiliency of the system and its ability to cope with future droughts, thus leading to a vicious cycle of increasing risk vulnerability and water scarcity (Gómez and Pérez, 2012).

As compared to traditional surface water irrigation systems, groundwater irrigation offers more reliable supplies, lesser vulnerability to droughts, and ready accessibility for individual users (Garrido *et al*., 2006).

Mainly private agents carried out the development of groundwater exploitation, as the scale of required investment was smaller than the needs for surface water regulation. Thus, at the onset of the 20th century, the exploitation of aquifers was based on private management of groundwater allowing the expansion of traditional irrigated agriculture. This, together with other circumstances, meant that during the first half of the century there was a swift in the way water was used, firstly based on the meagre offer of water resources, and then based on a larger and more reliable supply (SRBA, 2013).

Along technological progress and exploitation of groundwater resources, different conflicts on water use arose. (Water management, after all, is conflict management). In 1956, the first groundwater restricted area was established to halt the further increase of overexploitation as the area was already exposed to significant irrigation and urban supply demands. Within the limits of the restricted area, it was forbidden to open new wells and to make current ones any deeper (*ibid*.).

In January 1st, 1986, a new Water Law was passed. This law declared continental waters as part of the public domain, and enacted a set of measures to move towards a more rational use of resources (which became scarcer). Studies developed in line with the law allowed qualifying a severe overexploitation in a number of aquifers, resulting in important deficits for irrigated areas. These fostered the passing of the order in council 3/1986 including urgent measures for water use regulation in the SRB. Since then, the SRB has been declared as overexploited, thus no new water use entitlements can be granted (WWF, 2006).

In the SRB management plan of 1998, water scarcity was pervasively acknowledged. The assessment of water resources used in irrigated agriculture shows that the gross water use at that time was 4,900 m^3/ha·yr, while the 'desirable' average endowment should have been at 6,000-7,000 m^3/ha·yr. The plan estimated that annual water withdrawal pumped from the aquifers would be 430 hm^3 per year (corresponding to 10,000 soundings) and 210 hm^3 per year (*circa* 49%) were not renewable (*ibid*.).

Droughts have been recurrent in both watersheds

The Segura River Basin experienced different drought events between 1990 and 1995. In that period, a major drought occurred indeed: rainfall dropped from an average of 365 mm to values of 200 mm in and 196 mm in 1994/95, which meant a total runoff in the headwaters of 140 hm^3/year (26% of regulated resources upstream and diverted to fertile lowlands). As demand remained higher than actual supply, overexploitation of aquifers resulted from sustaining the existing water uses in the short and medium terms.

The Upper Tagus also registered a meteorological drought during that period (1990-1991 to 1994-1995), implying a reduction in transferred resources to the SRB. In addition to the structural deficit stemming from overexploitation (300 hm^3/year), the additional deficit due to the drought period hit 160 hm^3/year, as non-renewable withdrawals increased by 50% (thus implying a low probability in aquifer restoration in the long-term).

During 2005-2009 the SRB suffered one of the most important drought events. It was characterized by 4 consecutive years (2004/05, 2007/08) of rainfall below the historical average, with values of 219, 336, 434 and 385 mm, respectively. The average dam reservoir in 2004/05 was at 9.37% of its capacity, 8.76% in 2005/06, 11.04% in 2006/07, and 12.53% in 2007/08. Also, a reduction in the phreatic level of aquifers was recorded due to overexploitation. It is however considered that in irrigation, the situation became chronic since 1980, as the availability of resources to cover irrigation water demand was clearly not enough. According to the drought index (Figure 1-4), the basin overcame the drought situation in February 2010, and did not recover a "normal" status until July 2012.

The TRB also suffered a new drought event in 2004-2005 to 2007/2008. Yet, the drought of the beginning of the 1990s is recalled for its long duration and high intensity. Comparing annual rainfall average with the historical average, there was a reduction of 23.1% for the 5-yr period. Regarding net contributions, and comparing the same groups of data, the reduction for the period was 46.6%.

In turn, the average annual precipitation for the hydrological year 2004-2005 was 344.5 mm (45% of it fell in October), the lowest record since 1940-1941. The estimated contribution for that year in the TRBD was between 3,000 and 3,500 hm^3 (there was only one year that recorded contributions below 3,000 hm^3 and five years under 3 500 hm^3). Regarding contributions to the relevant dam, the historical average was 173 hm^3 while the recorded amount for that year was only 39 hm^3.

It is clear, though, that water shortage, even more from an economic viewpoint, is not an issue of low rainfall levels and minor contributions to reservoirs, but it can rather be explained, as above, by socio-economic drivers, such as demographic change, ill-defined planning some decades ago, and economic development patterns, amongst other things.

Different policy responses have been implemented

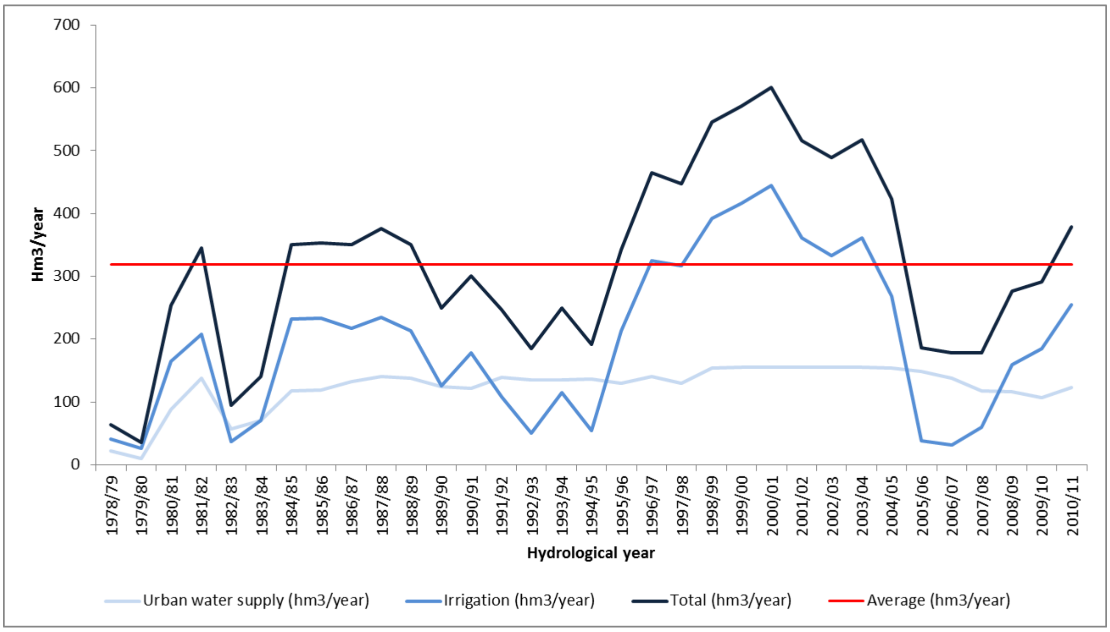
Nowadays, the SRB is an example of water efficiency both in their irrigation systems in place and in the drinking water distribution networks (SRBA, 2013). Paradoxically, all these efforts have not been reflected so far in a reversal of the long-term trend of increasing water demand and water use (*ibid*.). Structural water scarcity can be more severe if the recent reductions in rainfall and runoff do establish as a deep-rooted shift in long-term water supply. In addition, extreme variability of natural supply along with lower ability of water infrastructures and aquifers to store water and stabilize water supply have severely reduced the robustness and resiliency of the entire water provision system and increased both the likelihood and the severity of droughts (Gómez and Pérez, 2012).

Among these policies, the most important one was the construction of a massive infrastructure from the Tagus' headwaters to the SRB. The Tagus-Segura (TSWT) inter-basin major diversion project has been one of the driving factors pushing irrigation development. Its construction ended up below the designed capacity (only 600 instead of 1,000 hm^3/year) and since 1978, when the project became operational, has only been able to transfer an average of slightly over 320 hm^3 per annum (see Figure 2-1).

Despite its limited success and unfulfilled expectations in the SRB district the policy debate around the TSWT has increasingly focused on whether it has served to spread water scarcity elsewhere rather than to cope with water supply deficits in the Segura. As evidenced in the stakeholder process of this case study (with insightful inputs from MU-FHRC: McCarthy, 2013), the different views about the costs and benefits of the TSWT inter-basin transfer is undoubtedly one of the critical elements that needs to be sorted out to reconcile the River Basin Management Plans (RBMPs), whose submission to the European Commission is pending since 2009[10] (OJ, 2012).

[10] Only Catalonia RBA reported to the European Commission its River Basin Plan (on October 14th, 2010). This is 1 out of 25 expected RBMPs. The intra-regional RBMPs of Tinto-Odiel-Piedras, Guadalete-Barbate, Cuencas Mediterráneas Andaluzas, and Galicia Costa RBs were approved on September 14th, 2012. The National Council of Water approved the RBMPs of Guadalquivir, Guadiana and Western and Eastern Cantábrico RBs in December 2012. The other RBs (Miño-Sil, Duero, Tajo, Segura, Júcar, Ebro, Baleares, Gran Canaria, Fuerteventura, Lanzarote, Tenerife, La Palma, La Gomera, El Hierro, Ceuta, and Melilla) are still pending of approval. A court ruling of the European Court of Justice against Spain on the failure to adopt and report RBMPs for all the above RBs was published by the end of 2012.

Figure 2-1. Water transferred through the Tagus-Segura Water Transfer (TSWT) major diversion project



Source: SRBA, 2013

The traditional response of water authorities to water scarcity in Spain (i.e. supply-side policies to increase water availability) was mirrored in the SRB. This included subsidies to drill new wells, the construction and modernization of transportation, distribution and irrigation networks, further to the construction of the TSWT, a massive pipe with the capacity to transfer the above-mentioned 600 million cubic meters/year from the Tagus River Basin, located 242 km away[11].

It was assumed that the social and economic cost of leaving most water demands unattended would be too high; besides neither any national management plans nor alternative water resources were available at that time. In order to expand supply, controlled and temporal overexploitation of aquifers were approved. The environmental outcome was clear: withdrawals during 1989-1993 amounted to 148 hm^3/year; these became 314.20 hm^3/year during 1993-1995, which meant an increase of 112% in overexploitation.

Although such policies have made new irrigation developments possible and these have helped revitalize the local economy whilst stabilizing population in rural areas, they have also caused severe environmental problems, such as aquifer depletion and the destruction of riverine ecosystems (e.g., the formerly perennial Segura River does not reach now the Mediterranean Sea during most of the year).

[11] The actual capacity of the TSWT is 1,000 million cubic meters/year, but it has been limited to 600 million cubic meters/year by law. However, since its opening in 1978, this infrastructure has been working much below this legal limit and has transferred on average 329.3 million cubic meters/year (SRBA, 2013). In addition, it has been the cause of a major conflict between the regions of Castile-La Mancha (largely belonging to the Tagus RBD) and Murcia (largely belonging to the Segura RBD).

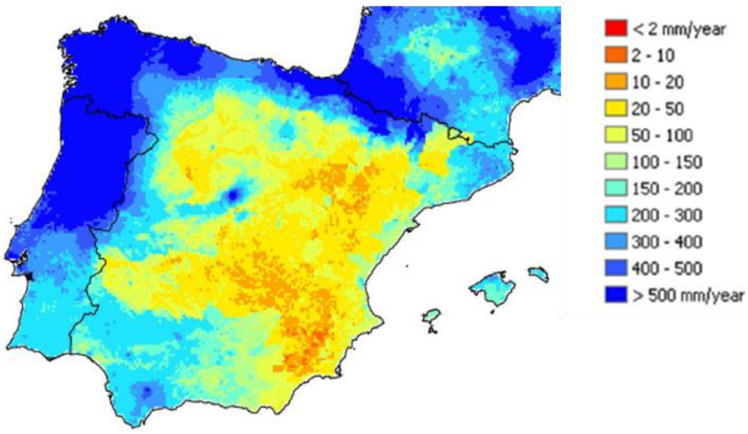
When it was clear that conventional water sources were already at their limit, authorities turned to non-conventional water sources, including treated wastewater and, especially, desalinated water. Only in the last decade, public authorities invested more than EUR 400 million in the construction and modernization of desalination plants in the SRB. In an effort to keep the pace of infrastructure investment, the Spanish Ministry of Agriculture and Environment is now trying to negotiate an additional EUR 700 million loan, following a EUR 500 million loan used to rescue the public water company in charge of supplying desalinated water in Southeastern Spain (ACUAMED) in 2012 (GWI, 2013). All this investment and the increasing energy prices have made desalinated water an expensive source with a production cost around 1 €/m³.

Despite subsidies to make this water source more attractive to farmers (bulk desalinated water is sold in many agricultural areas at 0.36 €/m³) (GWI, 2012), the low or even null price of conventional water sources make desalinated water unattractive (in the SRB, conventional bulk water prices range from 0 €/m³ in irrigated areas supplied with groundwater to 0.22 €/m³ in those areas receiving water from the TSWT) (SRBA, 2013). Consequently, desalinated water is mostly used as a buffer stock during drought events, and only in those areas without access (legal or not) to reliable groundwater sources. This means that desalination plants, with the capacity to supply up to 1/6 of the annual water demand (*ibid.*), are being used much below their potential.

2.3 A challenging meteorology

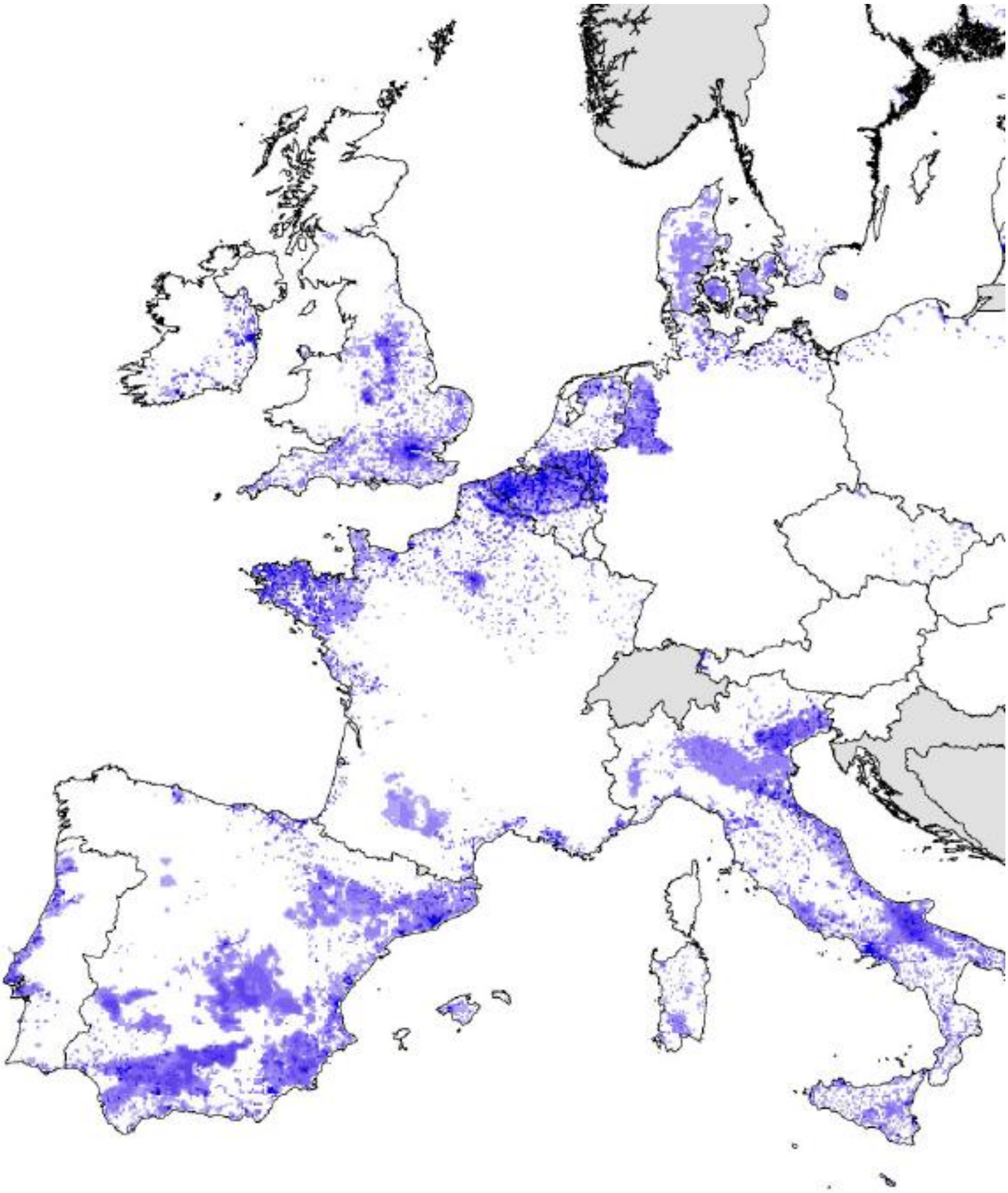
Except for the North and several areas in Central Spain, land is in arid and semi-arid regions with very low rainfall (see Map 2.1) (i.e. lower than EU average) and few long-term available resources per unit of land and on a per-capita basis. In addition, what is probably most important: there is high variability (see Figure 2-2) between wet and dry years and the evolution of rainfall and runoff patterns is uncertain (see Figure 1-1 and Figure 1-2). Private and public responses to these constraints in Spain make water management notably singular in the European context (see Map 2.2).

Map 2.1. Water scarcity: Long-term average runoff



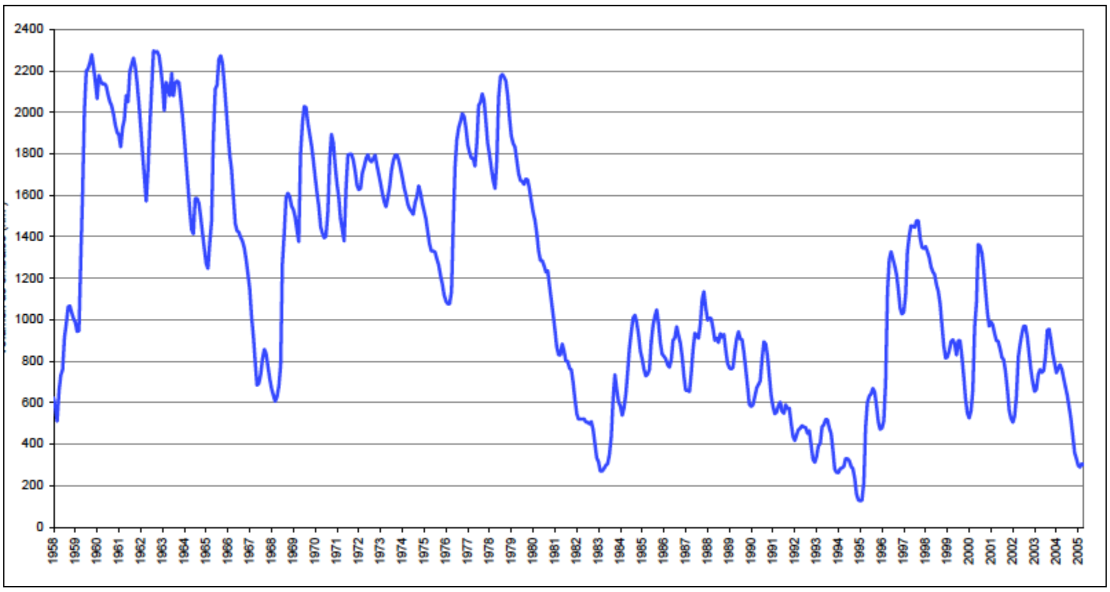
Source: De Roo *et al.*, 2012

Map 2.2. Estimated water scarcity with respect to combined water needs from all sectors (average 1991-2010)



Source: De Roo *et al.*, 2012

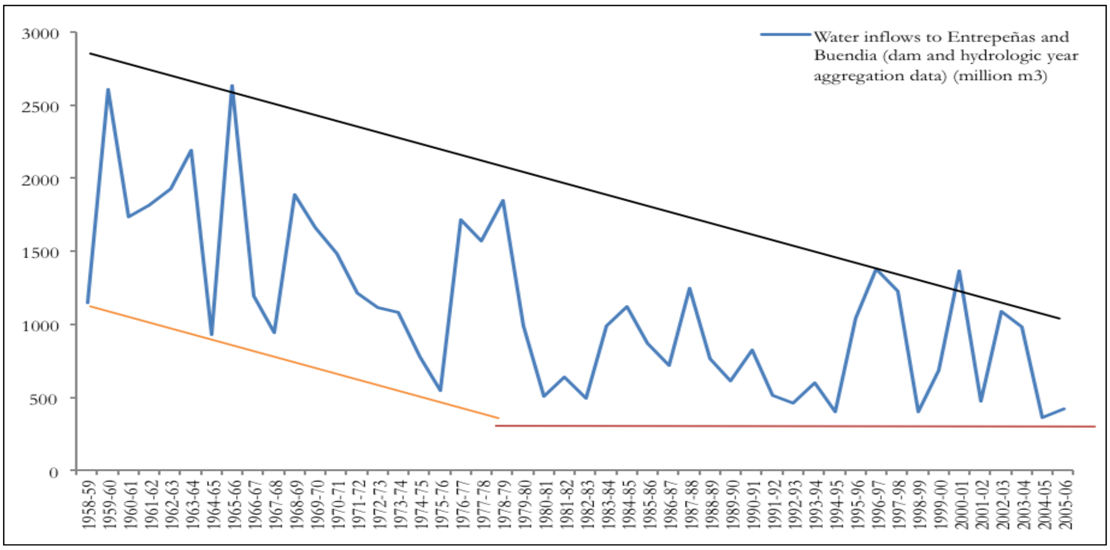
Figure 2-2. Volume (hm³) in Buendía and Entrepeñas dams (Upper Tagus), 1958-2005



Source: TRBA (2013).

Furthermore, hydrological patterns are not only characterized by variability. Figure 2-3 shows how the aggregated values of inflows in the above-mentioned dams in the Upper Tagus indicate that humid years reflect a decreasing trend during the whole period while dry years have been more stable for the past 30 years.

Figure 2-3. Water inflows to Buendía and Entrepeñas dams, 1958/59-2005/06



Source: Own elaboration.

Quantification of available water resources is a crucial challenge in any water management plan. In arid catchments such as those of southeastern Spain this task is particularly difficult as a result of precipitation variability along time. Under these conditions a primary goal of water management in these areas is maintaining a long-term balance of water resources.

Overexploitation of water resources in the SRB is well known and documented (EC, 2000; SRBA, 2007, 2008, 2011; EEA, 2009); what is less known is the supply-side dynamics and its main drivers which have been emphasised under this section, as a contribution to a complex explanation of scarcity patterns.

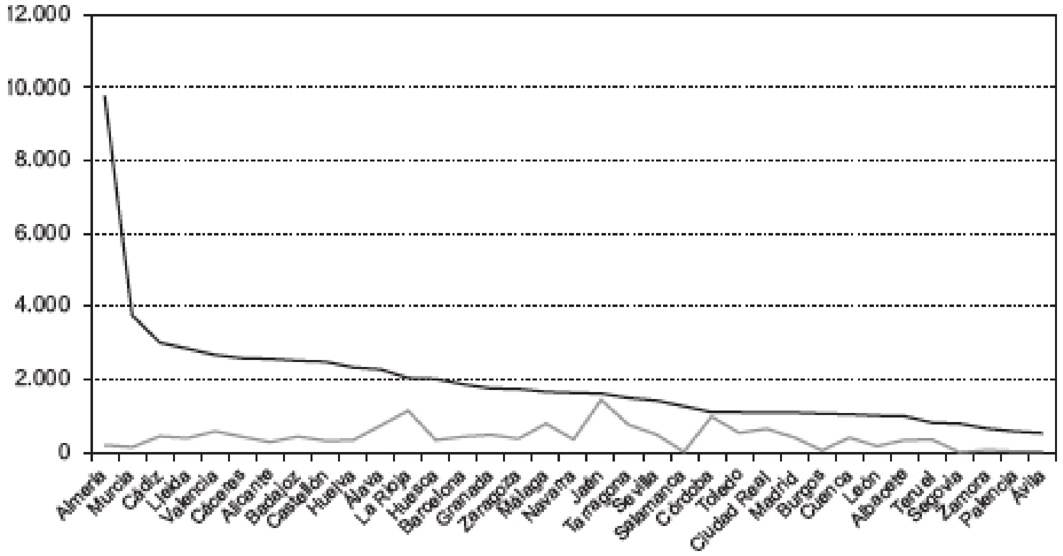
Because of variability, the major challenge for most large water systems is the spatial and temporal matching of supply and demand. Storage has been historically the key response to controlling the temporal variability in supply, while inter-basin diversions have been used to overcome the spatial mismatch (Hanemann, 2006). The overriding need to regulate water resources is not just a feature of the SRB water management but also a generic trait of water management in Spain. As a matter of fact, without water works it would not be possible to use more than 10% of long-term renewable resources in the country (MMA, 2000). Aggregate runoff coefficients range from 60% in Northern basins to 11% in the SRB, which exacerbates even more rainfall asymmetries.

2.4 Powerful economic incentives

As shown in *Chapter 1*, water is the missing factor required to mobilize prevailing comparative advantages for the development of a thriving agriculture and a seemingly strong tourism economy as well as to further progress in the energy, building and manufacturing sectors.

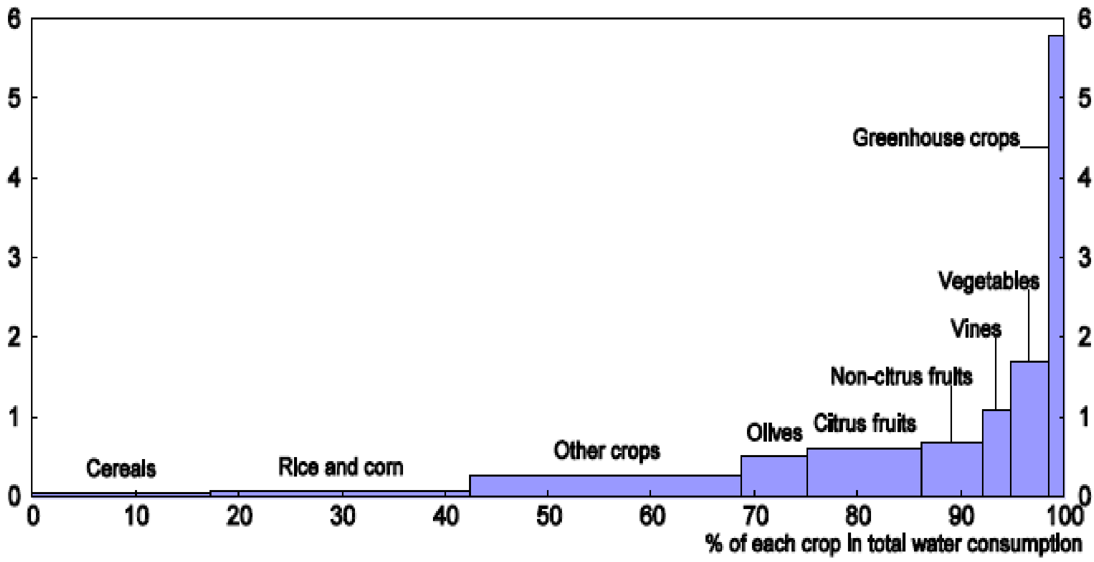
Water is not only valuable itself but rather for its potential to harness other economic factors, and definitely for its ability to multiply income, employment opportunities and the production of goods and services – i.e. access to water is the critical factor explaining the difference between crop yields and profits in irrigated *versus* rainfed agriculture (see Figure 2-4*a* and Figure 2-4*b*) and also of productivity (Figure 2-5).

Figure 2-4a. Net average margin of rainfed (light line) and irrigated (dark line) agriculture (€/ha·yr): province average 2001



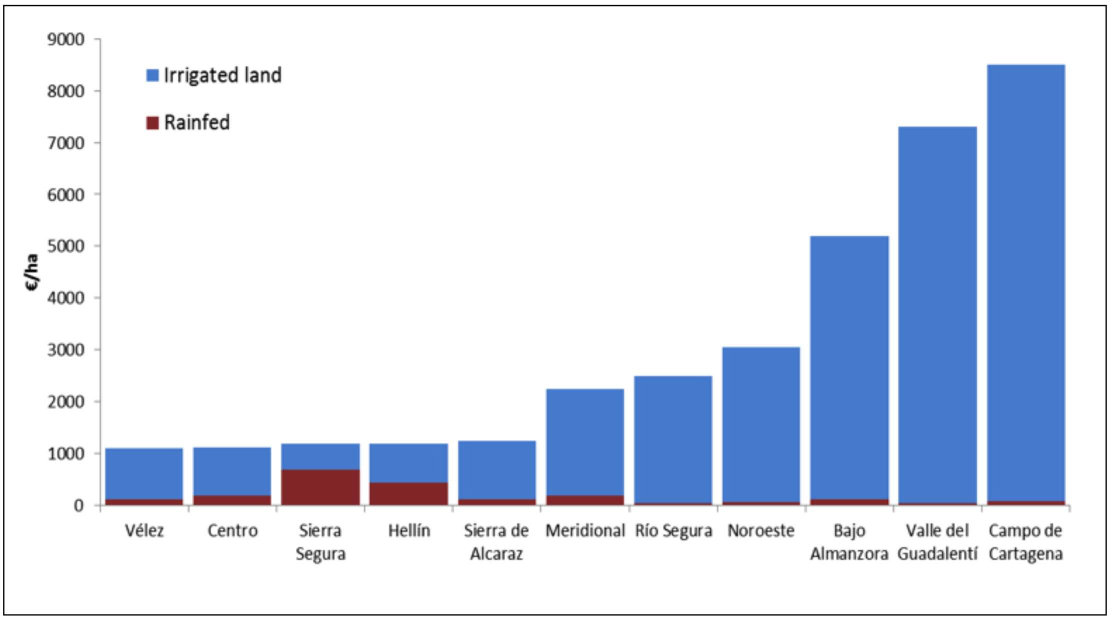
Source: Gómez (2009)

Figure 2.4b. Gross value added at market prices, by crop



Source: Maestu *et al.*, (2007)

Figure 2-5. Agricultural productivity (€/ha) in the SRB



Source: Maestu *et al*. (2007)

Economic incentives in place lead to the demand of increasingly unsustainable amounts of water. Depletion goes further the more profitable is water use. In line with this trend, the demand for further public responses for different purposes also increases: to solve local and regional deficits that are difficult to make compatible to each other at a national level; to use as much water as possible wherever; and also to the engagement of further withdrawals of those resources that are not yet under full public control (i.e. groundwater).

As above, many semiarid and drought-prone regions have significant competitive advantages for irrigated agriculture (Gómez and Pérez, 2012). Land is abundant and cheap, as not many alternative uses exist, solar radiation is guaranteed and, apart from abundant and cheap labour, many of these areas are located close to the seashore and to high demand markets. Anything but water seems to be in place to develop a wealthy agricultural sector. Water for irrigation is thus the critical production factor determining the feasibility and the financial returns of agriculture, together with the availability of water infrastructures (the latter in those regions where water is not that scarce). This is not just the case of the SRB but also of many European Mediterranean regions where the survival of a competitive and highly productive agriculture critically depends on the ability to meet water demand.

The link between incentives and water exploitation is also evident if looking at groundwater overexploitation, where the hypothesis to be tested in this report is that aquifer depletion stops when agriculture is not so profitable – the only driving force able to halt unsustainable water pumping is the energy cost (in relation to water productivity) (see *Chapter 4*).

According to the SRBA (2013a), 14 groundwater bodies have been officially declared as overexploited in the Segura. 10 additional groundwater bodies are in the process of obtaining an official declaration of aquifer overexploitation. Difficulties in implementing management plans in these aquifers are considered a SWMI (significant water management issue) in the river management plan. A prerequisite for this implementation is the creation of water users' communities but just was created in 2006 (Ascoy-Sopalmo) and other three are in the process of creation.

2.5 Water governance failures

Pricing for cost recovery, wrong incentives and lack of an evaluation culture

Economic policy instruments can be said to be useful if they contribute to solve government failures or, in other words, if they provide an alternative and more successful institutional arrangement to manage water scarcity and drought risk.

Governance failures are mainly caused by a combination of poor enforcement of property rights and incentive compatibility problems. Prevailing water institutions and water policy failures themselves drive some relevant economic incentives:

a. *'Use it or lose it' incentives.*

Incentives result from private property rights limited to water use in specific locations. Property-protected water rights are often subject to conditionalities on behalf of public interests (that is the case in Spain and most of the European Union). The requirement of effective and beneficial use of those water entitlements is one of them. Rights not used are lost through forfeiture or revocation (Solanes, 2013). As a result of that, non-used water cannot be traded in Spain. Permanent nominal entitlements favour hoarding and speculation and trades of nominal rights (not allowed in Spain) have negative effects on sustainability (see Loch, 2013, with evidence of the Australian case). However, this can be said to yield no incentives to save water since the water you save if the water you actually lose.

b. *Inconvenient water pricing systems.*

- The pricing scheme deployed by the river basin authorities in Spain is one aimed at a limited financial cost recovery (mainly upfront investment costs and a share of operational and maintenance costs). It is mainly based upon the so-called *canon de regulación* (a fee charged on beneficiaries of surface / ground water regulation works, dealing with water abstraction and storage in dams and reservoirs owned by the basin authority), and the *tarifa de utilización de agua* (an additional fee paid by the beneficiaries of water works not dealing with regulation but rather with water delivery).
- No specific provisions are available as yet for the recovery of environmental costs and the resource cost (or scarcity value)[12].

[12] According to water planning guidance and regulation (the so-called *Instrucción de Planificación Hidrológica*, investment costs in basic measures to comply with European regulations can be used as a proxy for environmental costs. This would imply EUR 3,835.77 million for the Tagus (TRBA, 2013) and EUR 2,254 million for the Segura (SRBA, 2013c), which implies an equivalent annual costs of EUR 248 million a year. As to the resource cost, guidance suggests that the scarcity

– As a result of that pricing system final water prices do not convey any incentive. Provision costs paid to water authorities along with those associated to provide the service to any individual user, are transferred with the same purpose: cost recovery. Prices themselves have thus never been a demand management instrument but rather a mere financial cost-recovery mechanism.

The WFD explicitly states that water pricing has to be used as an incentive to adapt water demand to the EU environmental standards, especially in overexploited areas such as the SRB (EC, 2000). Higher prices for conventional water sources in agriculture may improve the status of water bodies in the SRB in two ways.

On the one hand, they can reduce the expected income and thus limit water demand from low productive crops; on the other, they favour the replacement of overexploited conventional water sources by largely idle non-conventional ones.

Although the average bulk water price for agriculture in the SRB is the highest in Spain (0.096 €/m^3 for conventional water sources, almost twice as large as the Spanish average of 0.05 €/m^3) (SRBA, 2013d; Maestu and Villar, 2007), this price only reflects the higher financial cost of supplying water in that basin district as compared to other basins in Spain.

As above, this water price does not take into account neither the scarcity value of the resource or the environmental costs of water supply, which could significantly increase water price. Moreover, the observed water price is not even high enough to guarantee a full-cost recovery, with cost recovery ratios ranging between 54.08% (for intrabasin surface water resources) and 80.82% (for the TSWT) (Maestu and Villar, *op. cit.*).[13]

This is even more striking should we consider that most of these investments were ultimately aimed at guaranteeing water security in agriculture, a private endeavour. This alone could justify a price increase on the grounds of the cost-recovery rationale, as required by the EC. Nevertheless, such a policy may also generate adverse effects on the local economy, which heavily relies on agriculture, as shown in *Chapter 1*.

It must also be stressed that there is actually no culture of *ex-post* assessment. The real outcome is never contrasted with the promised result (López-Gunn *et al.*, 2013). There is no comprehensive *ex-post* assessment available of any of the most significant actions to manage water supply and to coordinate supply and water demands. Evaluation is mostly focused on interim aspects, such as work done, transformed hectares, reduced leakages… but not on the most relevant issue (i.e. environmental outcomes): water saved, water left, increase in phreatic strata, or whatever indicator which is closer to the ecological status of water bodies.

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cost (measures as an opportunity cost) should be used as a proxy. No information is available for the Tagus and Segura RBDs.

[13] TRBA (2013) reports global cost-recovery levels for 2008 of 75% (bulk water services, 58%; domestic water services, 79%; irrigation water services, 59%), whereas SRBA (2013d) in turn reports full (100%) cost recovery for hydropower, 88.38% for domestic and industrial uses (2002), and 91.53% in agriculture (2001), which decreases to 85.64% in 2005 and onwards.

As a result of that, poor impact evaluation translates into poor policy design. Benefits tend to be overestimated and drawbacks overlooked (in particular those associated with users' reactions as a response to changes in incentives).

Conventional policy responses (reference policy instruments)

This section includes the main responses to water scarcity and a brief rationale of why they have not been successful, which calls for the use of the innovative economic policy instruments assessed in this case study.

1. The Tagus-Segura Water Transfer (TSWT)

Current law sets the maximum volume received in the SRB in 540 hm^3, of which 140 are for urban supply and 400 are devoted to irrigation (335 hm^3 of which are applied within the boundaries of the SRB). Its construction ended up below the designed capacity (only 600 instead of 1,000 hm^3/year) and since 1978, when the project became operational, the average volume transferred has been around 320 hm^3 for all the Tagus-Segura transfer users. Approximately, 33% of the irrigation water demand in the SRB comes from the TRB (considering volumes devoted to irrigation and those diverted from urban treatment plants).

It is important to point out that not all resources transferred from the TRB remain at the SRB: for instance, from the 400 hm^3/year for irrigation, 335 are for the SRB and 65 for two neighbouring river basin districts (Júcar and Sur).

a. Key element of a coordinated development programme designed in the 1970s

This major diversion project was firstly planned back in 1933 during the second Spanish Republic as part of the National Plan of Hydraulic Works. The aim of the plan was to propose an integrated management plan that could soften differences in water availability among regions.

Agriculture was one of the main targets as it was considered that the hydrological imbalance was hindering economic development as the most productive areas (i.e. the Southeast), were also the poorest in terms of water availability. In the original planning document water was considered scarce in that region and the hydrological regime rather unreliable.

Rainfed productivity was low, even in the most humid areas. Therefore, the plan aimed not only at providing water to the already existing and poorly supplied irrigated lands but also to increase irrigated land using water surpluses from other river basins.

The specific plan for the SRB had to adapt to the likely water transfer from the TRB of 700 hm^3, to be shared between an area of 125,000 ha, and different alternatives for the development of new irrigated land. Besides, the Plan considered that the regulated waters of the SRB could also be used, using for its estimation the hydrological period 1926-30. During those years, after meeting all irrigation demands and with a normal functioning of the regulation dams, the river discharged in the Mediterranean Sea and average of 362 hm^3 per year.

A first assessment of the renewable water resources of the basin was made, adding the discharges to the Mediterranean to the yearly average water consumption, which brought an estimated amount of 860 hm^3 per year (and considering that no overexploitation was yet recorded). It is worth mentioning that water allocated to irrigation was already 60% of total water renewable resources (SRBA, 2013).

The original allocation of water resources to be transferred (the above-mentioned 600 hm^3) in the SRB was designed and approved by the Spanish Cabinet in 1970. The main objective of the project was to restructure irrigated lands with the basins own resources and to bring up to date the allocation established in 1953. The net average supply for each agricultural district was between 5,300 and 5,700 m^3/ha·yr (weighted average: 5,384 m^3/ha·yr). The expected allocation of external resources in the National Plan of Hydraulic Works (and its application in the Segura River Basin; 1,604 and 999 hm^3, respectively) were higher than those established in the decision of 1970, which as it has been said could not go beyond 600 hm^3.

The Law 52/1980 on the Regulation of the Tagus-Segura Aqueduct established the technical rules for the transfer exploitation (volumes and flows), geographical distribution, and use allocation.

After the general allocation of resources coordinated plans were launched between 1980 and 1986 with further specifications defining irrigation lands and its closed perimeters. In the RBMP of 1998, total renewable resources in the SRB were estimated in 1,483 hm^3/year: 767 hm^3/year of own resources, 540 hm^3/year of transferred resources (transportation losses were estimated at 60 hm^3/year), 90 hm^3/year of water re-use and 86 hm^3/year of irrigation physical returns.

Besides, the plan included an amount of available but not renewable water resources of 250 hm^3/year, resulting in 1,733 hm^3/year, in an average hydrological year, with the transfer working at its maximum installed capacity and including overexploitation and water re-use. On the demand side, the plan identified 172 hm^3/year for urban water demand, and 23 hm^3/year for industrial and service uses not connected to the distribution net. Regarding irrigation, the gross and net demands were 1,622 (1,571 for the SRB) and 1,423 million m^3/year, respectively. However, the plan estimated for agriculture a volume of 1,250 million m^3/year, highlighting the concern about water scarcity. Adding 4 m^3/s of e-flows the plan's estimation of total demand grew up to 1,932 hm^3/year.

b. *Water demand increased as expected but water supply grew below expectations*

The development of irrigated lands after 1980 was actually different than what was planned; areas were modified, crops changed with time and still tend to evolve to more productive crop varieties with higher financial appeal, own available resources (surface and groundwater) were actually lower than what was foreseen (SRBA, 1998).

Currently, total water demand in the SRB is estimated at 1,962 hm^3/year of which 1,662 hm^3/year are for agricultural uses (Calatrava and Martínez-Granados, 2012). Total renewable resources of 1,592 hm^3/year do imply a structural deficit of 370 hm^3/year., mainly explained by irrigation expansion during the last three decades. This deficit is mainly covered through non-renewable groundwater withdrawals and a *de facto* deficit in some plots of around 230 hm^3/year.

c. *The supply failure increased pressures over local resources and made them scarcer*

Despite its limited success and unfulfilled expectations in the SRB district the policy debate around the TSWT has increasingly focused on whether it has served to spread water scarcity elsewhere rather than to cope with water supply deficits in the Segura. The different views about the costs and benefits of the TS inter-basin transfer is undoubtedly one of the critical elements that needs to be sorted out to reconcile both the Tagus and Segura RBMPs whose submission to the European Commission is pending since 2009 (OJ, 2012).

2. **Alternative water resources as a response to the failed major transfer from the Ebro (NE Spain)**

The regulation of transfers in Spain had traditionally been limited to those cases in which powerful public-interest arguments would apply. Even in those cases, legislators have included significant caveats in terms of environmental and socio-economic impacts, in order, for instance, to prevent the future economic development of the river basin with water surplus from being jeopardized. This implied that current uses, e-flows and the preservation of ecosystem services, had to be guaranteed.

The 1985 Water Act was definitely a landmark in Spanish water planning evolution, since river basin plans were a binding requirement in that legal body. In the late 1960s and early 1970s, two river basin plans had already been developed (in the Eastern Pyrenees, in Northern Spain, not a legal basin anymore, and the Guadalquivir, SW Spain).

Despite major achievements, water planning has never been a bed of roses in the country. In 2001 a National Hydrological Plan (NHP) was passed with the status of law (10/2001, July 5th). The National Plan included measures for the co-ordination of river basin plans, solutions for policy alternatives identified in those plans at a basin level, projections and conditions for inter-basin water transfers and adaptive management of changes in water balances that may require new policy measures, specially for irrigation and domestic water uses. The main project of the NHP was the controversial Ebro (NE Spain) inter-basin transfer to SE Spain (an old idea, since in 1933 a former director of the Ebro river basin authority had already suggested that this water transfer was more rational than the Tagus-Segura one).

The planning document (not the Law, but the NHP itself) provides a rationale for inter-basin transfers: "to solve water deficit as described in the White Paper on Water in Spain (2000)". The Ebro basin was seen as a "territory prone to inter-basin transfers" to help mitigate "water structural deficit in Eastern and South-Eastern Spain". The solution was seen as "the most efficient [one], after considering all other alternatives, and carrying out a rigorous cost-benefit analysis of water transfers, valuing environmental, socio-economic and technical variables and submitting the analysis to a wide social debate".

The transfer was formally designed on the basis of cost-recovery principles and an environmental charge (transfer fee) was established (art. 22, Law 10/2001) to compensate for ecosystem service losses in the Ebro basin.

The proposal for water transfer from the Ebro river basin was designed to solve severe degradation of Southeastern Jucar, Segura and Sur basins, by transferring 820 hm^3 from the Ebro to areas 750 km away, as well as sending 180 km northwards an additional volume of 200 hm^3 to Barcelona's metropolitan area. The main (formal) argument against the transfer was that supply-side approaches to water management were obsolete and water demand policies were rather needed. Albiac *et al*. (2006) analysed both the costs of alternatives and the response of demand to water prices, pointing out that the Spanish water authority had ignored both critical aspects in those days.

As a matter of fact, policy instruments such as water pricing (based upon "full cost recovery" principles), abstraction limits both on surface and groundwater resources, water markets, revision of water concessions, measures for quality improvement, or even alternative resources (desalination, water re-use, etc.), were put aside.

Not only were these alternatives unduly or not at all considered; since most of the water transferred would have gone to agricultural uses, benefits for farmers were assessed on the basis of estimations of the average value of water productivity. Conceptually this was wrong, since the benefits of an incremental supply of water in SE Spain's receiving basins should have been the marginal value of water, so as to calculate the avoided profit loss by importing transferred water.

Furthermore, through relying on the average value approach, the project ex-ante evaluation incurred in two additional misconceptions: it was assumed that profits are only dependent on water availability (ignoring the role of other inputs) and also that the average value of water is constant and non-declining with the amount of water. Needless to say that, as in other world examples (i.e. the Central Arizona Project, see Hanemann, 2006), sound economic analysis would have found that farmers' actual willingness to pay would have turned out to be substantially less than their estimated ability to pay, as calculated in the transfer proposal evaluation.

These mistakes are not negligible. Yet, the main failure or omission can be seen in a different context, highly related to the pervasive conventional disregard of efficiency, sustainability and equity impacts within water project appraisal. The fact that water policy is every so often biased towards supply-side approaches has the unwanted outcome of project evaluation based, at its best, on financial profitability terms. Cost recovery tends to be financial cost recovery, subsidies are poorly assessed, there is no formal economic evaluation of environmental externalities (either positive or negative). Just to keep it brief: no economic evaluation is performed; rather, just a financial one.

The Ebro transfer proposal evaluation did not take account of uncertainty in estimating future costs and benefits (thus ignoring that increased water availability does not imply, more often than not, additional water inputs to current crops but rather a crop mix shift, as part of farmers' optimal decisions). Neither was the energy cost (nor ancillary external costs in terms of air pollutant emissions) taken on board. The conservation of biophysical flows of water ecosystem services in the Ebro delta was also subject to lack of thoughtful attention.

One may argue, though, that all these omissions are within the context of welfare (that is, efficiency) appraisals. There are some equity aspects, though, that should have received a sound analytical treatment. The fact that the project costs and benefits were wrongly appraised, does have implications in terms of equity since benefits for farmers in receiving basins were systematically overestimated whilst those of farmers in the Ebro basin were underestimated in turn.

Advocates of the Ebro inter-basin transfer argued that it would contribute to territorial social cohesion, via the creation of wealth in SE Spain. Again, from an efficiency perspective (that is, in terms of Pareto optimality), it is clear that a project can only be deemed to be optimal if those better off with the project do not gain welfare at the expense of those worse off with the transfer, regardless of who is a winner or a loser. From an equity perspective, though, the State should have taken account of who specifically would have lost and who would have won with the transfer, thereby using distributional weighs to appraise the social profitability of the proposal.

The Ebro inter-basin transfer proposal was cancelled after a different Government took office in 2004. The legal amendment (11/2005, June 22nd) was passed in 2005, after very intense public debate and participation. The new Government approached scarcity problems in SE Spain through the AGUA project, whose main thrust was to increase water supply via water desalination (see Rico, 2010, for a very detailed description of the programme).

Official reasons for the transfer cancellation were: the overestimation of benefits and the underestimation of costs, the inadequate explanation and analysis of pricing issues, the wrong estimation of the price-elasticity of demand, threats to ecological flow conservation in the Ebro, the ecological threat of invasive species expansion, lacking analysis of energy provisions, lack of rigour in the estimation of surplus water to be transferred, and the subsequent opposition of the European Commission authorities, which would have conditioned the project funding.

Activities under the AGUA programme (see Table 2.1), designed in 2004 as a response (and a major investment effort, see *section 2.2*) to the failed Ebro inter-basin transfer, included:

- A shock plan of irrigation modernization with estimated water savings of 114 hm^3/year.
- Expansion of installed desalination capacity for irrigation: 169 hm^3/year in a first tier (2009) and 252 hm^3/year in a second tier (2015).
- Expansion of desalination capacity for domestic supply: 181 hm^3/year.

None of these projects is actually working as planned (Cabezas, 2011). Desalination costs, rather than decreasing, as wrongly estimated, have increased as a result of the stagnation of energy returns and the increasing cost of energy inputs. Cabezas (*ibid.*) estimates that against 0.21 €/m^3 of groundwater, current unit costs in the most advanced desalination facilities in the country hit 0.8-1 €/m^3, 4 to 5 times higher, which implies that desalination facilities are being used at less than one fifth of their installed capacity.

Table 2.1. Desalinated water for irrigation and other uses (Segura River Basin - planned)

	Provisional Outline of Important Issues		**DRAFT PLAN**					
	Expected production capacity 2015 (hm^3) [a]		*Expected production capacity 2015 (hm^3) [b]*		*Expected production capacity 2027 (hm^3) [b]*		*Maximum production capacity 2015 (hm^3) [b]*	
Desalination plant	*Irrigation*	*Others*	*Irrigation*	*Others*	*Irrigation*	*Others*	*Irrigation*	*Others*
Alicante I		45		13		14		45
Alicante II								
San Pedro Pinatar I		48		33		48		48
San Pedro Pinatar II								
Valdelentisco (Murcia)	17		17	2	17	11	30	20
Águilas ACUAMED (Murcia)	34	2	34	1	48	9	48	12
Torrevieja			*	0	*	22	40	40
El Mojón	2		2		2		2	
C.R. Virgen Milagros	10		10		10		10	
C.R. Marina de Cope	5		5		5		5	
C.R. Águilas	4		4		4		4	
Escombreras (CARM)		2		1		1		23
Bajo Almanzora (Almería)	7		7		7		7	
Total (per use) (hm^3)	79	97	79	50	93	105	146	188
Total (hm^3)	176		129		198		334	

Sources: [a] SRBA, 2013a (ETI); [b] SRBA, 2013e (Draft River Basin Plan).

[*] To be used as a source only in the event of drought

Note: According to draft plan "Expected production capacity for the year 2015" is based on the volume of water to be supplied by already existing formal supply agreements. Values are lower than maximum production capacity due to the fact that with high tariffs for desalinated water, the full production capacity cannot be reached.

The use of regenerated water and treated wastewater has also increased very remarkably over the last few years (see Table 2.2). Water directly or indirectly re-used during 2010 from Segura River or tributaries hit 100 hm^3 (around 90% of it was treated water) (DGA/ESAMUR, 2012). At river basin scale, according to data from the public record of water rights in 2008 the SRB was the continental basin with the highest volume of requested concessions on reclaimed water (139 hm^3), and the only Spanish basin that uses 100% of the available volume of treated water (this could be slightly overestimated because of salinity levels that make around 10% of that water not available for use).

In 2010, as reflected in the SRB draft plan, 62.82% of the volume of treated wastewater from urban WWTPs was directly re-used; should indirect water reuse considered, the ratio would soar up to 98.49% (slightly over 140 hm^3). For 2015, this is expected to be 99.98%.

Table 2.2. Water reuse (Segura River Basin: 2010, 2015, 2027; hm^3/year)

	2010	*2015*	*2027*
Treated volume (municipal WWTPs)	142.2	143.6	167.7
Wastewater discharge (WWTPs into river)	59.6	58.6	56.9
Direct reuse (Municipal WWTPs)	82.6	85.0	110.8
Direct reuse (Private WWTPs, for irrigation)	4.3	4.3	3.3
Direct reuse (Private WWTPs, golf courses)	2.4	3.6	8.2
Direct reuse (TOTAL)	89.3	93.0	122.4
Wastewater discharge (sea)	8.9	8.0	0.2
Indirect reuse (all uses)	50.7	50.6	56.7
TOTAL Water reuse (all WWTPs)	140.0	143.6	179.1

Source: SRBA, 2013e

Desalinated water supply, however, is reliable and its financial cost is higher than its economic one. Conventional water, on the other end, is financially cheap but economically expensive and unreliable. Let us review some data on prices to provide evidence on this.

The official fee of the TSWT diversion project since March 2012 to syndicated irrigators in the Southeast of the country (i.e. SRB and other neighbouring basins), is 0.124579 €/m^3 (it was 0.08 from 2001 to 2005, 0.09 from 2005 to 2009, and 0.174 from 2010 to 2012).

In addition, the average cost of groundwater in the SRB is around 0.21 €/m^3 (Cabezas, 2011) and may range between 0.25 and 0.30 €/m^3 (GWI, 2012), depending on factors such as depth of the water table or pumping equipment efficiency.

Desalinated water real production costs ranges from 0.8 to 1 €/m^3 (*ibid.*) or from 0.59 to 1.19 (according to Villar, 2013a), with average values around 0.91-0.93 €/m^3 (Rico 2010). The AGUA programme factored in a subsidy to desalinated water which explains a unit cost estimate of 0.6 €/m^3 and a final price of 0.42 €/m^3, which is far from being a reality (even more in the absence of subsidies as part of fiscal consolidation strategies).

Reclaimed water unit cost (SRAB, 2013b) is estimated at 0.37 €/m^3. According to DGA/ESAMUR (2012), the average operational cost would be at 0.062 €/m^3 (ranging from 0.055 to 0.080 €/m^3, according to technology and quality of water to be regenerated).

These data clearly explain why water users demand these non-conventional water resources just as an emergency source but this makes cost recovery and the maintenance of installed capacity more challenging.

3. Modernization plans for irrigated agriculture.

Modernization of irrigation systems is another story of great expectations linked to the expenditure of big money. But what about if investments in water use efficiency in agriculture, to mention a relevant example, did not lead to actual water savings?

Water saving potentials are based on the following argument: should one be able to improve her irrigation technique, less water would be required, thus diminishing water withdrawals (provided off-site losses were kept constant); water bodies would thus be in a better condition (i.e. their ecological potential would be enhanced) to the benefit of all relevant stakeholders.

Yet, there may be a fair way to go from water saving potentials to actual ones. Regarding hydro-economic models, the validity of some assumptions has been questioned in recent years and the scientific community is currently aware of a number of paradoxical outcomes that may occur. It is well known that, for instance, using less water per crop does not necessarily mean using less water overall (at a farm, irrigation district or basin level), (Ward and Pulido-Velazquez, 2008). Likewise, water losses at a farm scale are not equivalent to water losses in a hydrological sense (Perry *et al*., 2009). Therefore, environmental benefits could be said to be likely outcomes rather than proven facts.

Surprisingly (or maybe not so much), one to the most water-stressed regions in Europe (namely the SRB) is at the same time a very efficient river basin district. In 2010, 65.7% of irrigation systems were drip ones, 6.5% were sprinkler systems, and only 27.8% were still gravity systems.

The National Irrigation Plan, NIP (MARM 2002, horizon 2008), programmed investment to improve and consolidate irrigation systems nationwide. EUR 5,024 million were planned for roughly 1.4 million ha, and expecting water savings of 2,000 hm^3/yr. In the SRB, EUR 263.8 million for 69,872 ha were planned in turn.

In 2006, an Irrigation Shock Plan (SP) had already planned investment in the SRB for EUR 222.1 million, for estimated water savings of 65.34 hm^3/yr. In Spain, EUR 2,344 million were invested for 866,898 ha and 291,024 farmers.

There are at least two questions to be answered and assessed in this case study (see *Chapters 4* and *5*). Why do not farmers massively invest in irrigation modernization spontaneously (i.e. without public support) if it is such a seemingly convenient investment? Why could the result be disappointing from a water policy perspective?

As to the former, the question could be rephrased as: are farmers interested in using a thing they would never buy on their own? What we have observed in this analysis is that, under certain circumstances, the answer might be yes but not so much because they have a genuine interest in water efficiency at a plot level but rather to use that water elsewhere (in another plot) or mostly to increase water security, as the echo of a risk-adverse behaviour. And if they do not it is precisely because of an *incentive / policy* paradox.

The answer to the latter is trickier. Nature and mankind adapt to new conditions in ways that need to be understood beforehand. Paradoxically, the success of water efficiency measures, as the desired outcome of these investments (either public or not), could actually mean an actual saving at a plot level, but not necessarily at a higher spatial scale (catchment, basin).

In economic theory, part of these effects is conceptualized under the proposition of the so-called *Jevons'* paradox[14] or rebound effect (Alcott, 2005; Polimeni *et al*, 2007; Madlener and Alcott, 2009). Unlike common wisdom, technological progress (introduction of low-pressure irrigation systems, for instance), that increases the efficiency with which water is used, tends to lead to the growth of the rate of consumption at a certain scale. Energy economists, studying consumption "rebound effects" from improved energy efficiency, have revisited this issue (Brookes, 1979; Khazzoom, 1980; Lovins. 1988; Saunders, 2000; Schipper and Meyers, 1992; Howarth, 1997; Wirl, 1997; Schipper and Grubb, 2000; Brookes, 2000; Binswanger, 2001; Sorrell *et al.*, 2009).

Efficiency measures do actually reduce the amount of water demanded for a given use. However, in addition, improved efficiency lowers the relative cost of using water (making water a more productive input), which in fact is an incentive to use more, potentially outweighing any savings from increased efficiency (Gómez, 2009; Olmstead, 2010). There may just be an overall rise of water consumption, since the resulting water savings do not compensate for the increased demand brought by the expansion in irrigated area and the shift to higher-value and more water intensive crops enabled by higher irrigation application efficiencies (Cots, 2011; Lecina *et al.*, 2009).

Further to this paradox, explained through economic theory, there could be a *hydrological* paradox. Again, one assumes that efficiency improvements do reduce water use, as commonly believed. However, water depletion may increase through an overall rise in consumptive use and, therefore, reduced physical return flows (and water supply downstream) and lost aquifer seepage (Ward and Pulido-Velazquez, 2008). According to SRBA (2013e), irrigation efficiency measures to be carried out in the SRB during the period 2010-2015 will entail a reduction in return flows of 9.97 hm^3/yr.

In addition, there is an increase in energy consumption and energy dependency brought about by the generalized mechanization of irrigation systems. This is what we call the *sustainability* paradox. In irrigation the energy component (kWh/m^3 applied) increased up to 0.34 kWh/m^3 in 2008 as compared to 0.15 kWh/m^3 in 1990 (Corominas, 2009). There is evidence, though, that the energy bill for irrigation may have increased by 50% in terms of installed capacity contracted (fixed cost) and 200% in terms of consumption (variable cost) (Sirasa, 2010).

There have been overwhelming changes in irrigation since 1950. Irrigated land multiplied by 2.5 and its energy needs by 7 (Hardy and Garrido, 2010). This leads to an average of 1,560 kWh/ha and 0.24 kWh/m^3. Corominas (*op. cit.*) estimates that water use efficiency improved by 21% (from 8,250

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[14] This paradox is part of an essay (Jevons, 1865/1965) called *The Coal Question*, in which Jevons maintained that technological efficiency gains (specifically the more economic use of a natural resource – coal in his case), actually increases the overall consumption of the resource itself.

to 6,500 m^3/ha, from 1950 to 2007) whereas water consumption only decreased by 3.7% and energy demand hit 1,560 kWh/ha from 206 kWh/ha in these almost 60 years (+757%) (Rodríguez-Díaz *et al*., 2011). There is obviously some averting behaviour by farmers (such as reducing labour costs linked to energy use or expanding irrigation in areas with an increasing height or plots with higher slope) but unable to overcome at a major scale the increase in energy costs.

What is clear is the paramount importance of incentives. Apart from making water more productive, taking this opportunity requires guaranteeing that at least part of the water thus saved is not used for new activities or to expand current ones. This is precisely the role EPIs can (and should) play. Price increases may, for example, offset the productivity-driven increase in water demand; the water authority may ask for a reduction in water abstraction rights in exchange of financing the upgrade of the system; or the option to sell use rights in more abundant areas may be used to foster water savings and reduce scarcity in the most scarce ones. The basic lesson from is that without EPIs the outcome is not guaranteed and bridging the water efficiency gap may be counterproductive as a means to reduce scarcity.

4. Drought management plans

Last but not least, drought management plans are contingent constraints on water supply but without provisions to reduce water demand.

As in *section 1.5* a number of measures at a EU level (and not just in Spain) have been recently adopted to tackle the structural problem of recurrent droughts. In what was perceived as an advance towards the replacement of the emergency responses of the past by the apparently more appropriate planned and anticipated risk management response, several river basin authorities from Spain, UK, Portugal, the Netherlands and Belgium approved their respective Drought Management Plans (DMP) (EC, 2007).

Basically, for the case of drought events these plans set up more stringent constraints to the access of publicly provided water at the same time that priority uses such as drinking water were guaranteed and minimum environmental services preserved. As a result, the declaration of a drought event automatically reduces in a predictable amount the quantity of water delivered to the irrigation system from publicly controlled water sources. The DMP defines the precise thresholds of possible drought situations and sets water constraints that will enter into force in each one of these cases.

For example, in the SRB, as above, a four-tier classification system is used (normality, pre-alert, alert and emergency) (see Figure 1-4): in the case of an emergency, an optimistic[15] 50% of planned irrigation resources will be allocated, trying to guarantee in the first place the survival of ligneous crops (although water distribution can be re-assessed by local authorities). Less stringent water constraints are established for alert (75%) and pre-alert levels (90%) (SRBA, 2010).

[15] During past drought events, observed irrigation resources conceded have reached in many cases levels well under 50% of initially planned irrigation resources. This was the case of the last 2005-2008 drought event, when irrigation resources conceded were fewer than 25% of initially planned for the whole period (SRBA, 2010 and 2011).

DMPs do therefore reduce *de jure* water supply during drought events. However neither the DMP nor water authorities introduce any instrument to tackle groundwater illegal abstraction[16], which is not only one of the main causes of the increased scarcity and drought risk in arid and semiarid watersheds but also one important limit to the ability of the water authority to reduce water use during droughts. In fact, the deficient enforcement of property rights on groundwater use in several European Mediterranean basins raises some remarkable doubts about the effectiveness of the DMP.

Reductions in water supply from controlled sources, while proved to be efficient for surface water resources, are more difficult to enforce over legal and illegal groundwater sources (Llamas *et al*., 2007; SRBA, 2010). As in the past, farmers may try to use informal and more reliable groundwater to compensate for the lack of formal legal withdrawals of surface water. Under prevailing drought management rules aquifers can be considered as a *de-facto* insurance against drought[17] making drought risk equivalent to groundwater depletion risk (Gómez and Pérez, 2012).

2.6 Concluding remarks. Why EPIs?

So far, the focus has been placed on instrumental objectives such as increasing water transport facilities (i.e. TSWT), developing new sources (i.e. desalination and reuse) or making any use of water more technically efficient (i.e. irrigation modernization).

When judged separately and against these technical objectives those alternatives have been successful. Current infrastructures allow for the reallocation of significant amounts of water; alternative or non-conventional sources do already exist and might provide significant and reliable water services; and water use, particularly in those areas when water is scarcer, is close to the standards of best available technologies. In the same sense drought management plans have been successful in setting contingent water constraints on resources controlled by the water authority and seem to be progressing from preceding reactive, discretionary and emergency responses towards a new anticipated, contingent, and planned response to water risks. Yet, the economy continues using an unsustainable amount of water and no evidence exists that drought risk has been reduced indeed.

The important lesson behind the success and failures of water management in the Segura river basin is that the overall objectives of water policy cannot be taken for granted. This is particularly true in a region where important economic incentives do exist. The real explanation needs to be found precisely in those economic incentives. Not only can they explain peoples' behaviour but also why, for example, water demand increased despite the unfulfilled promise of the TSWT facility. Along the same line, prevailing incentives are the reason why water saved after making farming practices more efficient is reallocated to other uses or why not many farmers are willing to use desalinated water on a regular basis or why when the provision of surface water is limited by

[16] Rather, river basin authorities have explicitly postponed the compliance of Environmental European quality and state Standards for aquifers further than the initially planned deadline of 2015 (EC, 2003; SRBA, 2010, 2011).

[17] Conventional response against outlawed water abstractions has consisted in more infrastructures and the concession of additional irrigation entitlements (Gómez, 2009). This partly explains why irrigated land in the SRBA has grown by over 275% from 1990.

the water authority, farmers turn to many already overexploited, but uncontrolled, groundwater sources.

Reinstating coherence between private decisions and public objectives is quite the defining role of economic policy incentives: prices must be designed in such a way that demands are in accordance with the amount of water the environment can sustainably supply, water trading must serve to reallocate water to its more productive uses increasing welfare without further pressures over the water environment... The genuine objectives of water policy, after all, are finding the way to foster economic progress while improving and protecting the status of water resources. They cannot be taken for granted and, particularly in regions where water is valuable to the economy, incentives, driving the decisions of all individual water users, should not be in contradiction with the collective objectives of water policy.

3 The way ahead: EPIs, opportunities, instruments and how to assess them

3.1 Introduction

EPIs are means to an end. Along the same line, EPIs hereby proposed are a means to serve the actual objectives of water policy which in this case study consist in changing current water scarcity trends, reducing drought risk so that water security and resilience are enhanced while improving sustainability of water management in the long term.

EPIs and CRIs

These ambitious resolves can only be attained provided other intermediate and more instrumental objectives are also met. To deliver its contribution to sustainable water management EPIs must also serve (and not be in contradiction with) the purposes of cost recovery so that the financial sustainability in the provision of water services is guaranteed and all water users in the economy receive the adequate signal of the environmental costs they trigger and of the benefits foregone for not using water in its best available alternative.

Yet, unlike cost-recovery instruments (CRIs), EPIs are incentives to induce changes in individual decisions (Strosser *et al*., 2013). Current practice in Europe shows that if assessed against its capacity to recover the financial costs of water services, some instruments may be judged as adequate without actually having any capacity at all to change the *status quo* (i.e. current practice).

This is for example the case of flat rates that perform as cost-sharing mechanisms, as in irrigation water in Spain and Italy and drinking water in England (Lago *et al*., 2012), guaranteeing the financial sustainability of water provision. Of course, one may also find the opposite situation in which strong incentives may exist to save water in a context with low levels of cost recovery. Indeed this is what happens when informal markets of subsidized water exist or when transaction and delivery costs in water trading are financed through public funds.

As a guiding principle there is a need to go beyond deceptive full cost recovery instruments that encourage an unsustainable use of water and also beyond 'nice' incentives to save or reallocate subsidized water. To date, substantial progress has been recorded in improving cost-recovery levels and that is an opportunity to transform prevailing instruments into more effective water-saving incentives.

In any case the distinctive nature of cost recovery and economic policy incentives has to be emphasized (Strosser *et a*l., *op. cit.*). Essentially, what makes CRIs and EPIs different is the capacity of the latter to reward individuals for decision changes that may contribute to the public purposes of water management such as encouraging the responsible use of water, the adoption of best available technologies, or fostering innovation.

While CRIs appeal to the fact that prices must be at their right level EPIs in turn emphasise on the idea that they must be of the right kind. Higher / lower prices versus 'better' [designed] prices (Lago *et al*., 2012; Strosser *et al*., 2013). In other words, when designing CRIs our main concern is that revenues must be sufficient to recover the involved cost while in designing EPIs the main concern is that the delivery mechanism must be effective in changing peoples' behaviour in some beneficial way both for the economy and the environment.

Having this nuance in mind is essential to designing water management instruments able to work both as cost-recovery and as economic policy instruments. Prices may be designed so that they allow for the financial sustainability of water provision services and convey right information about the opportunity cost of water (let us say environmental and resource costs). At the same time they may be designed in such a way that water demand is reduced or controlled at a level that may be satisfied without further degradation of the water environment, water users find it profitable to save water when alternatives such as trading or better technologies become available, and anyone perceives that any effort devoted to innovation is rewarding. Similarly, water trading can be designed in such a way that water provision and delivery costs are fully recovered while the price set in the market does reflect the information about the value of water in its alternative uses.

Summing up, our research is constrained to finding the best way to design cost-recovery instruments but in such a way that they can (also) provide incentives to change water users' behaviour and contribute to the social purpose of reducing scarcity and managing drought risk.

EPIs and water management

Two basic conditions need to be fulfilled for an effective EPI.

Firstly, contrary to prescribed behaviour, putting EPIs into practice requires clearing space for individuals to make their own decisions. For instance, decisions on what crops to grow with what inputs and technology or how much water to use, to trade or to conserve for future uses. Secondly, water users must bear the consequences of their own decisions. Yes, right what you try to explain your kids as they grow up.

Both conditions are necessary (although not sufficient). For example, if water utilities are free to reduce leakages in the distribution network but do not perceive any benefit from it (i.e. in the form of energy cost reduction, water trading or higher water supply guarantee) then no action will be taken. The opposite exists when alternative decisions are available but water users are constrained by the technology selected by the water authority. The institutional set-up must allow for the proper implementation of EPIs.

Nevertheless, EPIs are complements rather than substitutes for command and control and prescribed behaviour.

3.2 EPIs and the policy mix

The discussion above helps define the two main objectives of our research.

First, rather than offering a brand new water policy we are committed to explore some particular EPIs that can be streamed into current Spanish (and EU-wide) water management practice in order to make a significant contribution to meaningfully solve some relevant water governance problems.

Second, we analyse how the current institutional set-up would need to be adapted in order to provide leeway for the proposed EPIs (and for individual decisions, responsibilities and rewards), and also to guarantee their effectiveness by reducing barriers, providing useful information, and minimizing transaction costs. In such a way, besides exploring some particular EPIs we also include recommendations about how to put them into practice through improving the enabling pre-conditions required, choosing the right sequence of reform, and packaging innovative and prevailing instruments (*Chapters 4* to *0*).

For that purpose, we follow a "one objective, one instrument" rule. EPIs can obviously serve many different objectives but are deliberately designed to perform with regards to a singular one while having ancillary benefits or costs concerning others. We thus prefer to see EPIs as policy responses to specific water challenges. This helps focus, at first instance, in how the particular EPI takes advantage of the opportunities available to respond to a certain challenge and, in addition, to explore how this may contribute (or not), in combination with all other instruments, to the overall objectives of water policy.

The importance of opportunities in water policy

The overarching aim of water policy in Europe is to improve and protect the ecological status of water resources, as defined by the EU WFD. In areas such as the Tagus and Segura interconnected river basins this is equivalent to curb water scarcity down and to reduce drought risk. Real opportunities to progress *vis-à-vis* this overall objective do exist when it is possible to reduce pressures over water natural sources without decreasing the production of goods and services, dropping employment alternatives or impairing anyone's welfare. In economic terms one refers to these opportunities as Pareto potentially improving alternatives to allocate water resources that while enhancing the quality of water bodies still manage to yield social welfare gains.

Somehow what is assumed is that the degradation of water resources has already gone too far. Hence, an improvement in the status of water sources, despite its short-term opportunity cost, might result in some economic gains at the end of the day. For example, for those farmers pumping water from a certain aquifer reducing water withdrawals at a given opportunity cost might result in a more abundant and more secure supply in the medium term in such a way that future welfare gains are high enough to compensate for short-term economic losses.

If these opportunities do exist the following step is trying to understand why if it is in the best interest of water users, the change does not naturally occur. Quite often the answer lies on the sort of incentives in place: for instance, farmers may not be confident that their prudent use of water will be mirrored by other farmers around or because the pre-condition for this opportunity to be attractive depends on the existence of an alternative water source that needs to be transported from elsewhere and distributed among the farmers.

Sorting all this out requires building a new infrastructure that may be expensive but if successfully managed could also lead to high enough profits in the long term so as to recover its building and maintenance costs. Identifying why current incentives do not work and existing opportunities are not actually used is a basic starting point in order to define the rationale of public interventions and, in our case, to define the precise role EPIs can play: correcting existing incentives in order to realize the potential of real opportunities for water policy.

What are then the main existing opportunities to restrain scarcity, to reduce drought risk and to increase drought resilience? The following are the most significant examples of opportunities to make the objectives of water policy compatible with the maintenance and the increase in market-driven welfare:

1. Increase in the efficiency with which water is used so that production can be increased or maintained with lower pressures over water sources.
2. Reallocation of water from less to more productive uses, so that overall production of goods and services can be preserved or increased while reducing water abstractions.
3. Use of alternative resources to replace freshwater in order to increase adaptation capabilities in dry periods and water security overall.
4. Introduction of formal insurance systems provided by the financial sector in order to reduce exposure of farmers' incomes to water uncertainty while shifting the role actually played by groundwater as a buffer stock to stabilize farmers' welfare during and after extreme events.

The need of instruments to meet current opportunities

Although these opportunities do exist and as seen (see *Chapter 2*) the potential gains associated are not difficult to document, a well-known element of water management is that those gains are not spontaneously met following the logics of the market and/or of the existing incentives in place that, as stressed above, are highly determined by water institutions.

For example, in many places, technical opportunities to improve the irrigation system exist but farmers do not see them as financially attractive. They imply installing expensive equipment and assuming higher operational costs (due to the additional energy required for pumping and applying water in the field). Hence, water use efficiency is naturally higher in places where water is more productive, and irrigation efficiency is perceived as a way to increase water productivity and to reduce exposure to water shortages.

The need for water policy to enhance water efficiency is often a symptom of the lack of private incentives and not surprisingly water is used less efficiently in places where it is less productive (the opposite also applies). Further, trade parties might perceive the reallocation of water as beneficial; yet water users are not entitled to trade water itself but only to use a certain amount of water for a certain purpose and in a certain location. Institutional lock-in might preclude the reallocation of water and may even be a powerful incentive to use all available water in despite its reduced marginal value (because of 'use it or lose it' kind of incentives when property rights cannot be exchanged through voluntary agreements).

Nonetheless, the discussion so far cannot lead to the very simple conclusion that incentives are the only thing actually required to meet current opportunities. Even if the essential upgrade in fixed capital was given for free, farmers might not be interested in efficient irrigation infrastructures, because of the burden of the energy bill. Permitting trading with water might result in few transactions, if any, in normal conditions of water supply and discussions abound on why not many trades occur in places where even water rights have been detached from land ownership.

3.3 The actual governance problem: matching EPIs with water policy objectives

Using opportunities is not equivalent to reducing water scarcity and drought risk. Abundant evidence now exists showing that one particular economy might be using water according to the best available technology but still consuming an unsustainable amount of water.

Water trade might serve to put into use water that might not have been used otherwise and when not controlled properly water trading may extend scarcity problems across river basins instead of tackling shortages where they appeared. Similarly, alternative sources may help cope with increasing demands rather than replacing already depleted underground sources. Moreover, an insurance system may stabilize income without reducing water withdrawals in dry periods. The first and fundamental purpose in designing and implementing EPIs consist in harnessing the potential of existing opportunities to reduce scarcity and drought risk.

It is not the EPI itself that guarantees its effectiveness. For example, a water-trading scheme is not effective because it allows a large number of trades or a high volume of traded water; not even because of the existence of a massive number of market players (buyers and sellers). Competition, a fine property of any market, in the case of water is by no means the best way to make water trading effective to increase resilience and the adaptive capacity of the economy to better face an uncertain supply of water. A great insurance system may lead to no water savings, and thus may be considered a proper instrument to stabilize income but not to control water diversions at all. Subsidies may enhance efficiency without saving any water...

Yet, EPIs are not the 'silver bullet' of water policy but rather instruments that contribute to cope with specific water challenges. No one instrument can fulfil the promise of being the panacea to complex water management problems. This is important because, apart from its contribution to the overall objective (curb scarcity) each EPIs is an incentive address to a specific particular challenge that need to be identified in advance so to exploit better the potential of the opportunities at hand.

In other words, the intermediate objectives of water policy (we call them challenges for the purposes of this report and this chapter) EPIs might contribute to cope with, are important in the whole design process because they inform about the conditions that need to be met for the EPI to be considered effective (i.e. partially successful).

In what follows (*section 3.4*) we present three particular challenges of water governance in the study site; for each one we propose the particular EPI we consider is best suited to face it. EPIs have been selected both for its capacity to make a direct contribution to solve a particular problem and for its synergies with other EPIs in order to enhance water governance. This way, each instrument can be designed and assessed by its direct contribution as well as by its indirect impact on the effectiveness or the enabling conditions of the remainder of proposed EPIs.

On methodological grounds, *Chapters 4* to *0* will first explore three problems (let us say water security, uncontrolled abstractions, and resilience to water supply risk) (*Chapter 4*) and will then analyse one instrument for each purpose (*Chapter 5*). Then it will be discussed how each of those innovative EPIs and the full package of incentives (*section 5.2*) contribute to reduce scarcity and manage drought risk. Furthermore, synergies of any instrument with each other and with the entire policy mix will also be assessed (*section 6.5*).

To match EPIs with water policy objectives, the following principles will be followed:

- Whatever EPI considered is a CRI (our selection is only among CRIs).
- Any EPI must be *a priori* implementable, in the sense that the pre-conditions required must be in place or can be set up with a reasonable effort in due time.
- Any EPI is designed and implemented for a specific objective (one means, one purpose) but overall it must serve to the general purpose of water policy (in our case curbing scarcity, reducing drought risk, and increasing resilience). These two levels will be binding and both must apply: for instance, a market may serve to its particular purpose (increasing adaptability to an uncertain water supply) without reducing scarcity; should that be the case, this would not be a valid EPI for us.
- We will identify particular areas of water policy where EPIs can be more helpful (we call these areas 'water governance challenges'). In the following section we define these challenges and define the problem.
- We will identify opportunities in two senses (the essence of a successful EPI consists in making rational for individuals what is rational for the entire society):
    a. Social opportunities: water efficiency gains (i.e. welfare enhancing) of alternative courses of action, such as using a formal insurance scheme instead of depleting the already overexploited aquifers in order to have a stable income level (resilient revenue).
    b. Individual opportunities: the alternative or innovative course of action must not only be better for society as a whole (as water must be less scarce and safer at the end of the day) but also for individuals directly involved in the EPI implementation. Agreements must be beneficial for all the parties involved, i.e. the cost of providing insurance must be lower than the willingness to pay to hold it...
- We will then propose particular instruments to use these opportunities to cope with these challenges and explore:

a. The feasibility under the current institutional setting or the potential to successfully enabling institutional conditions in due course.

b. Key issues regarding transaction costs (barriers that need to be overcome): transport costs of traded water? Information costs for a properly operational market? Information asymmetries such as moral hazard or adverse selection? Bargaining costs?

c. Whether these barriers can be overcome within the range of opportunities identified: i.e. is the transaction cost of a water-trading scheme lower than efficiency gains from water reallocation thus obtained?

d. If hurdles are not high enough, do those holding stakes have the incentives to proceed with the desired course of action (i.e. purchasing the insurance policy, saving water, selling or buying a water use right, etc.)?

e. Depending on the two previous answers: what role can the Government play in lowering transaction costs, improving the effectiveness of each EPI or enhancing individual incentives?

f. How may the instrument be best designed by taking into account all the previous elements?

- Finally, we perform an overall assessment to show how the selected EPIs would perform in social terms and how they combine with each other and with other water policy instruments in place.

3.4 What is special about water and what are the implications for water management?

The following are the mayor guiding principles and ideas we need to take into account in the design and implementation of innovative EPIs as part of changing current practice in water management (and then of the alternative institutional responses), in order to go through the social adaptation required in situations where water is scarcer and its supply more uncertain.

Coping with scarcity and drought risk is a major social adaptation challenge

Rather than the technical and management complexities associated to finding a substitute or a more efficient way to use a replaceable input provided by Nature (as it might be the case with a number of non-renewable minerals and many renewable energy sources), the case of water refers to an overarching social adaptation problem to manage an unique resource which supply is limited, when not diminishing, and increasingly uncertain.

In developed countries scarcity and water associated risks challenge the preservation of the social and economic gains already obtained rather than barriers that need to break poverty traps and to pave the way for sustained development to start up, as in many poor countries. Spain, Australia and California (USA) are examples of relatively affluent economies that evolved from an initial situation where natural systems were perceived as ductile for the benefit of economic development towards a new situation where holding the benefits already obtained from economic progress is heavily dependent on water provision.

On the other side, the scope of changes experienced to harness the potential of water for economic development, is so intense that they may be irreversible and make water ecosystems unable to provide the services required for the maintenance of life and its diversity, economic performance and the preservation of ecosystem functions and services on which water provision but also the economy itself are dependant on (Marshall, 2013).

Most of the complexities of water policy derive from the distinctive features of water as an economic good (Hanemann, 2006; Meinzen-Dick, 2007).

- **Water is different from 'normal commodities' where demand and supply can be mostly left to the market economy**. Water supply is variable across space, time and quality. Its marginal value depends on its use, location, quality and time. Dams, channels and other capital assets involved in water supply cannot be used for other purposes and water provision costs widely vary among water sources. Contrary to electricity, the other almost irreplaceable input, water is expensive to transport and cheap to store. Particularly in arid areas, investments in water supply show large economies of scale and scope for surface water (in particular in water impoundment, treatment and distribution), but not that much in other sources (such as ground, desalinated and regenerated water).

All this has major implications for water management. For example, in arid countries the provision of surface water requires coordination, collective management and strong water institutions while, especially over the last 50 years, other options can be profitably accessed and used at a local or even individual scale (in fact the pumping technology available in the second part of the past century allowed farmers with access to a groundwater source to find their way on their own in what has been dubbed as the "silent revolution"; Llamas, 2007).

- **Water is also an atypical capital asset**. In fact, the ability to provide the economy and the environment with commodities required for its proper functioning depends on the status of conservation of each water source and the hydrological cycle at large. Hence, the conservation of water assets becomes a social priority and the overall objectives of water management are beyond the scope of any individual or any stakeholder's private interest (Ostrom, 1999).

Collective action implied both by economies of scale and the essential protection of the water resource base is always important but becomes imperative in arid economies. There, the provision of basic water services is a precondition to spur economic growth and the conservation of water resources is a prerequisite to make the gains of economic progress sustainable (WAAP, 2012). The binding constraints of water resources over the economy are more severe as water becomes scarcer and its supply more uncertain (Brown and Lall, 2006). The importance of water management seems as a cornerstone to foster economic development. In extreme cases it might even lead to centralized institutions and to the political capture and authoritarism (as in the so-called "hydraulic societies", a concept first coined by Wittfogel, 1957).

- **Water resources provide both private and public goods.** Most of water policy dilemmas are about the mix of both kinds of goods to be produced. The way this question is actually solved determines how and how much water is made available for consumption and production and, at the same time, how and how much water resources are preserved or transformed. Water, when diverted as a production factor, becomes a private good, thus a rival and excludable property right. However, it remains a public good, therefore neither rival nor excludable, when left on site to secure future uses, preserve aquatic ecosystems, and to provide recreation opportunities or simply to regulate the flows and the quality in streams or aquifers. "The value of the private good is that of a single user while the value of the public good is that of many people" (Hanemann, 2006).

The conflicting public/private values of water are translated into water management dilemmas. In a meaningful sense this is the same discussion as to whether prescriptions instead of incentives are the best response to address a particular water problem. This is because water management needs to consider the trade-offs between the need for a collective action, in order to preserve common water assets and public goods at stake, on one side, with the must for individual freedom, required for people to find ways in which water might contribute the most to the production of goods and services in the market economy, on the other.

- **Decisions on water use are interdependent** because of the interconnected nature of the hydrologic cycle. Water, for instance, can be sequentially used and re-used, stocks and quality of groundwater depend on uses in the surface and diverting water affects runoff, evaporation, seepage and many other components of the hydrological cycle in many different (and often unpredictable) ways. A number of cross externalities that are practically impossible to follow, not even track, then pervades water management.

Not many of these cross externalities pose a particular problem when water is abundant relative to its use. These issues become more problematic as water demand grows, supply sources are spoiled and emerging environmental concerns become more important and the water demanding economic activities turn out to be more vulnerable to weather variability (e.g. Marshall, 2013).

This trait of water makes the setting of proper institutional arrangements to clarify rights and responsibilities of any water user even more challenging (Meinzen-Dick, 2007). When water is scarce, physical returns might become important to supply water downstream, badly known aquifers connected with runoff are important sources for a myriad of users scattered throughout the river basin, water sources change into less and less natural but produced by the own economic activities, and externalities are pervasive. More often than not, property rights on runoff, e-flows, infiltration, and other water flows shift towards uncertain and undefined sources by prevailing regulations.

When externalities are likely and unknown, as when water is scarce and uncertain, this has an important influence over the policy-making process. Policy discussions around new water uses or instruments are affected by the real or presumed existence of many plausible collateral effects (as the so-called expected third-party effects) that are often impossible to measure giving rise to extreme precautionary attitudes delaying or even blocking new projects or innovative institutional arrangements (this is the so called *institutional lock-in*, see *section 6.4*)

Adaptation requires collective action…

In fact, the ability to reduce water scarcity and better respond to increased drought risk is determined by the ability to act collectively (Marshall, 2013). Given the above-mentioned specificities of water as an economic good it is not surprise to hear that the problem of water is not just one of economics but also of politics, and not one of physical shortages but rather one of governance (Hanemann, 2006). From the previous discussion we can draw a preliminary list of basic economic explanations of water governance problems regarding water management under scarcity and drought risk:

- The conflict between the flows of services and the conservation of water assets (stocks).
- The challenging trade-offs implied in the joint provision of private and public goods from water ecosystems.
- The critical importance of water use for economic growth but the essential role of water conservation for sustained progress. The pervasive externalities derived from the interconnected nature of the hydrological cycle.
- The importance of water security and the increasing uncertainty about future supplies that makes extreme precautionary options a sensible policy attitude for many, and
- The high fixed cost of water infrastructures and the still unsolved problem of how to design effective and efficient cost-sharing schemes.

All these circumstances, which simply do not arise in normal commodities, create a need for collective action in water policy (Libecap, 2011; Hanemann, 2006). Collective action is a mixture of many different projects, norms and other institutions such as public works, definition of property rights and responsibilities, technological standards, prescribed behaviour with adequate monitoring and enforcement, etc. All these are governance instruments that, under the above-mentioned circumstances, might reduce the production and transaction cost of water services and may effectively be used to protect common-property assets as well as to satisfy individuals' water demand.

… but collective action requires proper incentives and EPIs

As it has been recognized since Olson (1965) the provision of goods through collective action may be flawed because of the *fiasco* of incentives. Actually, the way scarcity has been addressed so far in the Tagus and Segura interconnected basins can set a good example of this kind of governance failure. Collective action might fail in aligning individual actions with the collective goals of maintaining all water uses within the limits of available resources (see *section 4.2* of this report).

In the Tagus and Segura but also in California and Denmark, the Government has been successful in taking control over those water sources that require collective action and with uses associated to higher economies of scale and coordination advantages, such as the case of surface water. At the same time, though, only limited success can be displayed in the State's ability to control those sources that individuals can profit from at lower scale (such as groundwater). Farmers may actually turn to those resources if failures in the collective facilities occur, thus expanding scarcity trends far beyond the limits of long-term renewable resources.

This has happened in Southern Spain, Australia, California and many other arid economies. In fact, groundwater is not better controlled in the North as compared to Southern Europe. The most meaningful difference between Spain and Northern EU States in this regards is not on control grounds (albeit important) but rather in the incentives farmers have to pump groundwater in a an economy where water is structurally scarce (in contrast to other places in Europe where it is not).

Apparently successful collective actions may have the embedded incentives that might make them fail after all. For example, more stringent constraints on water use, even socially accepted and enforced through the delivery of lower amounts of water from publicly controlled sources during droughts might increase farmers' willingness to pay for water and create incentives to proceed towards alternative resources (i.e. groundwater) that may increase scarcity and reduce the resilience to droughts in future periods (Gómez and Pérez, 2012).

Alike, the government can do a lot to foster the diffusion of best available technologies and to enhance water efficiency but prevailing incentives might avoid the water thus saved to be left in (or diverted into) the streams instead of being pushed into new uses as water productivity increases (Camacho, *et al*.).

Those are some examples showing the need for EPIs, as supplements of command and control, in order to improve the effectiveness of collective action and water governance. In particular, in addition to norms and regulations, *ad-hoc* incentives must be introduced to control two kinds of individual behaviour: free riding and rent seeking (Hanemann, 2006). The latter refers to individuals who capture the benefits of collective action (e.g. water savings from publicly fostered technology diffusion), whereas the former refers to members of the group that withhold their contribution but still enjoy the benefits from their peers (as in the case of groundwater depletion).

EPIs can only be effective within the framework of collective action

Since EPIs are means to and end these instruments cannot be said to be good or bad themselves. They rather need to be judged against their contribution to the objectives of water policy (or of collective action). Prices, for instance, are not right or wrong on their own but, as EPIs, might be effective or ineffective in inducing a responsible use of water. Of course, prices should recover all the cost implied in the provision of the service, but this is only one side of the problem. Full-cost-recovery prices may be in place but the overall water used might exceed the amount of long-term renewable resources.

Likewise, for example water trading may be effective in finding beneficial alternatives for sellers and buyers but, when unduly controlled by institutions, it might contribute to increase water scarcity instead of reducing it. Early development of water markets shows this is more than a theoretical possibility. Water trading has actually put into use water that would not be used otherwise; farmers allowed to sell surface water rights might end up using groundwater instead, and inter-basin trading might expand water scarcity elsewhere instead of reducing it where it actually is. Collective action, through a precise definition of water use rights and conditionalities, and effectively monitoring and enforcing property rights (and individual responsibilities) is a basic pre-condition for water trading to deliver its promise in terms of reduced scarcity and enhance the resilience of the economy in the face of drought risk.

EPIs cannot be judged in isolation

An important insight from the previous analysis is that EPIs are but one piece of the institutional change required in current water management practice. According to Ostrom (1992) the water governance challenge consists in finding a suitable non-coercive mechanism that motivates collective action.

Other approaches that must be discarded in the light of previous analysis are those considering individual alternatives as “silver bullets” to cope with complex ecological challenges. For example, experience in the last 50 years illustrates the radical failure of promoting the so called “water panaceas”, whether strong bureaucracies, water users’ associations or tradable water use rights. According to the empirical tests conducted by Meinzen-Dick (2007), not one of these approaches “live up to expectations”. This is not only because extrapolating water institutions from one context to another is not enough to transfer success or failure (and this is one of the main concerns in this report). When water is scarce and variable, whatever institution in place needs continuous fitting and tuning up so as to adapt its performance to the particular needs of water policy.

The on-going adaptive process of water markets in Chile and Australia to environmental demands is just one example on how this kind of schemes cannot stand alone to its promise of being a self-maintaining institutional arrangement. Similarly, to better serve the objectives of water policy prices need a continuous fine-tuning in order to adjust water demand and supply in the short term and to allow for water security in the longer term. This is something that cannot be fulfilled only when pricing policies consist setting prices right (even if they are of the wrong kind: as flat rates for irrigation water may show).

EPIs are a milestone in a long-term process of water policy reform

Apart from the institutional setting enabling the proper functioning of EPIs (such as, for instance, the right definition and proper enforcement of property rights required to trade water and the metering and monitoring needed for marginal pricing), what is important is the dynamic consistency of all this with the purposes of sustainable water management.

An effective solution of current scarcity and drought problems, rather than single-policy solutions, require a nuanced approach based on a social ‘learning by doing’ process to find solutions adapted to local problems, institutional contexts and economic and physical circumstances (Marshall, 2013). As other sections in this report show, sensible approaches that might work in other water scarce regions cannot work when transplanted to southern Mediterranean European countries. Water policy transitions must then progress towards adaptive policy mixes rather than to simply implement basic principles or one-size-fits-all solutions.

It is not difficult to agree upon previous statements. However, the acceptance of this line of argument leads to specific methodological challenges when, as in our case, trying to assess *ex-ante* the potential of alternative EPIs.

3.5 Lessons can be drawn for the *ex-ante* assessment of these EPIs

In developed but water scarce societies, the nature of water policy challenges and the appropriate response to them have some key distinctive characteristics. At the same time that the potential of water for economic development is being harnessed, many accompanying circumstances add up to the need of changing the strategy of water policy and the kind of institutions thereby involved. Experience shows that water demands might proceed growing above the combined capacity of man-made and natural capital to cover them, the supply of water becomes unsafe but also more uncertain due to global change and aspirations to preserve the environment have scaled up in the social agenda. All this changes and potential social conflicts thus involved ask for radical (i.e. deep-rooted) changes in the way water is managed and social alternatives are assessed and screened.

One may need to start by accepting that to cope with current water challenges there is not much room for pursuing the major strategies followed in the past: new major infrastructures to transfer water have difficulties in passing the test of social acceptability. Most importantly, it is already assumed as a proven fact that the main constraint to transfer water rather than the lack of appropriate infrastructures relies on water scarcity itself and the difficulties to operate the existing capacity at an acceptable utilization level. On the other hand, scarcity is a main driver of water efficiency and experience in the SRB shows it is actually a powerful incentive to increase water productivity (not no save water for the environment though), so that marginal benefits of bridging the so-called efficiency gap in the scarcest areas are already low even though alternative policies might help in transferring these incentives to areas where water is less valuable (and farmers don't have any incentive to use it more efficiently *per se*).

But, what are then the basic characteristics of the change required in water policy?

The following are some basic but important aspects that ask for a change in current water policy practice:

First, hard options need to be replaced by softer alternatives. This is not an ideological option but a logical need as well as economic realism. As human-made capital-intensive options reach their limits the door opens to replace fixed capital-intensive alternatives by other intensive in water management, human capital and natural capital conservation.

This variation has not trivial consequences for the assessment and comparison of alternatives. Traditional alternatives can be appraised via classical methods focused on transformation costs (capital, operation and maintenance, abatement costs, etc.), but with EPIs and other "soft" options, transaction costs cannot be considered insignificant anymore. Within new water policy these may in fact become a major share of the overall costs of water policy (Marshall, 2013; Krutila *et al.*, 2010; McCann *et al.*, 2005; Pavola and Adger, 2005).

Second, all this change comes along with different criteria regarding success in water policy. Success is not measured anymore by the ability to mobilize water into the economy at the lowest possible prices coherent with the importance of water to foster growth but rather by its faculty to restore and protect the status of water ecosystems at prices that are high enough to recover the financial, environmental and scarcity costs of diverting water from the environment and to the economy.

Third, change in means needs to be consistent with the still emerging ends of water policy. The original focus of adapting water supply to increasing demand in the growing economy must shift towards the inverse priority: accommodating demands to actual supply capacities. All this applies to the design and assessment of any alternative EPI. In the new context, for example, prices are not only cost-recovery mechanisms but ways to adjust supply and demand; water trading in turn is much more than a means to put water into its more beneficial use but, more important for the purpose of water policy, a way to reduce drought risk and scarcity. Likewise insurance on water for irrigation is not just an appealing device to stabilize farmers' income but also an instrument to increase drought resilience and curb scarcity trends.

Finally, *ex-ante* appraisal methods need to be changed accordingly. The information and methods that were considered as adequate for the *ex-ante* appraisal to build consensus and to gain political acceptance of water-related projects and measures in the past now might seem clearly lacking when not unfitted for the same purpose. Hydro-bio-land/use-agent based-economic models and valuation methodologies are increasingly calling to fill in this gap. Yet, at the same time, the decision-making process these sophisticated tools are expected to feed into becomes less technical but more inclusive and participative instead.

In fact, many researchers have already stressed the futility of engaging efforts in trying to perform a fully-fledged cost-benefit analysis. The main reason is not the lack of information (which is also a feature of command-and-control instrument assessment), but the overwhelming importance of transaction costs (or the cost involved in overcoming with institutional and technological lock-in, negotiation, monitoring and enforcing and defining precise property rights) (Marshall *et al.*, 2013). The main difficulty therefore lies on the changing nature of the problem at hand and the unpredictability of the whole policy adaptation process[18].

Transaction costs are significant but cannot be predicted in advance. This does not mean that the usual cost-effective framework is useless to account for the consequences of path-dependency. It only means that the analysis must go beyond the boundaries of simple measures and balances of costs and benefits. We follow the approach suggested by Quiggin (2011) of using the bounded-rationality framework to proceed along two stages:

- The first one consists in using empirical economic analysis to identify and, when possible, to measure the direct costs and benefits of the alternatives. This analysis is basically

[18] Batie (2008) coined the term "wicked problems" to these situations were "no single governance enterprise has sole jurisdiction responsibility, the different enterprises involved cannot agree on the problem, since their divergent interest leads them to frame it differently and each attempt to identify the solution changes the problem" (Marshall *et al*, 2013; see also Bellamy, 2007 or McCann, 2013).

illustrative to see what the maximum surplus at stake is by, for example, allowing water trading or insuring farmers' incomes and also to provide critical information about how high transaction costs must be for these alternatives to be deemed undesirable. This stage is dubbed "naïve" economic decision theory because the analyst deliberately ignores surprises that may come around along the implementation process.

– At the second stage, the analyst proceeds by using a kind of precautionary principle to look further into the alternative courses of action to implement a given alternative, let us say water trading, and to discard those posing a higher probability of unfavourable bombshells. The alternatives considered at this stage are those that have the highest potential to reduce transaction costs and, at the same time, to avoid problems such as irreversibility, institutional or technical lock-in.

The basic recommendation consists in identifying whether there is a way to implement an EPI or a policy mix that ranks high according to the naïve cost-benefit analysis and is not exposed to adverse outcomes regarding institutional and technical lock-in. If such option does not exist then the preservation of the *status quo* needs to be seriously considered. Although not a full cost-effectiveness analysis, this heuristic procedure still entails a rational (or bounded rational as preferred by their advocates) to minimize transaction costs and find the least-cost effective way overall to sort water problems out. This is basically the procedure followed in this report for the design and *ex-ante* assessment of streaming a set of EPIs into water policy reform.

4 Changing current practice: water governance challenges and opportunities to make EPIs part of a response

4.1 The three water challenges in the Tagus and Segura interconnected river basins and how EPIs can make a meaningful contribution to cope with them

The *EPI-Water* research project (under *task 4.2*) has singled out the following three major water policy challenges to which properly designed and implemented EPIs can make a significant contribution as well as improving the social response to water scarcity and risk mitigation whilst increasing the resilience of the economy. These water policy challenges were discussed and validated in a series of three meetings with relevant stakeholders, as previously reported in the project.

Recognizing and managing the river basin closure

The notion of "river basin closure" has proved to be a catalyst in areas where overexploitation of water resources is already an issue (Falkenmark, 2008; Molle, 2008). A river basin is said to be closing when there is not enough water anymore to meet social and environmental needs and demand exceeds long-term renewable resources. River basin closures are said to be affecting 1.4 billion people worldwide. The closure is more a fact than a decision.

Closed river basins can obviously be managed by reducing water use or by increasing water supply (i.e. transferring water from other basins, using groundwater and desalination, etc. – see *section 2.4*).

It is important to recognise that one day the basin will reach a stable water portfolio (probably mixing all the existing water sources). The real question is then how to get to that point, leaving it to the baseline scenario (that can easily be anticipated with the current trends in water demand and supply, see *Chapter 2*) or managing the transition so that the most valuable resources are preserved, the overall water portfolio is sustainably used and it all provides water security so as to guarantee economic performance.

Should the problem not be recognized the unavoidable transition from financially cheap towards more expensive water sources would induce significant harmful effects on the economy. Water is a particular sector where scarce and unreliable goods are priced lower than their abundant and reliable substitutes, unlike microeconomic theory would suggest. This pricing failure translates into incentives in such a way that users prefer financially cheap but scarce and unsafe water sources rather than the financially expensive but relatively abundant and reliable alternative water sources. Dubbing these sources cheap and expensive water only reflects the fact that environmental and resource costs are ignored in water pricing practices. In the best scenario surface water supply will remain close to renewable runoff and demand in excess will be met from groundwater (already exploited under unsustainable patterns but still less expensive than non-conventional sources).

This is clearly not desirable from a sustainable water management perspective. In the baseline scenario, some still cheap renewable water sources will be used to the point of exhaustion and the continuous depletion of groundwater sources will reach the backstop price of alternative sources that while being currently available were not being used because of their high financial cost.

Current trends are bound to a situation where groundwater depletion will make the use of non-conventional sources unavoidable; at this point security will only be possible by investing in, e.g. desalination excess capacity, even more costly and with no minor environmental implications. In the interim, the use of the already existing desalination plants will be avoided, except in dry periods when this water becomes available through public subsidies to mitigate drought losses. Currently installed plants are in serious risk of being financially unsustainable and might then not be available in the future when they will be increasingly needed.

To some extent, the "business-as-usual" scenario leads to the destruction of resources that might be needed in the future: groundwater, which is best suited to act as buffer stock (and provide water security), and desalination plants that (under any likely scenario) are called to provide water on a regular basis in the future.

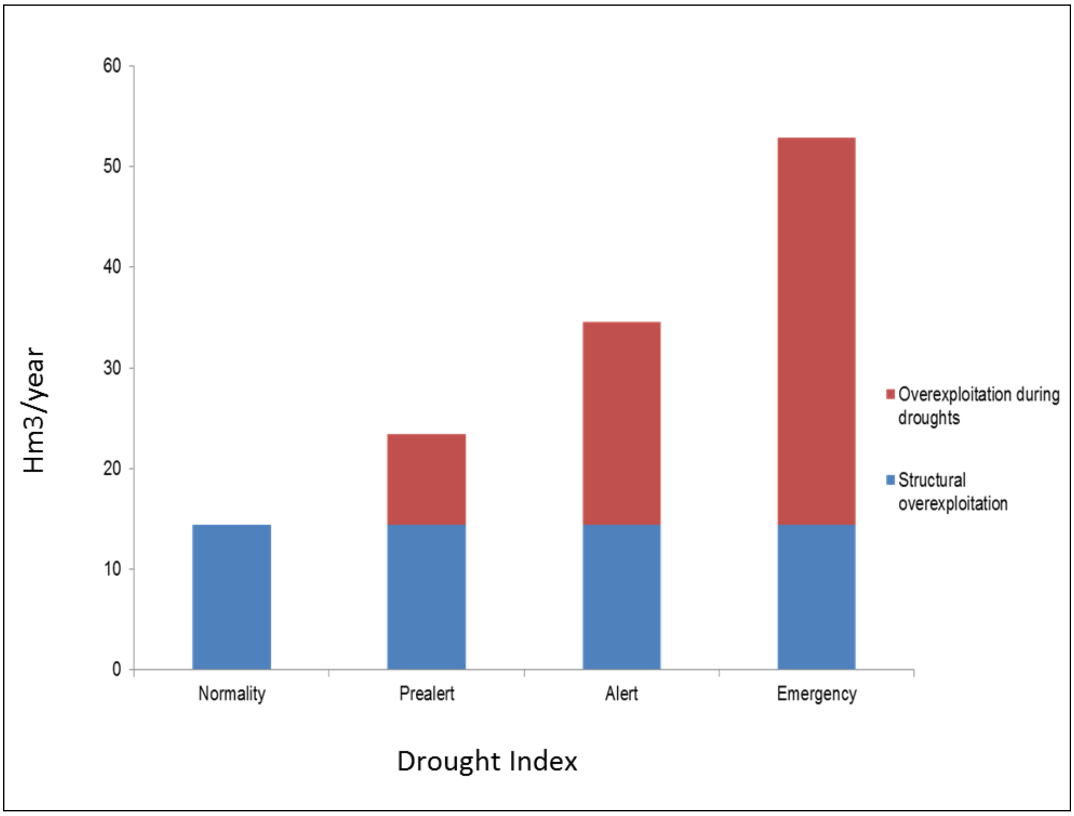
Regaining the control over groundwater in the river basin.

Until the 1950s, rainfed agriculture was predominant in the SRB. Despite being technically feasible since the onset of the 20th century, the costs of exploitation of reliable groundwater bodies were deemed too high for private initiative.

This situation started to change in the 1960s, some years after the *National Colonization Institute* (*Instituto Nacional de Colonización*, INC) was founded. The INC mapped groundwater bodies and favoured irrigation expansion through the use of soft loans and subsidies. The outcome was a steady increase of groundwater demand.

Although water authorities established safety belts to reduce groundwater withdrawals in what rapidly became overexploited areas, the phenomenon could not be halted at all. Currently, groundwater abstractions in the SRB equal 542.1 hm^3/year, of which at least 285 hm^3/year (over 52%) are non-renewable (see Figure 4-1 for an example from a remarkable irrigation district in the SRB). Accumulated groundwater overexploitation in the SRB amounts to 8,425 hm^3 (SRBA, 2013).

Figure 4-1. Groundwater overexploitation in the Campo de Cartagena Agricultural District under different drought events, SRB



Source: Gómez and Pérez, 2012

As shown in *section 2.2*, three main drivers explain the problem: a challenging meteorology, perverse incentives, and governance failures. Abstraction wells are private (so are abstraction licenses) but water is part of the public domain.

Uncontrolled groundwater withdrawals are currently playing the role of insuring water supply. Individual spontaneous and non-coordinated responses to drought risk, although apparently appropriate in the short term are counterproductive because they actually make water scarcer, and increase drought exposure and risk in the long term. In other words, in a river basin district where water is (physically and structurally) scarce this solution is not sustainable.

Considerable progress has been made thanks to the drought management plans (see *sections 2.4* and *2.5*). To some extent, they made drought response anticipated (rather than discretionary and reactive) and planned (rather than improvised), but failed to tackle the real problem: the lack of control over a important part of the available water resources available. Furthermore, higher constraints may also lead to higher incentives for overdrafting, thus leading to lower buffer stocks and higher drought risk, clearly unwanted outcomes.

Harnessing the potential of water and providing resilience to economic development

The explanation of why water is inefficiently allocated among uses and sites can be found in the current institutional setting.

Large differences in water productivity are obvious consequences of the lack of alternatives to use water elsewhere, even in low-productivity applications. The 'use it or lose it' kind of incentives occur when farmers and other agents perceive the value of water but do not have any alternative other than using it. Each person might only have one possible use for available water, but the scope of society is necessarily wider. If water is unable to find a more productive use is mainly because of its lack of mobility (sometimes due to the inexistence of the enabling transport infrastructures). Let's recall that property rights are issued, under Spanish legislation, but they are conditioned to a specific use in a given place.

This situation increases water demand, even when it has already outweighed long-term water supply. Prevailing incentives push sectoral demands up and make it difficult to close *de facto* the river basin to accommodate current uses within the range of available water resources.

The 'use it or lose it' framework doesn't mean competition is absent. On the contrary, it finds its role in different ways and, for example, regions, or jurisdictions, in the face of existing alternatives to use the water, find the way to build up and consolidate the right to use water through building infrastructures (urban and rural): in a way, they create the right to ask for local resources. In addition, if water is enough to cover existing (although potentially not too productive or even wasteful) water demands, no incentive to save would exist in less scarce areas. This is especially true when it implies incurring in the cost of new investments and higher use of inputs, such as energy, to yield the same revenue and continue producing the same set of goods.

A possible explanation on why not all the mutually beneficial alternatives to reallocate water are visible, is the absence of a system able to transfer information about the relative abundance / scarcity of water and then about the willingness to pay (WTP) to have access to additional resources (on the demand side) or about the minimum compensation required (CR or WTA) before being able to sell water use rights anytime, anywhere and linked to whatever use (on the supply side).

Bargaining and trading on water use redefines water use and make it more flexible. In a way, it is a means to restore the information flow, and then to intersect WTP and WTA and allow for agreements to trade for the mutual benefit of parties involved. Additionally, having the option to sell water might become a powerful incentive to make water use more technically efficient (i.e. to bridge the efficiency gap) in less scarce areas, and to avoid the need of purchasing water in the scarcest ones.

In such a way, water trading might open new opportunities for economic development, and make the economy more resilient to the vagaries of water supply. These basic advantages of trading on water use have been demonstrated by existing water trading experiences, which basically confirm that "markets" can work well to the mutual benefit of the parties engaged in trading. What is a matter of discussion is under what conditions markets may work for the common interest as expressed in the objectives of water policy (notably EU water policy).

This is why the proposed innovative EPI within this context (see *section 5.5*) is a combination of local markets, to improve water allocation efficiency at confined levels and to enhance water use technical efficiency, combined with an inter-regional water trading scheme to transfer water from relatively more scarce areas to the least scarce. While environmental concerns are more likely to be at a "manageable" size at local scales, big concerns arise at a wider one.

The challenge consists not only in showing that trading may be environmentally neutral but also that this is not a means to expand current water scarcity all over the place, making water scarcer in the ceding basins without making it more abundant in the importing ones. Finding water-trading alternatives that fulfil these two conditions might be difficult but without transparent information showing that this is not happening, the social acceptance of water trading will remain a difficult when not impossible mission.

4.2 Opportunities to match individual and public interest in order to cope with water governance challenges

Managing the entire water mix

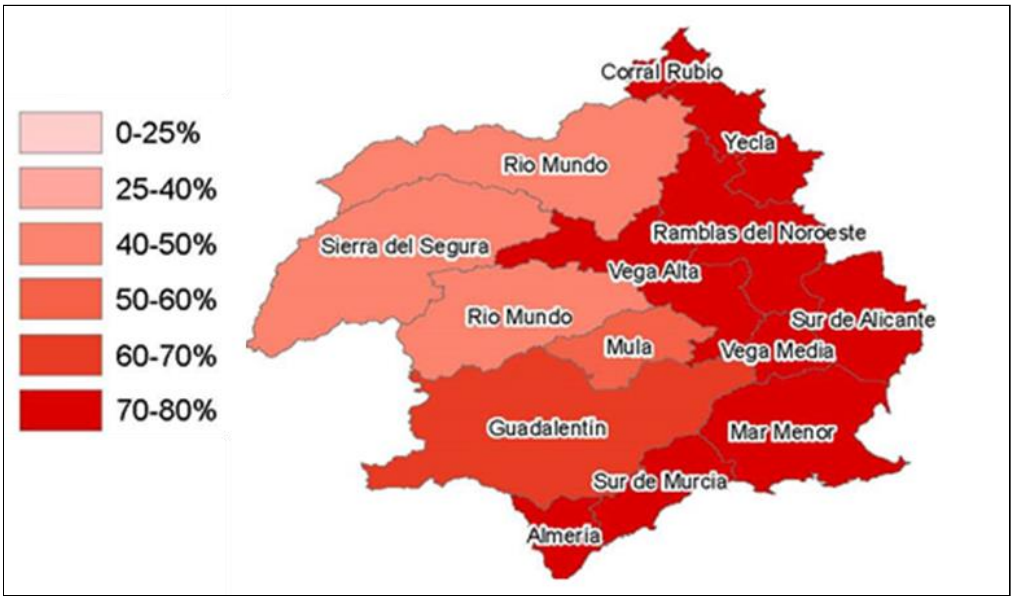
Water supply is a complex combination of different water sources that diverge in many significant aspects that need to be explicitly considered in water management. Once almost all the potential for water development has been mobilised, water supply is actually a 'portfolio' made of a diverse range of sources that provide water in different volumes to cover different demands with dissimilar levels or reliability and that are produced with specific technologies and diverging financial, environmental and resource opportunity costs, and subject to diverging levels of control from the water authority.

In semi-arid catchments such as the SRB the quantification of the water balance is particularly challenging as a result of precipitation variability over time. Although the average precipitation in the SRB is low (381 mm/year), it may hit peak values of 1,207 mm/year during rainy years, and minimum values of 84 hm^3/year during dry years.

Standard deviation is around 150 mm/year (39.4% of the average rainfall value) (SRBA, 2013). Under these conditions a primary goal of water management in these areas is to maintain a long-term balance of water resources. However, the large irrigation expansion witnessed during the last five decades has significantly increased pressures over water resources. This has ended up increasing aquifer depletion, reducing water availability and undermining the robustness and resiliency of the system and its ability to cope with future droughts (Gómez and Pérez, 2012).

In addition, most recent rainfall data shows a decrease in annual rainfall during the last three decades (362 mm/year). Now, droughts in the basin are frequent and require even larger amounts of non-renewable groundwater resources to avoid more relevant financial losses.

Figure 4-2. Drought probability in the SRB – The increasing vulnerability of the SRB

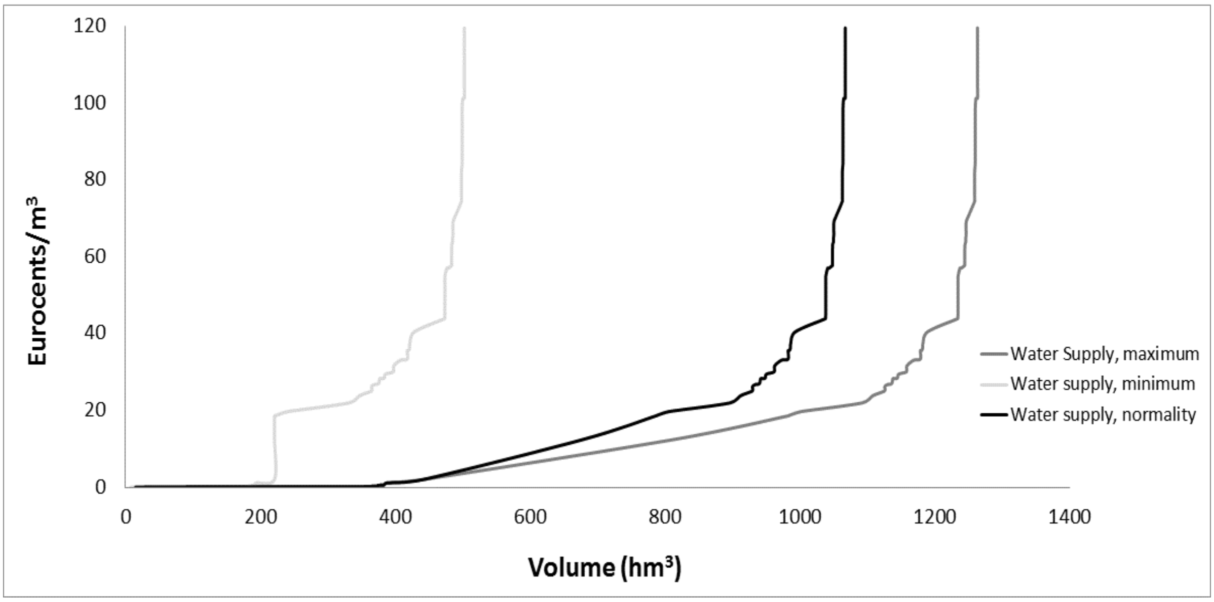


Source: Own elaboration

According to the draft RBMP overall demand in a normal hydrological year amounts to roughly 1,900 hm^3, but as above the renewable resources in the river basin are approximately 800 hm^3. A substantial part of this deficit is being covered by water imports from the Tagus (*circa* 320), reuse of wastewater (approx. 80 hm^3), the partial use of the already installed capacity to desalinate (some 330 hm^3) and the overexploitation of 285 hm^3 from already overexploited aquifers. Surface water only accounts for 30% of total demand and the difference is covered by renewable abstractions from aquifers and reuse of water from streams (Figure 4-3).

Water supply in the SRB is highly volatile due to rainfall variability (both in the SRB and in the TRB). It can therefore supply, from conventional sources, almost 1,300 hm^3/year if all the expected water resources are available (including the 540 hm^3/year from the Tagus headwaters), or barely reach 500 hm^3/year in the worst scenario (emergency in the Tagus and the Segura RBs). In a normal hydrological year, total water supply amounts to 1,070 hm^3/year.

*Figure 4-3. Overall water supply curve, SRB**



Source: Own elaboration

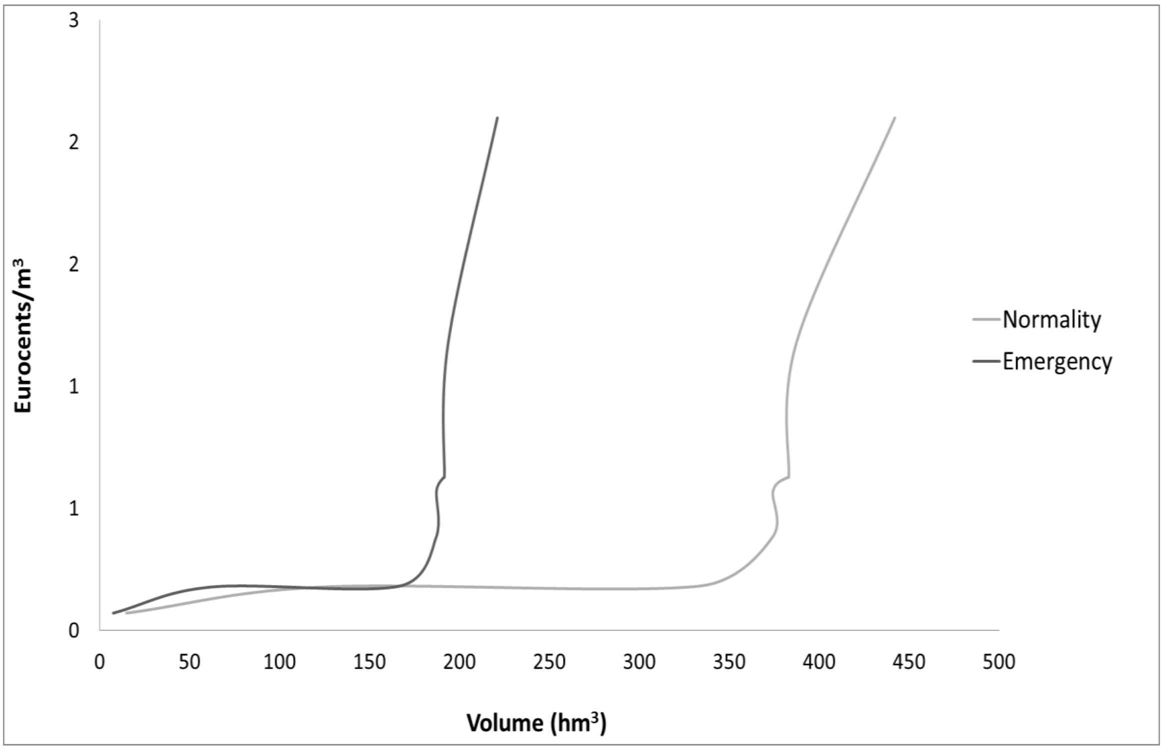
* Non-renewable abstractions excluded

On one side, surface water is still one important supply source, traditionally controlled by the water authority that delivers different amounts depending on both water demands and priority of supply (as established by the hierarchy or uses in the Spanish Water Law). For water users this is the least expensive water source but, as a result, as scarcity and drought risk increase surface water is also the least reliable. Supply provided by the Segura basin itself is complemented by different amounts of water from the TS Water Transfer. These imported resources are also uncertain and with a cost higher than water from the SRB runoff but still cheaper than other alternatives.

On the other side, these resources are unreliable (see Figure 4-4) and represent an important burden to the irrigated sector, which lags behind in the order of priorities that place domestic and urban uses in the first place. The relatively low price of these resources is explained by the fact that current prices do neither reflect environmental costs nor the scarcity or the resource cost of impounding and diverting water, but only the financial cost of providing the service.

As it is well known, runoff is a function of rainfall and the hydromorphological attributes of the basin, including humidity antecedents. Since precipitation is low and uneven in the SRB and the basin is located in a semi-arid area with very low humidity, the potential for runoff generation is limited and highly variable. Average runoff during the period 1940/41-2004/05 equaled 823 hm^3/year, though in the period 1980/81-2004/05 this value has been around 650-700 hm^3/year (SRBA, 2013). Water flow in the rivers of the SRB is highly volatile, with several watercourses running dry during most parts of the year. Under these conditions, droughts have significant impacts over water availability. Accordingly, Drought Management Plans foresee water restrictions as large as 50% for agriculture during emergencies (extreme droughts).

Figure 4-4. Surface water supply (own water resources) - The volatility of surface water resources in the SRB



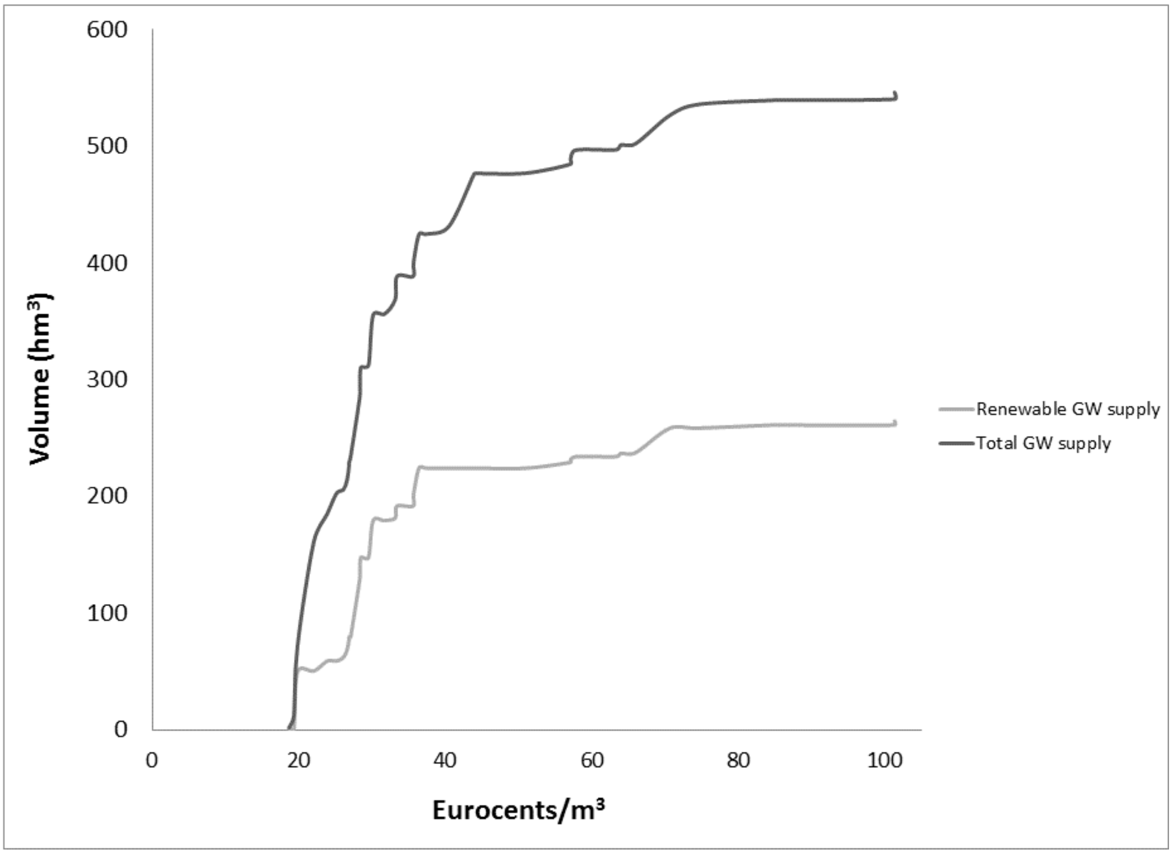
Source: Own elaboration

On the other hand, the amount of water transferred through the Tagus-Segura Water Transfer depends, as explained in *Chapter 1* and *section 2.4*, on the water availability in the Buendía and Entrepeñas reservoirs located in the Tagus' headwaters. When water available is deemed "normal" (namely stock in the Entrepeñas and Buendía reservoirs is above 240 hm^3 and runoff during the last 12 months is over 1000 hm^3), the maximum amount that can be transferred equals 600 hm^3/year. In a pre-alert situation (541 hm^3 < stock < 1,500 hm^3, runoff < 1000 hm^3), this maximum amount is reduced to 456 hm^3/year. Under an alert (240 hm^3 < stock < 541 hm^3, runoff < 1000 hm^3), the maximum amount is reduced to 276 hm^3/year. Finally, under an emergency (stock < 240 hm^3), the water transfer is closed. In any case, it is important to bear in mind that these are upper bounds; observed water transfers are usually lower: on average, 320 hm^3/year.

The next in this ordering according to its average cost is groundwater from spread abstraction points mostly built and managed privately. This allows farmer to control the source on their own so as not to depend entirely on the national, regional and river authorities and to protect themselves from shortages. The costs depend on the place and the state of conservation of the aquifer and the security it provides in the short term. Groundwater has meant an increasing share of water supply since the 19th century up to date. As a common-pool resource when access is not properly controlled it is subject to overexploitation (see Figure 4-5). Water thus obtained is self-produced so that the only costs considered are those of the infrastructure and pumping equipment while the scarcity cost (implied by the reduction of the stocks available for others and for future uses) is not considered.

Users perceive groundwater resources as reliable, though increasingly scarce and expensive as above. Aquifers managed in a sustainable way show the lowest abstraction costs (below 30 Eurocents/m³), while those with unsustainable drafting patterns (i.e. where water is located deeper) are the most expensive ones (close or even above to 1€/m³). Figure 4-4 shows the groundwater (inverse) supply curve, differentiating between total groundwater and renewable withdrawals.

Figure 4-5. Groundwater inverse supply curve (SRB)



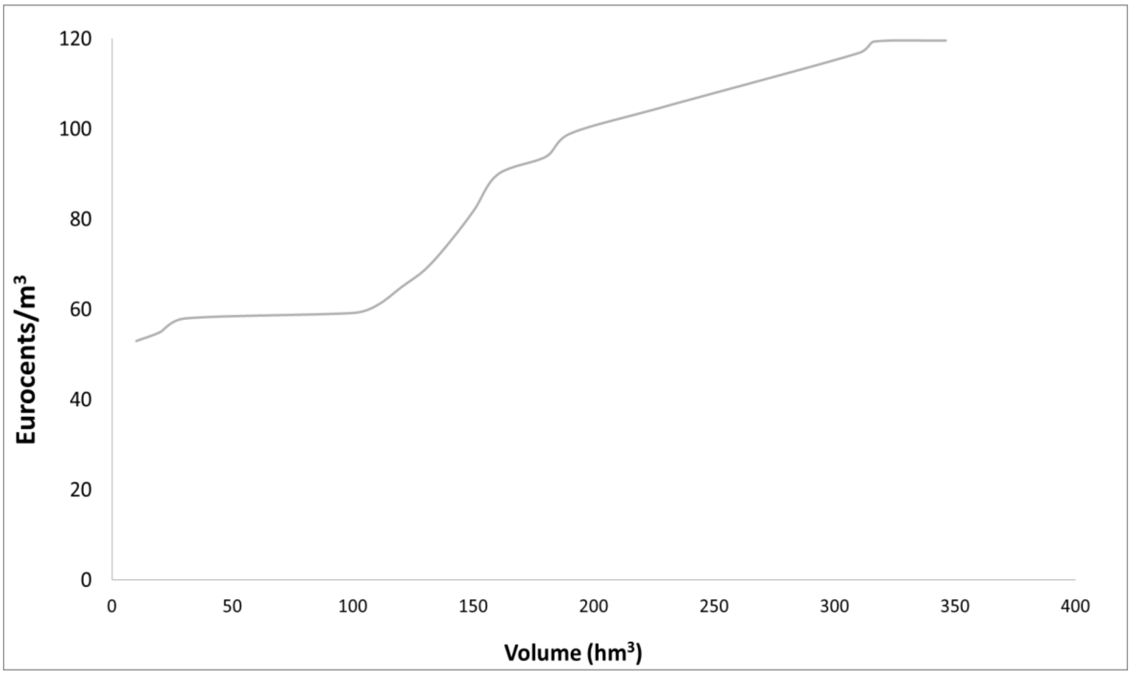
Source: Own elaboration

Additional water can be obtained from water reuse that may provide a reliable amount of water at a predictable financial cost. In the Segura and the Tagus river basins urban wastewater is the main input source and its use is permitted as far as some strict standards are respected. Although the potential for this kind of water has increased with the amount of water used in households and technological development on advanced treatments, the law allows using only a share of available resources such that the Segura river basin is already close to its potential output.

Desalinated water, as compared to regenerated water, represents a reliable source with a potentially unlimited supply but that can be provided at a high financial cost and with production systems that still are intensive in energy use. Although the capital, operation and maintenance costs of desalinated and regenerated water are higher, the environmental cost is lower and can even be negative if the water is used instead of natural freshwater sources. Similarly, the resource cost is not high since increases in its use neither imply reductions in other uses elsewhere nor in the environment (as it happens with limited freshwater sources once they become fully developed).

The SRB has the potential to supply around 346 hm^3/year of non-conventional water resources (see Figure 4-6): 100 hm^3/year of treated wastewater and 246 hm^3/year of desalinated water. Though the former has a lower production cost, its availability is constrained by urban water demand (it is possible to reuse between 50-60% of urban water demand). In any case, this means a potential for treated wastewater generation of around 130-150 hm^3/year, implying that an additional 40-50 hm^3/year could be added to the water portfolio. On other hand, despite the large installed capacity, desalinated water is largely unused due to its high production cost (SRBA, 2013).

Figure 4-6. The (mostly) unused non-conventional water resources supply curve (SRB)



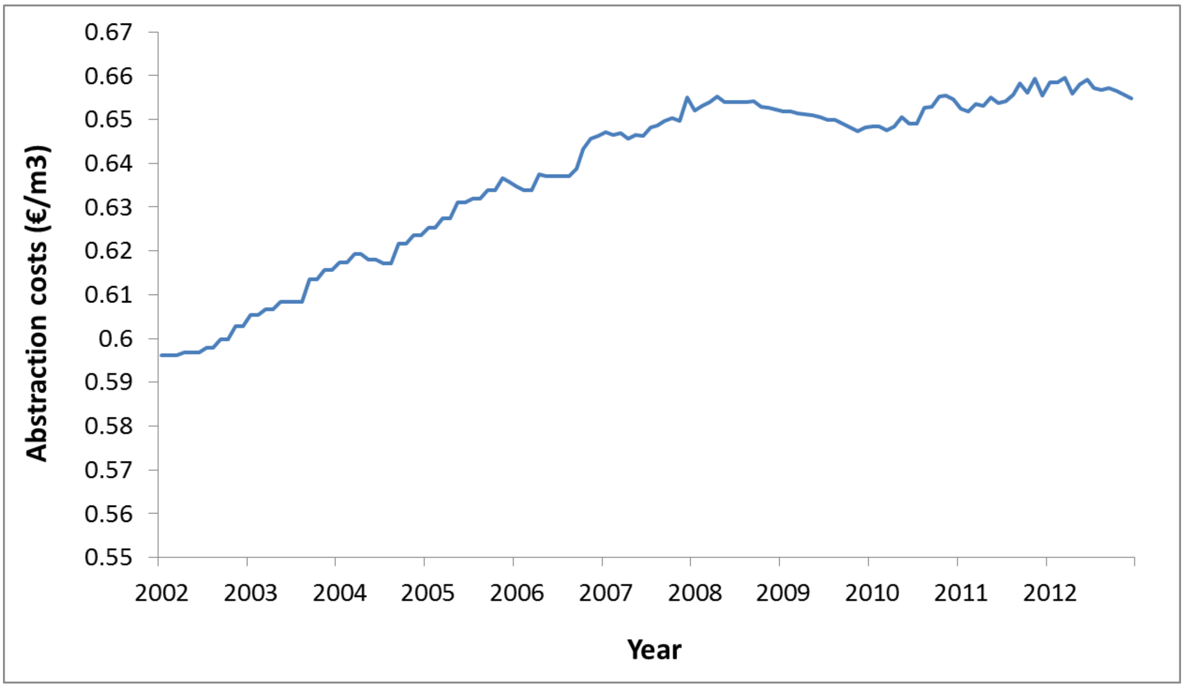
Source: Own elaboration

Once overall water demand is higher than the ability of freshwater ecosystems to cope with it, the water portfolio needs to be considered from a different perspective assigning each source a particular role, ensuring the water security required for the entire economy. Allocation rules in place might need to be modified to avoid undesirable trends. The following are examples of the kind of irrational decisions that may be avoided with a wise management of the water portfolio.

Using groundwater to cover structural water freshwater shortages is a wrong strategy because, in the long term, all this will reduce water security and, in the meantime, will lead to increasing provision costs as aquifers become gradually more depleted. As shown in the next section overexploitation only stops when pumping costs are high enough to deter farmers going deeper (Figure 4-7). When left to this kind of decisions a time will come when alternative sources (such as desalinated and regenerated water) will become a profitable option.

Groundwater has been historically regarded as a cheap water source. As opposed to other sources, storage and transportation costs are avoided, and distribution costs are considerably reduced. However, the energy cost of pumping water from an aquifer increases along with aquifer's depth, and in overexploited areas this cost may be as high as to reach groundwater's backstop price. In addition, the exposure of farmers to energy prices has increased recently, since the subsidy to energy consumption in agriculture was removed and energy prices have reached peak levels in the last years.

Figure 4-7. The prohibitive abstraction costs in Enmedio-Cabezo de Jara Hydrogeological Unit, SRB

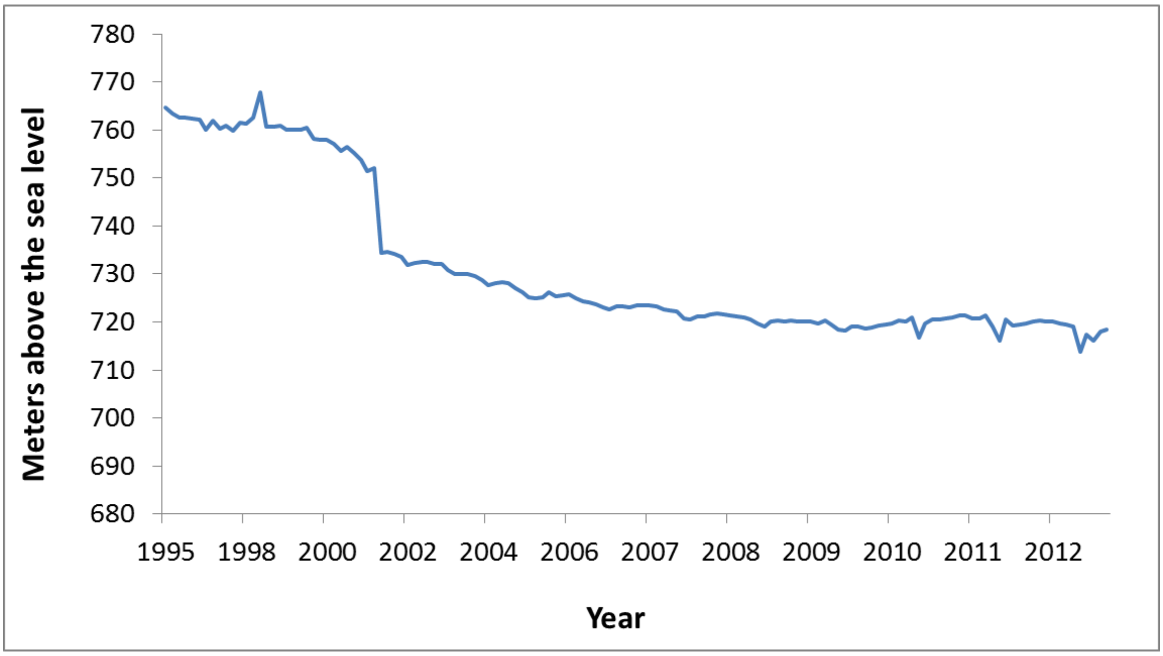


Source: Own elaboration

Groundwater is a reliable water source, since it is at the same time a flow and a stock that offers water users a greater flexibility at a convenient price. However, this is only valid as long as average water supply is equal or greater than average water demand in the long term. When the opposite happens, aquifer depletion increases abstraction costs. As in Figure 4-7 and Figure 4-8, in some areas, such as the overexploited hydrogeological unit of Sinclinal de la Higuera in northeastern SRB, abstraction costs are so high that they have reached the maximum willingness to pay for water security, and the piezometric level of the aquifers in this area has been stabilized.

Abstraction costs, and not environmental awareness or sound water management, have become the actual driver to prevent further groundwater overexploitation.

Figure 4-8. Groundwater overexploitation and abstraction costs: a sad way to reveal the maximum WTP for water security - Depth (meters above the sea level) of the La Higuera Well, La Higuera Hydrologeological Unit, SRB



Source: Own elaboration

In turn, using the water desalination capacity already installed as a buffer stock only for extreme dry periods might be irrational because of the high financial costs implied in maintaining capital assets. We estimate that this increases the average production cost by 25%, since capital costs are distributed among a much smaller amount of water than if desalination plants were used at their full capacity.

In fact, the high average financial cost of desalinated water is an important unsolved challenge, which can be amplified by the decision to make only a limited use of the installed capacity depending on the drought severity. By taking financial sustainability to stress situations current management decisions will compromise the very existence of these facilities.

The financial sustainability o desalinated water needs to be taken seriously. If these plants are used only in dry periods with a 16% probability the full cost recovery price will be 4€/m^3 (higher that the current 36 eurocents priced on average). All this explains why ACUAMED, the public company in charge of managing and operating these desalinated plants has been subject to financial bailout twice.

To a certain extent, the role of the two above-mentioned sources is exactly the opposite of what may seem rational from the perspective of a wisely managed water portfolio. If other sources are already scarce, one may think that alternative resources should be used on a regular basis (in such a way that the use of freshwater does not exceed the flow of available resources). Otherwise whatever the kind of economic progress obtained will reveal as unsustainable in the long term. Groundwater sources, if allowed to naturally recover, may be used as buffer stocks to cover temporal deficits (instead of structural shortages). If this wrong strategy is pursued we will not be able rule out a future scenario where groundwater resources will be depleted and desalinated infrastructures, the next best alternative, will not be available as a result of financial unfeasibility due to low cost recovery levels.

Summing up, in the Segura river basin there is a real opportunity to manage the water portfolio differently. The above-mentioned situation can be anticipated, and economic incentives can be used to redefine the role of the different water sources. These incentives will help in this purpose if:

- They are able to reduce over-abstractions of groundwater on a regular basis (resulting from water being scarce) and on a temporal basis (during droughts).
- They are designed to guarantee the financial sufficiency of water supply sources that, such as the desalination infrastructures, are playing the role of matching demand with supply variability and might play the role of covering structural water deficits in the long term.
- They contribute in the long term to water security such that the recovered groundwater stocks provide the buffer stocks to cope with variations of rain and runoff.

The high value of water security

Water security is much more than a public priority in the area. It is a source of conflicts, at local, regional and national levels. All this is evident in the discussions (i.e. our own stakeholder process) around the actual operation of the Tagus-Segura Water Transfer and in the difficulties experienced in matching the Management Plans of both river basins.

Harnessing the potential of water for local development has been the key for success in the Segura and the availability of enough and reliable water is perceived in the SRB as a condition to maintain the local economy (not only rural livelihoods but also the agro-industry and all the services associated as well as the important tourism sector). The way water authorities, utilities, farmers and other users respond to water supply variability is one of the driving forces behind past and current trends of water scarcity and drought risk.

Groundwater overexploitation has been recognized since more than a century as one important consequence of the spontaneous individual response of farmers' to the lack of water or to the variability of its supply. The difficulties to hold groundwater under public control in the Segura are equivalent to putting one important component water security in the hands of individual users instead of under the collective control of a water authority. It is critical to bear in mind that the situation in the SRB is one in which remarkable benefits of water access can be privately captured while the costs derived from the increase of water scarcity and drought risk are socialized.

This 'race to the bottom' can be illustrated by the trends observed in many aquifers in the area. Abstractions higher than natural recharge rates are translated into decreasing water tables, killing the goose that laid the golden eggs. Incentives are gradually modulated by the increase in the pumping costs, notably because of the additional energy required to go deeper on the ground, and/or by the degraded quality of the water thus obtained.

When groundwater reserves are sufficiently high or aquifers are deep enough these economic forces might stop water depletion at a point where the abstraction cost leaves no room for profits in the production of market goods. This fact, which also explains why groundwater depletion is not an important problem in areas where water productivity in the irrigated agriculture is low or surface water is still abundant as compared to existing demands, can be used as a proxy of the real, rather than the stated, WTP for water security.

Another way to understand the WTP for water security is by looking at individual farmer's decisions (i.e. by revealing preferences, see *Annex 2* for an in-detail insight on revealed preference model, RPM).

When deciding upon what mixture of crops to plant every season, farmers are not completely aware of many circumstances that are important to determine the actual profit they will make. Prices are uncertain, yields might vary depending on many circumstances, including water availability, and actual decisions imply assuming a certain level of risk.

One way to protect oneself against this is by choosing crops with more stable prices, or in which yields are easier to predict and so on. In other words, when choosing a crop mix farmers build a portfolio among alternatives that are feasible, according to available resources, agronomic constraints... On that basis, farmers choose also their expected profits and the risk they are willing to voluntarily accept. There is also an important trade-off between expected profits and risk: more valuable crops, such as vegetables or fruits, are associated with prices and yields which are more variable and difficult to predict, while other crops, such as cereals, have more predictable outcomes but leave smaller profits.

Similarly, a way to approach the importance given to water security in the irrigated agriculture is to see how much farmers are willing to pay for example to reduce the risk of their current crop decisions. Research on revealing farmers decisions under uncertainty showed that they are risk averse, or willing to accept less than the maximum expected profits in order to stabilize their income at the end of the day. One important part of this security can be provided by water at this outcome can easily be translated into a WTP for a more reliable water supply.

For this case study, we used our Revealed Preference Model (RPM) (*Annex 2*) for the *ex-ante* assessment of different water policies. This RPM is able to calibrate observed decisions with a procedure rooted in basic microeconomic theory. This method not only allows us to obtain simulation results but also offers a clear interpretation of farmers' responses to changing incentives and resource and policy environments. In our model, agents decide on cropland areas trying to maximize their utility, which is a function of a set of relevant attributes that may contain (but not be limited to) expected profit, risk avoidance and/or complexity management. We assume that the explanation of any decision, consisting in a distribution of the available land among the different crop options, relies on an underlying utility function formed by the many attributes that agents use to assess all the alternatives they have, given crop prices and costs, resource availability and the other relevant economic, agronomic and policy constraints (Gutiérrez-Martín *et al*., 2013).

Although expected income in irrigated agriculture in the SRB is high, this value is largely conditioned by recurrent water shortages that reduce farmers' revenues. Consequently, farmers in the SRB assign a relevant weight to risk avoidance in their utility function. In all the experiments ran in the agricultural districts of the SRB using the RPM, risk aversion was positive and significant. Risk aversion was also significant in most of the agricultural districts in the TRB. The WTP in order to avoid water security ranged between 72 and 230 €/ha in the TRB and between 152 and 949 €/ha in the SRB. If insuring the provision of water is to guarantee agricultural output and income, this would be the equivalent to paying between 2 and 5 Eurocents/m^3 in addition to the current water price in the TRB and between 2 and 20 Eurocents/m^3 in the SRB (uncertain water is actually being delivered at a cost of 10 Eurocents/m^3 in the SRB and 6 Eurocents/m^3 in the TRB).

There are at least three reasons why all this is an opportunity to implement properly designed EPIs as part of the policy mix in order to cope with water governance challenges identified in *section 4.1*:

- First, if users are willing to pay for more reliable water supply then there is a potential scope for any public policy alternative that provide them with more reliable water. If they have the right to a variable amount of unreliable surface water, they might for example be able to pay more for a lower quantity of water provided by a more reliable source (such as regenerated of desalinated water). This is something to keep in mind when considering the substitution of water sources: the maximum farmers are willing to pay for alternative resources is not the same they are actually paying for those sources they might have access now – it is higher. In other words, this opens the opportunity to overcome problems caused by the high cost of alternative sources: it is true that these resources are more expensive than the traditional ones, but users are also willing to pay more for having access to them.
- Second, water users might also be willing to cover the opportunity costs of maintaining or recovering the natural and man-made capital assets that may provide the additional resources required as buffer stocks in dry periods. These assets may either be non-conventional water facilities (for desalination or regeneration of water) or better-preserved groundwater sources. There is then scope to transfer the opportunity cost of enhanced water security to water users as they will receive a more reliable supply of water in exchange.
- Third, groundwater sources might be replaced by formal insurance systems in the role they are currently playing as informally insuring farmers' individual interests. If such a change were possible then the opportunity would exist of increasing resilience in the economy without compromising neither the conservation status nor the other uses in which water cannot be replaced, such as providing collective security making the gains of economic progress sustainable over time.

Differences in the value of water across space, uses and time.

The value of water widely differs among uses, time and space. Apart from these common characteristics economic development and the way water has been governed have resulted in even wider differences in the value of water.

At one end of the spectrum, the perception of water development as the cornerstone to push rural development has led to the construction of wide infrastructures to use as much as possible of the resource. In relatively water abundant areas this means expanding the use of often subsidized water to very marginal lands (partially because the alternative is to lose the resource) and for individual plots relatively low water prices might have resulted in production systems intensive in the use of water, with comparatively low technical efficiency, and not in capital or specialized production inputs.

At the other end, in water stressed areas agricultural systems make a more effective use of water in combination with machinery, specialized labour and production inputs that in combination allow obtaining higher yields and profits.

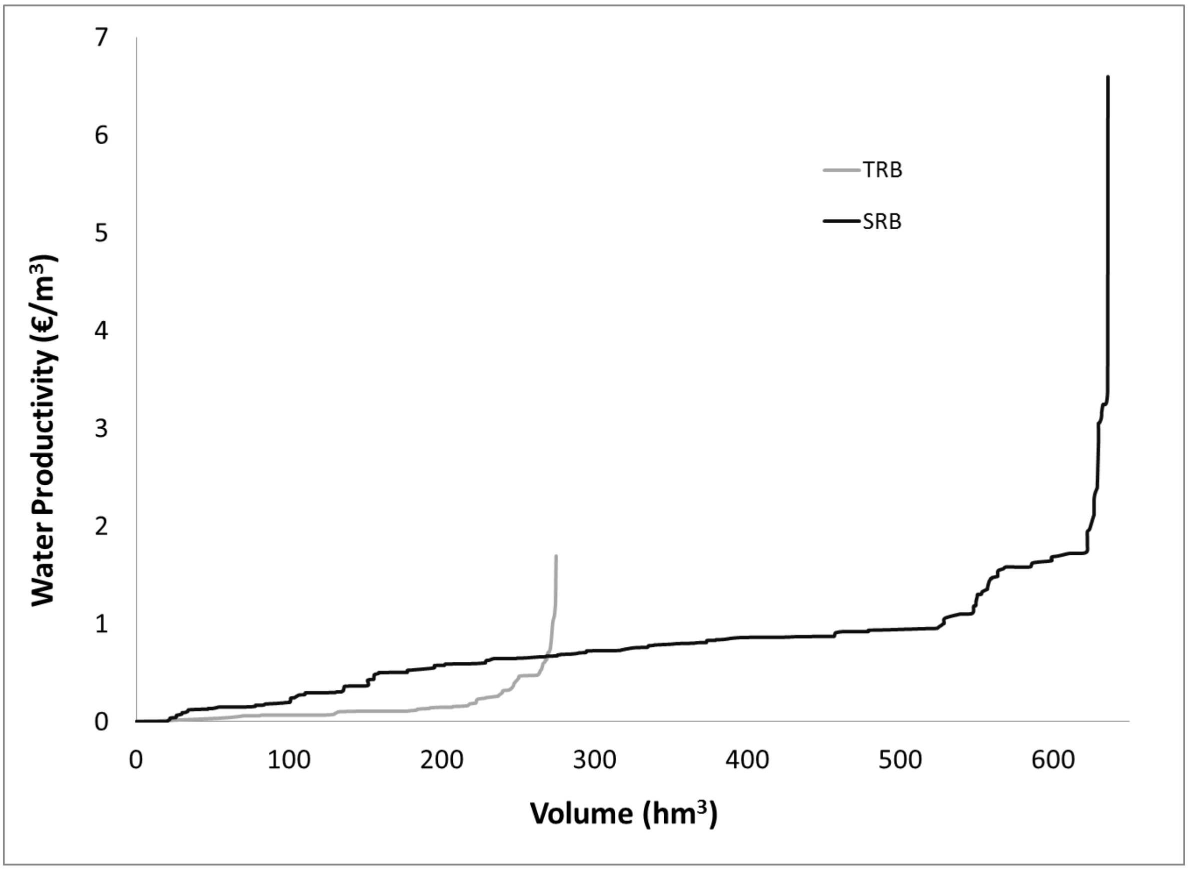
See for instance Figure 4-9. Water productivity largely varies between the Tagus and Segura interconnected river basins. Average water productivity in the SRB equals 0.77 €/m^3, whereas this value is slightly above 0.15 €/m^3 in the TRB. In addition, water productivity is above 1 €/m^3 for 17% of the water used in the SRB, while this number falls to 1% in the case of the TRB. Most importantly, 48% of the water use in the TRB has water productivity below 0.1 €/m^3, the average water price in the SRB.

Accordingly, inter-basin water trading is in principle an attractive option to increase overall revenue in both basins, with the same or even less water use. However, it should be noted that water markets might generate imbalances that may affect the environment, agricultural employment and the output and employment in economic sectors with relevant linkages with agriculture (e.g., the agro-food sector in the TRB).

Along the same line, Spain is characterized by a kind of dual agricultural economy. From one side there is the so called traditional agriculture existing in the interior of the country formed by mostly extensive crops with little need of labour and other inputs long-time protected by price support systems and subsidies from the EU Common Agricultural Policy (CAP), using cheap surface water and a limited amount of groundwater which is not that profitable to withdraw due the low financial returns implied.

This contrasts with a commercial agriculture developed in the Mediterranean, pushed mostly by existing market incentives and a limited public support, not depending on the access to output-linked subsidies, and specialized in high value added crops such as fresh fruit and vegetables that are also the primary products that are transformed, transported and commercialized by a diversified set of economic activities.

Figure 4-9. Water productivity and the potential for inter-basin water trade



Source: Own elaboration from MARM, 2009

Should it be possible to find the way to reallocate water without any environmental effect or any transaction costs this would imply the possibility of doing more with the same or even less water.

Seen from the perspective of opportunities a dual economy (see Lewis, 2008, for a revisited version of his model) represents the possibility of increasing the productivity of production factors (labour, in Lewis's case, and water) to its more productive uses.

Differences in the value of water among uses do not only mean possible reallocation gains with a given amount of water. They also mean different opportunity costs of water shortages and different levels of exposure to the lack of water when a meteorological or a hydrological drought hits the economy. When possible, given that water is a bulky good (cheap to obtain but expensive to transport), the reallocation of water represents an opportunity to reduce economic losses, thus increasing economic resilience against drought, potential 'winners' would compensate those with lower opportunity cost and have access to the water.

The efficiency gap

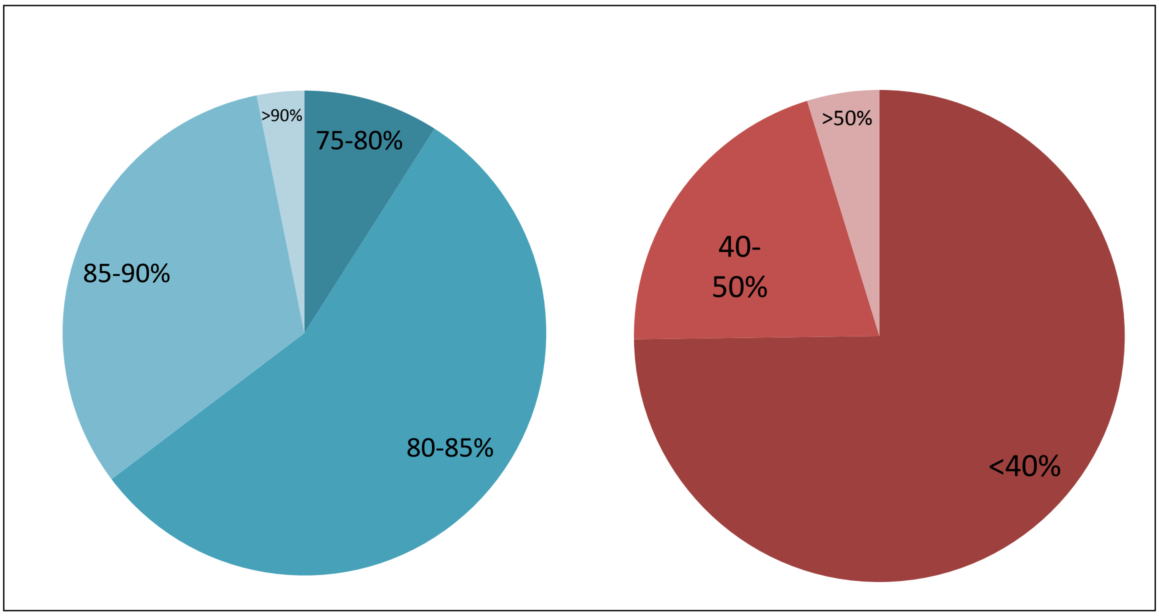
From the reasons already mentioned in the previous section there are wide differences in the effectiveness with which water is used in the different places and for different purposes. Technical analysis of the water that can be saved if the best available technology is used shows that there still is significant leeway for water savings. However, once the efficiency gap has been recognized, it is also important to understand the failures that explain why water users do not do their best to bridge this gap and whether water policy can correct them.

Besides some known coordination failures already explaining when making the case for collective action (e.g. economies of scale and scope and the need to share financial resources among the number of users served by a common infrastructure), the market itself is an important driver of the diffusion of better-adapted technologies. In fact these incentives explain why, without as much need of public support, water is used under the higher possible standards of water efficiency in the Segura than in the Tagus (with the likely exception of domestic uses), while the efficiency gap is wider in the Tagus.

The value of water is often linked to the concept of water (use) efficiency. Nonetheless, water efficiency is a rather vague concept that needs further clarification. It seems that most of the studies on the value of water refer to *technical efficiency*. That is the effectiveness with which inputs are used to produce an output, i.e., the ratio of outputs (in economic terms, if possible) to inputs (water use). However, this definition is different to the efficiency concept often used in economics, or *allocative efficiency*. The allocative efficiency is reached when the social surplus is maximized with no deadweight loss, i.e., when the value that society assigns to the outputs produced is larger than the value that society assigns to the inputs consumed. Although the difference is subtle, it does matter. For example, better irrigation technologies increase technical efficiency, but they do not guarantee steady or declining resource use. As a result, rebound effects may appear, offsetting efficiency gains and possibly generating an allocative inefficiency.

There is still an important technical efficiency gap in irrigated agriculture, especially in the least productive agricultural districts located in the TRB. Implementing the most efficient irrigation system (drip irrigation) in the agricultural areas connected to the Tagus-Segura Water Transfer would imply water savings as large as 244 hm3/year in the TRB (51.5% of the total agricultural demand). This water savings would be less relevant in the case of modern agriculture in the SRB (61.5 hm^3/year, 0.04% of the agricultural water demand) (SRBA, 2013; TRBA, 2013) (see Figure 4-10).

Figure 4-10. Irrigation efficiency in the agricultural areas connected to the Tagus-Segura Water Transfer, SRB (blue) and TRB (red) (by % over total area)



Source: Own elaboration from SRBA, 2013 and TRBA, 2013.

There is a significant difference between what is technically feasible and what is rational from a water user's perspective. More advanced technologies to transport, distribute, and use water do actually exist but they imply to a certain extent important fixed capital costs (as the implied in reducing leakages in a distribution network and transport, changing irrigation systems, etc.) and the operation of more water efficient equipment often implied higher operation costs (e.g. energy required for pressurized irrigation devices, labour to control drip irrigation, etc.). Under these conditions it is not difficult to understand why the most important opportunities to save water are in places and uses when they are less needed and there is no much room for additional technical improvements than in the places where water is more valuable and users are willing to pay more for additional resources.

The only way to reap the opportunities associated to bridging the efficiency gap is by matching them with the financial incentives in place. The potential failures of the alternatives promoted in the past make clear that collective action requires proper incentives (see *section 2.4*). Increasing water prices is an option, and this is what happened as the variable cost of groundwater increased when aquifers became depleted and irrigation more sophisticated. Another one is increasing the benefits of water savings, as, for example, allowing inter-basin trade so that incentives of water-stressed areas can be translated into incentives to save water in "more abundant" areas where most of the opportunities to save water do actually exist.

Reallocation and enhancing the technical efficiency of water represents the occasion to progress on the purposes of water policy by allowing one of the following alternatives, instead of just augmenting the scale of the economy:

- Producing more with the same. That is to say, to increase the production of goods and services in the economy without further deterioration in the water environment (i.e. preventing development to result in wider water scarcity).
- Producing the same with less. That is to say, leaving more water in Nature (e-flows) allowing for the recovery of water sources while not foregoing welfare gained through the production and consumption systems. For example, allowing the recovery of water bodies.
- Producing more with less. That is to say a combination of both alternatives making compatible the simultaneous advances in the economy and the environment. The mix of these two objectives can also be understood as the balance between the objectives of economic development and of water conservation, which is actually at the core of the discussions about the objectives of water policy.

The important issue is that differences in water productivity and technology represent a real opportunity for water policy in general (making it possible to reconcile economic development and environmental purposes) and the implementation of EPIs for that aim (allowing for financial gains that may push individuals to act in coherence with the social goals of water policy).

5 Policy design and performance – EPIs with the best potential to take advantage of current opportunities to face water policy challenges

Having in mind the previous analysis a combination of three innovative EPIs is proposed which may contribute to cope with the challenges mentioned in *Chapter 4* and, for this overall purpose, may take the most out of the above-mentioned opportunities.

Assessed in isolation each instrument is designed with a particular purpose but can make substantial contributions to other objectives. The set of instruments has been also selected because of potential synergies in such a way that each instrument performs better when supplemented with the other two.

The basic evaluation criteria that need to be followed in the selection and design of the instruments are based upon the individual advantages of each EPI but also on the package of incentives itself. Under this perspective the importance of sequencing (the introduction of the EPIs) and packaging (incentives) is considered right from the outset.

5.1 Three economic policy instruments…

The following are the three basic instruments along with their purposes and basic design criteria.

A. Pricing schemes

The main purpose of the pricing scheme is to progress towards a sound management of the water portfolio along the required transition towards a sustainable economy. This transition requires having in mind a clear picture of what the future water portfolio will be as well as identifying the adjustments that would need to be made in current water pricing practices in order to ease the transformation of the current one.

In addition to the role of BAU pricing practices as cost recovery mechanisms, the new (smarter) pricing system is called to play a relevant role through its contribution to the following intermediate objectives:

- Being an instrument to manage the SRB closure. It must be designed in such a way as to shift the roles currently played by water supply sources: e.g. excess capacity of desalinated water might be mobilized for second-priority uses while remaining available for first-priority ones during extreme dry periods. Groundwater currently playing the role of an ordinary source in more scarce places, if partially replaced with alternative resources might start to recover in the short and medium terms so as to be able to play the role of a security asset in the long term (not excluding the sustainable use of the aquifers still in good status). Hence, the existence of both sources is guaranteed: overexploited aquifers are protected and desalination becomes financially sustainable.

- Bringing water security to the forefront of water policy. Security is important for the entire economy and for water users themselves (who, as above, are willing to pay for that). The pricing system must progress towards the internalization of the resource costs into water prices. In water-stressed economies this water cost is mainly reflected in the value of water security.
- Evolving in the recovery of water supply costs in order to guarantee the financial sustainability of all the sources in the water portfolio but also to manage demand and balance water demand and supply through the recovery of resource costs.
- Reducing water demand, when possible, by a sensible design of the pricing system.

This is to be achieved by setting a price on water security (in exchange of having water in dry seasons). Users are willing to pay a price mark-up that guarantees steady water supply at a reasonable (known) and stable price. Initially this security is provided via desalination.

In normal times there will be excess supply of desalinated water. Yet, as the fixed costs are covered by the excess price, this water might become available at an affordable price (equivalent to operation and maintenance costs). Among the different alternatives there is the possibility to promote the use of this water source as a substitute for water abstraction in overexploited aquifers or making it available for water trading.

B. A formal insurance for the delivery of water for irrigation.

An insurance mechanism provided by financial markets may favour the transfer of the burden of drought risk from Nature to the financial sector. The main hypothesis is that stabilizing farmers' income is a way to reduce incentives to withdraw more water from ground sources that are already being used with unsustainable patterns.

One must be aware of a number of difficulties involved in the implementation of this kind of insurance but also recognize that in Spain there are exceptional enabling conditions as proven by the insurance sector success in covering many different natural risks in the agricultural sector.

The most practical way to identify the potential for this instrument is to identify the maximum welfare surplus at stake, that is to say gains associated to an irrigation insurance system without considering transaction costs. These gains are the difference between the minimum costs at which the financial market may provide this kind of insurance spontaneously and the maximum amount farmers are willing to pay for it. In theory this surplus exists because insurance companies have the possibility to pool individual risks and they are risk neutral while farmers, as revealed by the preferences model (see *Annex 2*), are risk averse and willing to pay even more than expected losses in order to get a permanent sense of security.

Furthermore, the proper design of this sort of insurance schemes requires putting up with many implementation challenges whose transaction costs might or not fall below the welfare surplus at stake.

This insurance might cover at least those farmers whose plots have access (either formally or not) to aquifers already or under risk of have being exploited unsustainably.

The rationale of insurance as a risk-management tool for drought and scarcity management is supported by the recent work from the EAA on climate change adaptation (EEA, 2013) and the Green Paper on the insurance of natural and man-made disasters [COM(2013) 213 final], which provides a rich policy-based discussion on insurance schemes.

C. A multi-level water use right trading scheme[19]

Water use right trading has been proposed in order to improve resilience in the economy and harness the potential of water for economic development. Specifically, we suggest a combination of intra-basin markets, to improve water allocation efficiency at local levels and to enhance water usage technical efficiency, combined with an inter-basin water market scheme to transfer water from relatively more scarce to the less scarce areas. While environmental concerns are more likely to be at a more sizeable at local scales, wider concerns apply for inter-basin trades.

To be effective, water trading requires making water use more flexible through allowing buying and selling to be an option instead of the strict use of water rights in the amounts, places and particular uses for which they are issued by the water authority. The definition of tradable water rights is a major change of the current institutions in place (as in Maziotis *et al*., 2013, see *Annex 5*) where, contingent to the availability of water at each moment in time, individual users are granted with usufructuary rights that, unless an intricate authorization process is followed, cannot be used for another purpose or in another site than that authorized by the water authority.

Regarding water scarcity and the other objectives of water policy, the main questions around the effectiveness of water trading have to do with guaranteeing that trading water (use rights) may be environmentally neutral. In other words, that what it is in the interest of specific individuals or parties agreeing on a transaction over water does not harm the socially agreed interest of preserving water sources.

A particular threat that would need to be avoided in order for water trading to gain social and political acceptance is the perception that instead of reducing water scarcity, trading might open the door for current scarcity trends in a particular place to expand to the rest of the territory making water scarcer elsewhere.

Water trading can only be part of the solution if the deficits that are covered in the receiving basis are compatible with the closure of the exporting one; that is to say if the capacity of the ceding one to yield the surpluses that can be transferred in whatever period are compatible with the maintenance of environmental objectives. Finding water-trading alternatives that fulfil these two conditions might be challenging but the real issue is that without transparent information showing that this is not happening, the social acceptance of water trading will remain a difficult, or even impossible, task.

Trading over water locally, e.g. among the members of a given irrigation district, does not raise important environmental concerns as far as all the parties directly involved in the agreement

[19] The design of this instrument, although following a different methodological approach, did clearly benefit from the outstanding contribution of MU-FHRC through Viavattene and Pérez (2013).

comply with the overall amount of water entitled to the group (such as in a any cap & trade scheme).

This might not be the case when imperfectly controlled groundwater sources are involved. In this case, some farmers might be able to sell additional amounts of water without reducing her use accordingly. If that happens that demand of water for trading is not covered with the resources already available but rather through increasing short-term supply at the expense of higher water scarcity, and lower resilience to droughts, in the future.

For this reason, the important question around the pervasive evidence of water trading in the Segura (Hernández-Mora and De Stéfano, 2013), is not whether they are means of local users to avoid transaction costs imposed by prevailing regulations than prevent water from finding its more valuable use in the economy (which might be a legitimate function of markets) but a means to encourage outlawed water abstractions (which is a way to get deeper in the current unsustainable trends of water withdrawal).

5.2 but only one package of incentives

The three instruments have been chosen for its potential to make a relevant contribution to face current water challenges but its particular role cannot be understood in isolation but as an integral part of a package designed as an element of a major change in water policy.

Firstly, as already mentioned in the previous section, each kind of EPI is itself a combination of particular instruments with precise objectives:

- The pricing scheme proposed does not simply entail increasing the current water prices so as to include elements that have been ignored so far (as for example resource costs which in water scarce regions have water security as a key component). On the contrary, in addition to internalizing the cost of providing water security (by guaranteeing the availability of production capacities to deal with temporary deficits without depleting freshwater sources), the pricing scheme must be designed to incentivize reductions in water demand (through marginal pricing) and to change the factors driving to overexploitation of groundwater (both through reducing water demand and shifting to alternative sources).
- The water-trading scheme may also be considered as a structured package designed for water to be allocated to its more productive uses (so as to increase resilience in the economy through auctions and spot markets, for short-term transactions). Also, to allow inter-basin trading with lease or futures contracts (option contracts, forward contracts) for longer-term agreements, converting the high value of water in one region into new incentives to save water in the other (so as to reduce scarcity in one region without increasing it in the other through multi-stakeholder bargaining).

The same can be said regarding the potential contribution of each EPI to cope with the three water governance challenges identified in the *Chapter 4*. Although one instrument might seem to be better suited for a particular problem, if properly designed, each one will be able make significant contributions to the three challenges (as shown in Table 5.1 below):

Apparently, water pricing has the better potential to balance water demand and supply and to serve as a privileged mechanism to closure the river basin.

Moreover, pricing systems can be designed to support controlling overdrafting of groundwater. The availability of alternative sources when affordable to farmers, in those areas where water tables are lower and water is more productive, might be used as an incentive to reduce overexploitation, so as to gain privileged access to alternative water sources. Further, water pricing contributes to making the economy more resilient by increasing buffer stocks and reducing or managing conflicts around water.

The insurance of irrigated water is designed *ad hoc* to replace groundwater as the privileged mechanism to stabilize farmers' income in dry periods. If properly designed and implemented it might help first in regaining the control over groundwater. However, this is also a pre-condition required for the river closure. In addition, the insurance system will stabilize local income and will help maintain expenditure and demand of final goods in the local economy as well as fiscal revenues smoothing the drought impact over the economy.

In turn, the main advantage of the flexibility provided by tradable water use rights relies on the possibility of water being allocated to its more valuable uses regardless of the fluctuations of water supply and of the drivers of water demand (such as the prices of goods and services, energy and other inputs, etc.). Nonetheless, if the mechanisms to allow trading with water are properly designed they may turn into powerful incentives to regain the control over groundwater. For example, the option to buy additional water might not be open to depleted aquifers or, after some time, it could be banned for some irrigation districts if water tables continue to drop. Furthermore, the granting of water use rights could be conditioned to the explicit proof that water use has been effectively reduced and not replaced by groundwater abstractions. Finally, the trading scheme will only make a true contribution to the overall challenge of reducing water scarcity and drought risk if it is able to help adjusting the overall use of water in the economy within the limits of available water in each river basin and at any point in time.

A third reason to consider the whole package of incentives, instead of each one on its own, is the existence of relevant synergies existing among them. Table 5.2 makes visible the possible interactions between each pair of instruments.

When seen in connection to each other it is easy to understand, for example, how the presence of one instrument can play an important role as a pre-condition that makes the other a feasible alternative. For example, water trades will never work to the benefit of sustainable development if the amount of water available for trading anytime anywhere is not predetermined in advance.

These preconditions of water trading are precisely the two water policy challenges (basin closure and control over groundwater sources) to which water pricing and insurance schemes may contribute the most, so that they can be effectively designed to create the requirements to control the risk, implicit in any water trading system, on increasing the use of water instead of limiting the overall demand strictly to the resources already in use. The drought insurance system, while serving to control the use of groundwater might also control the risk of the option to sell water resulting in higher groundwater depletion.

Synergies between EPIs are often reciprocal. From one side the pricing system would foster a better performance of water markets. From the other, water trading would reduce the cost of providing water security. In fact, water trading can be an effective way to allocate non-conventional water sources in normal periods reducing the financial costs of maintaining the production capacity available and fully operational to cope with temporary shortages. The combination of prices and trading, in this case, might contribute to reduce scarcity (adding non-conventional water to long-term supply) in normal periods, and increase resilience to droughts (reducing the costs of making "renewable" buffer stocks available in dry periods).

Instruments can also be designed as complementary and self-reinforcing, as it happens with insurance and water trading. Insuring irrigated water might be an effective alternative to control groundwater abstractions. Yet, farmers not willing to buy this kind of insurance or not having access to a groundwater source might compare it with the option of going elsewhere to buy additional water instead. Both, the market and the formal insurance, will add to the opportunities available for farmers to stabilize incomes and face an increasingly uncertain supply of water, thereby making the response to water uncertainty more efficient.

Important connections also exist between pricing and insurance. If, for example, the insurance system succeeds in reducing groundwater depletion this will be translated into a higher demand for surface water and the increase in water pricing will be easier to implement.

As mentioned with moral hazard concerns of water trading, not all the connections between the three kinds of EPIs are strictly positive. Something similar can be said about the connection between pricing and insurance. Higher water prices may result for instance in stronger incentives to deplete groundwater and this is something to be aware of when designing the insurance scheme (the risk premium, deductibles, etc.).

The basic lesson to be drawn from the previous analysis is that rather than being panaceas to solve water management challenges, EPIs are an integral part of adaptation strategies that need to be designed and implemented in combination to each other so as to exploit their self-enforcing advantages as well as to use the potential of one instrument to control the risks associated to the implementation of others.

Table 5.1. Links between EPIs and water policy challenges in the Tagus and Segura interconnected basins

	THIS EPI …	… MIGHT CONTRIBUTE TO		
		Segura's river basin closure by…	*Regaining control over the resource by…*	*Enhancing economic resilience by…*
EPIs	**PRICING >**	· Adapting water demand and supply. · Guaranteeing additional supplies to cope with temporary shortages. · Promoting the substitution of water sources in order to reduce overexploitation.	· Pricing access to non-conventional water sources in a way that induces farmers to signal their responsible use of groundwater resources under their control.	· Increasing water security for urban uses by reducing shortages of irrigated water, via relaxing the reduction in supply of surface water. · Increasing buffer stocks in the medium term (by excess supply of non-conventional sources in normal periods) and in the longer term (by allowing better conserved aquifers).
	INSURANCE >	· Setting an opportunity cost for groundwater overexploitation and making information about current trends in groundwater available for the water authority.	· Setting up an alternative way to stabilize farmers' income in dry periods through reducing incentives to withdraw already depleted aquifers and providing incentives to signal its responsible use of aquifers. · Creating conditions for a collective control of aquifers (as compensations in dry periods might depend on the proof that no overdraft happened in the irrigation district).	· Reducing the negative outcomes of reduced income over local expenditure and fiscal revenue and acting as an automatic stabilizer of the local economy.
	TRADING >	· Adjusting water demand and supply at every moment in time (accommodating water uncertainty) and space. · Serving as a transmission mechanism for incentives to save water across space and economic uses.	· Providing new incentives to signal the responsible access to aquifers and to avoid trading incentives resulting in further depletion.	· Allowing economic decisions to adapt to a water supply, which is increasingly uncertain and variable throughout time and space, and reducing economic losses in dry periods.

Table 5.2. Synergies between assessed EPIs.

THIS EPI …		… MIGHT BE DESIGNED TO REINFORCE: PRICING	INSURANCE	TRADING
EPIs	PRICING >		· Conveying information about the opportunity cost of water, farmers' attitudes towards water security and farmers' willingness to pay to avoid risk.	· Internalizing opportunity costs into the water price thus enlarging the amount of water that can be voluntarily sold at higher water prices and allowing for more competitive trades. · Increasing the volume of resources that can potentially be traded (e.g. non-conventional water sources), and providing additional incentives to save water (that can eventually go to the water market) as for example when higher water prices induce more efficient water use.
	INSURANCE >	· Setting an (explicit) opportunity cost for groundwater overexploitation and making information available for the water authority about current trends in groundwater. · Providing incentives to signalling that can eventually be used to promote metering and marginal pricing in places where these mechanisms are not already in place.		· Reducing the likelihood of moral risk problems associated to substituted water voluntarily traded with uncontrolled groundwater withdrawals. · Facilitating transparency and the availability of amounts of water effectively used.
	TRADING >	· Opening options for identifying the best uses of non-conventional water sources in normal periods and reducing the financial burden of maintaining these facilities available for dry periods. · Conveying information about the opportunity cost of water from alternative sources or locations.	· Providing an alternative to protect against droughts (buying additional water instead of insuring income) and allowing more efficient responses to risk.	

5.3 Water pricing system: basic design and results

In this section we will explore the design of the pricing system by solving with available data the most basic design questions. As above, we assume prices need to be designed to recover all financial costs implied in the provision of water services. In addition to that, we focus on how much current prices of water will need to be increased so as to guarantee the provision of water in dry period, according to available data and models.

As per the pricing scheme explained in the previous section, the system works as a cost-sharing mechanism among those interested in having a secure water supply. The pool is formed by water utilities (on behalf of households and other urban consumers) that, although having the use of water guaranteed by the hierarchy of uses in place, are also interested in paying for the cost of their own water security as a way to reduce conflicts with farmers and other (formally) low priority users. Also, to mitigate uncertainty, long bargaining processes, and transaction costs that characterize the achievement of urgent solutions to water shortages in dry periods.

Additionally some particular irrigation districts with particularly high WTP and inelastic water demand curves might be interested in sharing the insurance cost as a means to reduce uncertainty and to insure water supply (in spite of being, according to the Spanish law, a second-priority use).

Al those water users willing to take part in this kind of collective insurance system must pay on a regular basis for the capital costs of maintaining current desalination plants operative so that they can cover the deficits in due time. The first basic question is then by how much should the water price be increased in order to raise enough revenue to fund the capital cost of these desalination plants. As a first approach this analysis can be performed in the drinking water sector taking into account the main drivers behind water demand. That is to say, the expected effect of changes in prices over the amount of water demand, the positive effect of increases in income, the evolution of the scale of water consumption due to population change and to the expansion of other activities such as tourism, and so on.

For the purposes of this study, we have used our Prospective Model for Household Water Demand (HWD, for a full description of the model see *Annex 1*). The HWD assumes that the variation in household water demand is a consequence of the number of users (scale effect) adjusted by the effects that prices and income may have over the individual water demand. This basic idea reveals the relationship that exists between the water demand growth rate and the set of independent variables that determine water demand.

The model works at a municipality level and can be used to simulate future scenarios of water demand based on data of economic growth (current and future trends), population change (current and future trends at a municipality level), water prices, income per capita, price- and income-elasticity of demand, and water use coefficients.

The model can also be used as a financial tool to estimate, for example, the effects over domestic water pricing of investment policies, or to simulate the impact over tax revenue of different cost-recovery policies.

The cost of guaranteeing a stable household water supply in the SRB can be estimated from the fixed costs of desalination plants, so that they can be used at any time to satisfy a reliable and clean buffer stock. Taking into account the most recent population and income forecasts (INE, 2013; EC 2013), observed water prices (SRBA, 2013; TRBA, 2013) and income per capita (INE, 2013), and the price- and income-elasticities observed for household water demand in Spain (Martínez-Espineira, 2002, 2003a and 2003b; Martínez-Espineira and Nauges, 2004), our HWD model estimates that charging the capital costs of desalination plants to households would result in an annual price increase rate of 0.72% during a cost recovery period of 30 years and would have negligible effects over household water demand: a variation below 0.7%.

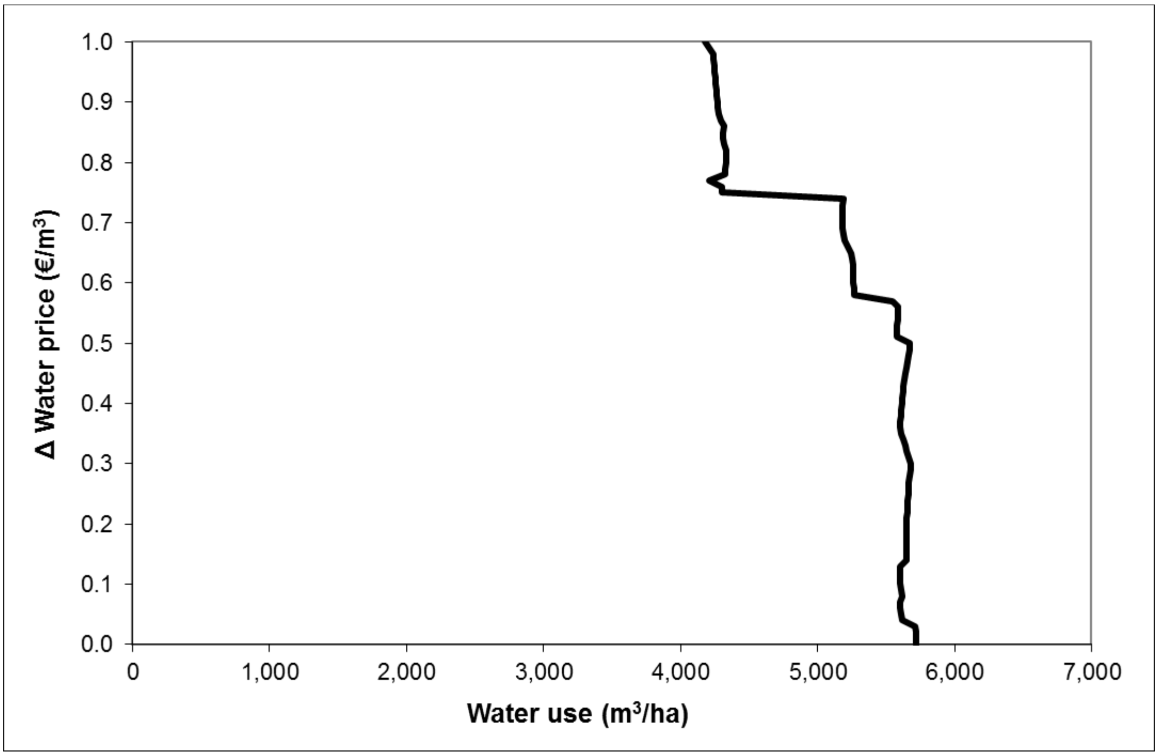
It may also be considered that any increase in the security of water supply for urban uses also means an increase in the security of supply for irrigated agriculture. The latter would benefit from the decision of the former of using desalinated water instead of further reducing water supply to the irrigated sector as permitted by the legal hierarchy of uses in place. A trade-off can be considered of increasing the price in one cent per cubic meter as a security mark-up. Given the elasticity of demand this would not reduce water use in the irrigated sector and would rather create additional revenues that could be used to reduce the burden to the urban sector.

Urban water security also increases water availability and water security in agriculture. This results in reduced income variability, stable employment and positive forward linkages with other economic sectors (e.g., agro-industry). Therefore, it seems reasonable to split the cost of water security among users that benefit from it.

However, while household demand is usually inelastic, agriculture is more likely to suffer more negative impacts from higher water prices (see Figure 5-1). According to our RPM (*Annex 2*), though, this is not the case in the SRB. Due to their high-expected income, farmers in this basin show an inelastic water demand curve up to price increases as large as 40 Eurocents/m^3.

The impact of higher prices is absorbed by the gross margin, with no negative effect over employment. This leaves in principle enough room to higher water prices in agriculture as well. Nonetheless, it should be noted that the impact of higher prices is not homogeneous: while coastal areas show a higher resistance to price increases, agriculture in mountainous agricultural districts could be threatened. Therefore, these results need to be taken with extreme caution since equity issues should also be addressed in further research.

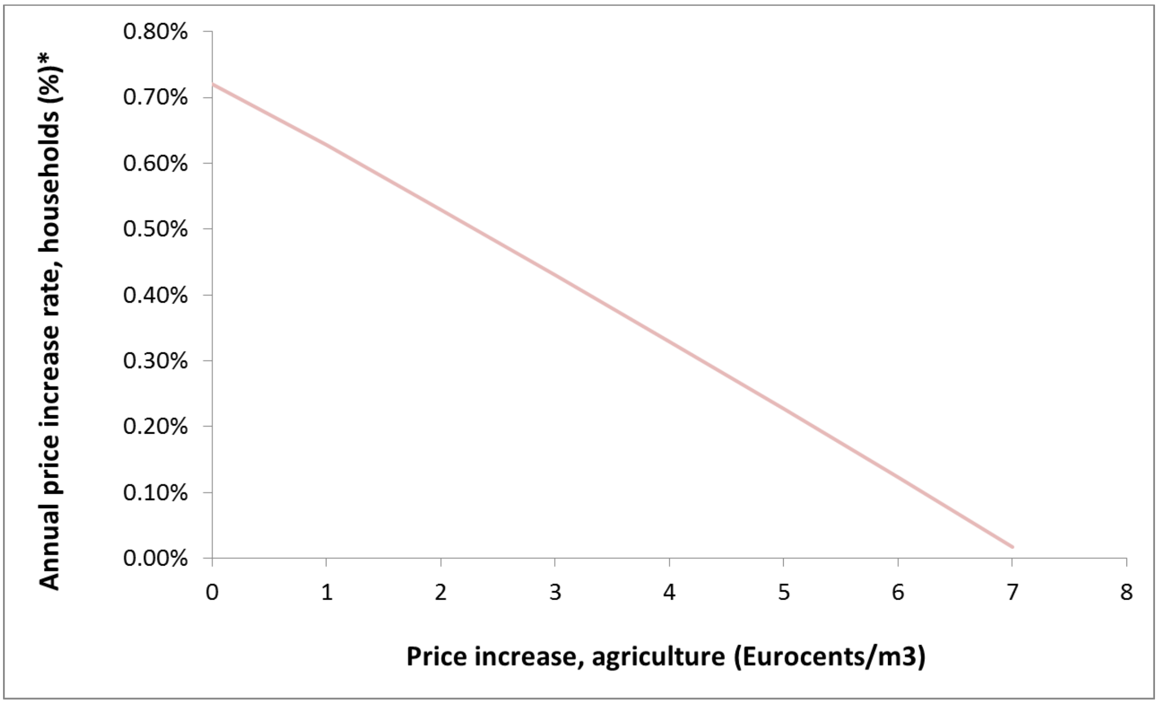
Figure 5-1. Water demand function in the SRB (m³/ha)



Source: Own elaboration

The costs of water security (i.e., the capital costs of desalination plants) may be split between households and farmers using different shares. A series of simulations were run in which we increased the price of surface water resources in agriculture (400 hm³/year excluding the water transfer). A constant surface water demand in agriculture was assumed (SRBA, 2013). In addition, we obtained the net present value (NPV) of this additional yearly revenue for a period of 30 years (cost recovery period) and this value was deducted from the capital costs charged to households in the HWD. Figure 5-2 (a sort of equity frontier of water security) shows the trade-off between agricultural price increases and the annual price increase rate for household water supply, providing useful information along the whole policy-making process in order to deal with equity issues at stake in the reform.

Figure 5-2. The equity frontier of water security



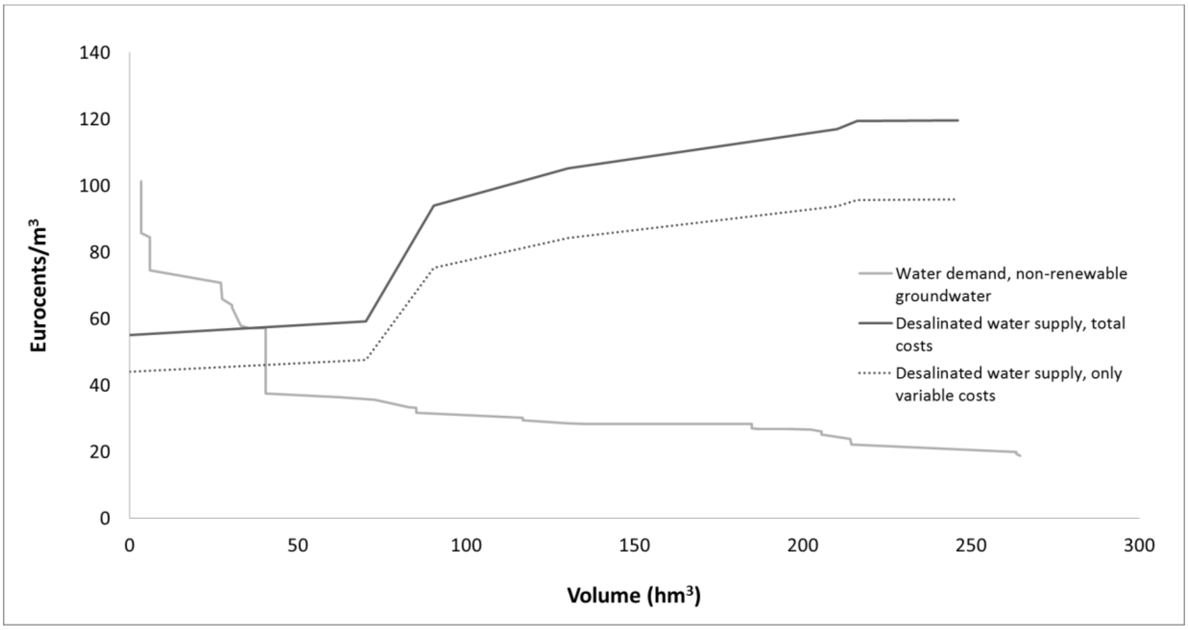
*Cost recovery period of 30 years

Source: Own elaboration

In dry periods, urban users will have unrestricted access to desalinated water instead of priority access to water that was used for irrigation otherwise, at a price equal to operation and maintenance costs. Thus, the scheme will also increase water security for irrigated agriculture, as surface water will become available in a higher quantity.

Can overexploited groundwater be actually replaced with desalinated water? Capital costs represent approximately 20% of the production costs of desalinated water. However, even if these costs were paid through higher surface water prices and/or higher household prices, the not minor variable costs of desalinated water (80%) would still be an impediment to shift from non-renewable groundwater resources towards desalinated water (see Figure 5-3).

Figure 5-3. Desalinated water supply and non-renewable groundwater demand



Source: Own elaboration

All this will leave an excess of water available for normal periods (at the same price) that can be offered for water trading. One alternative is to offer this excess water to those water users in irrigation districts that are already exploiting groundwater sources at pumping costs higher than the operation and maintaining costs of desalinated water. This alternative will lead to the substitution of water supply in some of the more depleted aquifers and farmers will receive these resources in exchange of allowing unrestricted access to the water authority to their premises in order to guarantee that abstractions have been finished.

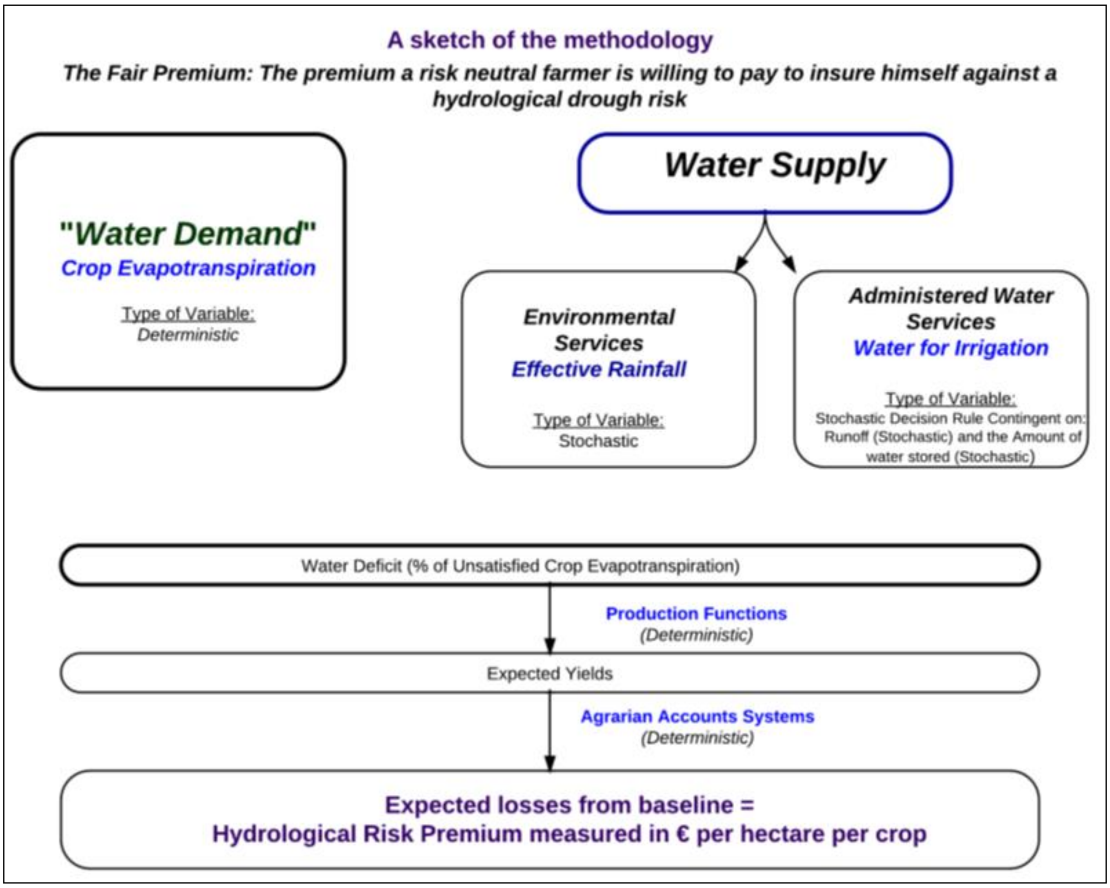
5.4 Insurance system for surface water: basic design and results

Among the different water sources that might be available for irrigation the only one that is not under the strict control of irrigators, individually or collectively through their irrigation district representatives, is the surface water delivered by the water authority.

Contrary to that, farmers also have certain control over the aquifers, and can actually turn to them in case of permanent or temporary shortages of surface water, or have the opportunity to use desalinated water (as seen in the previous section) and might have the opportunity to buy additional water from other basins (as explained in the following section).

In addition to the RPM (*Annex 2*), the design of the insurance for irrigated agriculture is based upon a Risk Assessment Model (RAM, see *Annex 3*). The RAM calculates the basic risk premium (see Figure 5-4) of the crops in the area through the implementation of a methodology that depends on the historical evolution of the insured product, i.e. water availability (Martin *et al.*, 2001). The model first estimates the Probability Density Functions (PDFs) of the variables that determine water availability in agriculture (runoff, stock in reservoirs and local rainfall). Subsequently, the quantity of water available for irrigation in every drought scenario and its corresponding probability are estimated according to the applicable decision rules, and the potential for water overexploitation is obtained. Finally, we use a deterministic agronomic model to estimate the expected yield, its corresponding production value and indemnity and the basic risk premium for every possible drought scenario.

Figure 5-4. What is the fair risk premium?



Source: Own elaboration

The lack of surface water is an important driver behind the decisions to use other sources. In the previous section we mentioned how the pricing system could be used to provide farmers regular access to non-conventional sources at subsidized prices conditioned to the cease of non-renewable groundwater abstractions.

If properly managed this might be a practical way to cope with structural water shortages while fostering the recovery of water tables. But this is not the solution to deal with water shortages in dry periods. Remember that the subsidy over non-conventional water is received in exchange of farmers being willing to release such resources for household consumption and other urban uses. This is precisely the role for which water insurance must be designed: to provide the required incentive to reduce groundwater overexploitation in dry periods. The design of this insurance system is based on a proper assessment of drought risk, the evaluation of the minimum costs at which this insurance can be provided by the insurance companies and, finally, farmers' WTP for such coverage against droughts.

A. Assessing drought risk

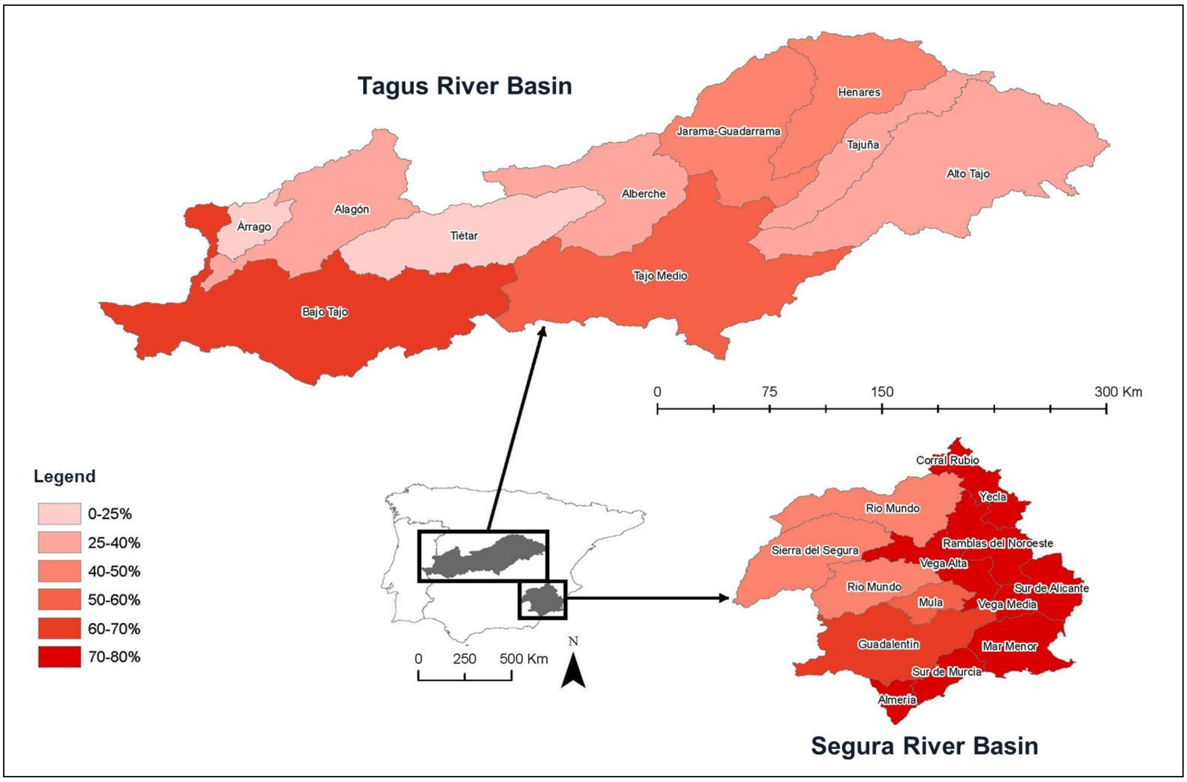
Droughts in inter-regional Spanish river basins are managed through *Drought Management Plans* (DMPs). DMPs are intended to avoid water overexploitation during drought events through a set of objective drought indicators and abstraction rules (EC 2008). These plans establish more stringent constraints to access publicly provided water while guaranteeing priority uses, such as drinking water, and ensuring e-flows and minimum environmental services.

As a result, the declaration of a drought will automatically reduce, in a predictable amount, the quantity of water delivered to the irrigation system from publicly controlled water sources.

Since the DMP defines the precise thresholds of possible drought situations and sets the water constraints that will come into force in each of these cases, this information can be used to assess drought risk. As above, in the SRB, a four-stage classification system is used (normality, pre-alert, alert and emergency). In the case of an emergency, an optimistic 50% of planned irrigation resources will be conceded in an attempt to guarantee, as highest priority, the survival of ligneous crops (although water distribution can be revised by the local authorities). Less stringent water constraints are established for alert (75%) and pre-alert levels (90%) (Gómez and Pérez, 2012).

Since DMPs establish in a straightforward way under what circumstances a drought will be declared, it is possible to estimate drought probability using the RAM. Figure 5-5 shows drought probability in the TRB and the SRB. Since some of the data series for runoff, groundwater levels and water stock in reservoirs in the SRB are only available for the last two decades (when water availability has been lower), results may be biased. In any case, climate change reports by the Ministry of Agriculture, Food and the Environment show that this may be precisely the trend for the next decades (MARM, 2011).

Figure 5-5. Drought probability in the TRB and SRB



Source: Own elaboration

B. Evaluating drought exposure and the fair risk premium.

To understand the economic impact of drought events over irrigated agriculture it is necessary to understand how the effective rainfall as well as the water delivered by the basin authority, as compared with the evapotranspiration requirements of the crops in place, result in a water deficit which, in turn, is reflected in lower yields and revenues. It is precisely this prospect of a reduced revenue and income that pushes farmers towards increasing abstractions of groundwater that might be avoided by an insurance system able to stabilize farmers' income.

Let assume the proposed insurance system is able to deter farmers of using groundwater to compensate the deficit. Once this deficit and its corresponding probability distribution function can be calculated they can be linked to a distribution probability of yields revenues and incomes so that exposure to risk can be evaluated and drought losses can be linked with a probability of occurrence.

This analysis leads to the estimation of the so-called fair risk premium measured as the expected losses. The basic assumptions are that insurance firms are able to serve as risk sharing mechanisms and may efficiently fulfil the required financial arbitrage so that the amount collected as risk premium from the farmers insured is equal every year to the expected indemnity that would need to be paid for drought losses.

The same analysis provides the information required to assess the potential of the insurance system to reduce water overexploitation in dry periods. In this case it is obtained as the irrigation deficit for any drought state and when combined with the probability distribution function in an expected water shortage. This final value can be interpreted as the maximum water overabstraction avoided by the insurance system.

The RAM was applied to the particular case of the Campo de Cartagena Agricultural District in the SRB. First, we estimated the expected evapotranspiration (water demand), the expected evapotranspiration satisfaction (water use) and the subsequent expected irrigation deficit, and from here the potential for illegal groundwater abstractions.

Expected evapotranspiration satisfaction is estimated at 43.31 hm^3/year, 92.32% of the total evapotranspiration of 45.72 hm^3/year. Accordingly, the expected irrigation deficit amounts to 2.41 hm^3/year, which given the low efficiency of illegal groundwater abstractions results in an expected potential for increased groundwater depletion of 9.45 hm^3/year (more than half the annual groundwater abstractions in the area, estimated at 16.7 hm^3) (SRBA, 2010). It is important to remark that this is an expected value: for example, during emergency situations, the expected potential for illegal groundwater abstractions soars up to 38.83 hm3/year according to our model (while in normal hydrological years it is 0).

Finally, using some basic agronomic production functions, we obtain the production and production value in a normal hydrological year, the expected indemnity and the fair risk premium for the ligneous crops in the Campo de Cartagena Agricultural District (see Table 5.3).

Table 5.3. Normal Agronomic Production (Q_{norm}), Normal Production Value (V_{norm}), Expected Indemnity (IE) and Fair Risk Premium (FRP) for the ligneous crops in Campo de Cartagena Agricultural District.

Variable/Crop	*Prunus dulcis*	*Prunus armeniaca*	*Citrus × limon*	*Citrus reticulata*	*Prunus persica*	*Citrus × sinensis*	*Pyrus communis*	*Vitis*
Q_{norm} (kg/ha/year)	9 159	15 210	23 010	23 398	25 001	23 726	19 441	13 999
V_{norm} (EUR/ha/year)	5 428	5 286	5 825	2 559	9 630	2 351	3 775	2 313
EI (EUR/ha/year)	0.5	49.7	213.2	233.6	13.5	199.4	5.3	0.2
FRP (%)	0.01%	0.94%	3.66%	9.13%	0.14%	8.48%	0.14%	0.01%

Source: Own elaboration

C. Evaluating farmers' willingness to pay (WTP) for drought income stabilization insurance.

The proposed insurance scheme, although related to the delivery of water decided by the basin authority is not exactly an insurance over water for irrigation.

Insured farmers are not entitled to claim a financial compensation anytime a reduction in the water delivery is decided. If this were the case the farmer would have the opportunity to receive the compensation and still retain the option to cover the water deficit with groundwater and have the same production and income as before.

To avoid this kind of moral hazard problems the insurance must be linked to an observable outcome. We assume the effective amount of water used does not fall under this category of observable facts, but yields might do so and market prices are public information variables over which the indemnity to be paid in case of a drought can be calculated.

Basically, once a drought has been declared (in accordance to the drought indices and the decision rules of the drought management plans), farmers are entitled to apply for compensation depending on the yields and the prices registered up to a certain level on income. In such a way it is clear that the insurance system does not work not only because it covers water delivery risks but also because it covers income risks: it stabilizes farmers' income as a way to eliminate the existing incentives to obtain water from the already overexploited groundwater sources.

Therefore to assess farmers' willingness to pay for such a kind of insurance we need to evaluate the welfare improvement they might have when a certain level of profits is guaranteed. For example, a full coverage insurance would guarantee farmers' profits will never fall below expected income (according to the average yields and prices registered over time) although it can be higher if prices, yield or both are above average or when costs are below average[20].

From the preference revelation model (*Annex 2*) we know that risk-adverse farmers welfare increases both with expected profits and security (measured by the standard deviation of expected profits). And the insurance system will actually increase both: expected profits, by avoiding below a minimum threshold profit, and risks, eliminating the variance for a full range of low-profit outcomes (see Table 5.4).

Abundant evidence shows that farmers are risk-adverse individuals (Lien and Hardaker 2001; Kim and Chavas 2003; Calatrava and Garrido, 2005; Gutiérrez-Martín and Gómez, 2011). Therefore, their willingness to pay for income security is larger than the increase in the expected income that insurance provides. Using our RPM, we obtain the expected income with and without insurance, and we reveal farmers' WTP for income security (see *Annex 3* for a full description of the methodology).

[20] In this analysis we assume farmers take crop decisions in advance, before knowing the exact amount of surface water they will receive and in case of drought they will incur in important production costs (except for harvesting). The results obtained with expected income are then very similar to those of expected benefits, as there is an important correlation between the two variables.

Table 5.4. WTP for income security, selected agricultural districts in the SRB

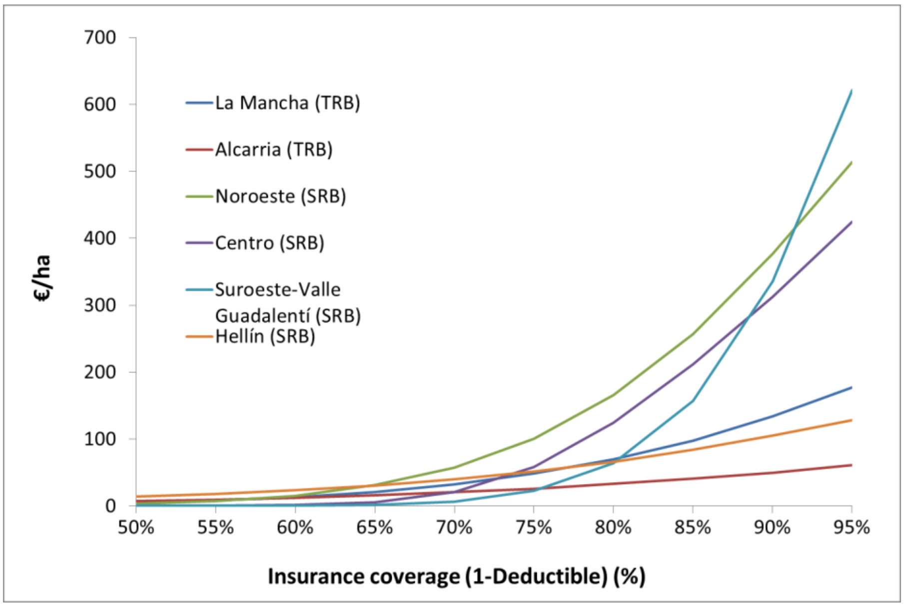
Variable/Agricultural District		*Noroeste*	*Centro*	*Suroeste-Valle Guadalentí*	*Hellín*
Expected Gross Margin (€/ha)	Not insured	1,869.2	3,719.9	3,602.1	611.2
	Insured	2,003.9	3,889.9	3,767.5	714.4
	Difference	134.7	170.0	165.3	103.2
WTP for income security (€/ha)		*647.5*	*546.4*	*949.3*	*151.7*

Source: Own elaboration

Based upon this information we can obtain the willingness to pay (or the maximum risk premium a farmer is willing to pay before giving up the possibility of buying the insurance. It is possible to draw the demand curve for insurance depending on the coverage over income. This analysis might be important as the implementation of the insurance might require sharing risk somehow (e.g. to deter moral hasard) between the farmer and the insurance provider (Figure 5-6).

Insurance systems only cover at most a share of the expected value of the production in a normal year. This threshold ranges between 70-80% in Spain (Bielza *et al.*, 2008) and aims at reducing the impact of the moral hazard (Miranda 1991), which under some circumstances may make agricultural insurance unfeasible. This threshold will likely reduce the WTP for income insurance. We use our RPM to estimate farmers' WTP for different degrees of risk coverage.

Figure 5-6. WTP for income insurance, selected agricultural districts in the TRB and SRB



Source: Own elaboration

The analysis therefore shows how between the fair risk premium and the risk-adverse farmers' WTP there is scope for insurance systems to stabilize irrigators' income and reduce incentives for groundwater overexploitation in dry periods.

5.5 Design elements of water trading and results

In a fiction world with zero transaction costs, opportunities to reallocate water to its most productive uses would exist when the value of water is variable across water users.

If these differences do exist there is then an opportunity for individuals or stakeholders to engage in a bargaining process to reach mutually beneficial agreements at a price which must be set in between the maximum WTP of the might-be buyers and the minimum compensation the might-be sellers are willing to accept for water use rights. In studies about the opportunities for water trading this is in general the approach followed as a first step to identify the maximum potential for water.

The second and most ambitious step consists in identifying the basic operational costs implied in the transfer of water from the buyer to the seller, typically including the transport cost and water losses due to evaporation and infiltration.

These water losses can be converted into increased monetary costs and used to recalculate the water available for trading[21] in addition to impulsion and other transport costs. Overall, this operational cost reduces the number of transactions that can be agreed on without any intervention of a third party (such as the government or the water authority) consumes an important part of the surplus available to fuel private bargaining over water.

As a first guess the result of this simple calculation would allow obtaining what the scope of bargaining is, but always ensuring that it is in the private interest of the potential buyers and sellers of this market. Even ignoring other transaction costs this is already an important result showing that opportunities for water trading decay with distance as transport costs increase.

Assuming that water can be traded with no bargaining costs, there are still two relevant constraints to water markets, namely transportation losses and transfer fees. Transportation fees directly increase the cost of water, while transportation losses do reduce the amount of water delivered at destination (SRB) as compared to water purchased at the TRB, increasing water costs as well.

Transportation fees in the Tagus-Segura Water Transfer are 10 Eurocents/m^3, while transportation losses are estimated at 10% (SRBA, 2013; Rey *et al.*, 2011). These costs alone reduce the potential for water trading by 30 hm^3 (10% reduction) and increase water prices by 16%. During some emergency droughts in the past, transportation fees were actually removed in order to encourage inter-basin trading (see Figure 5-7).

[21] For example if losses in transport are 20% of the water initially dispatched this is the equivalent of an increase in 25% over the original cost per cubic meter as for each cubic meter arriving the destination point 1,25(or 1/0,8) cubic meters will need to be bought and delivered at the origin.

In other words, the RPM yields an estimation of the marginal value of water depending on the decision they take to maximize welfare including the expected profit and their attitudes towards risk. Results are coherent with the well-known asymmetry in water productivity in the different river basins. If bargaining and transaction costs were equal to zero, farmers might then be willing to give up important amount of water voluntarily. Nevertheless when transport costs (including water losses) are taken into account these theoretical opportunities and the potential for inter-basin markets are substantially reduced (see Table 5.5).

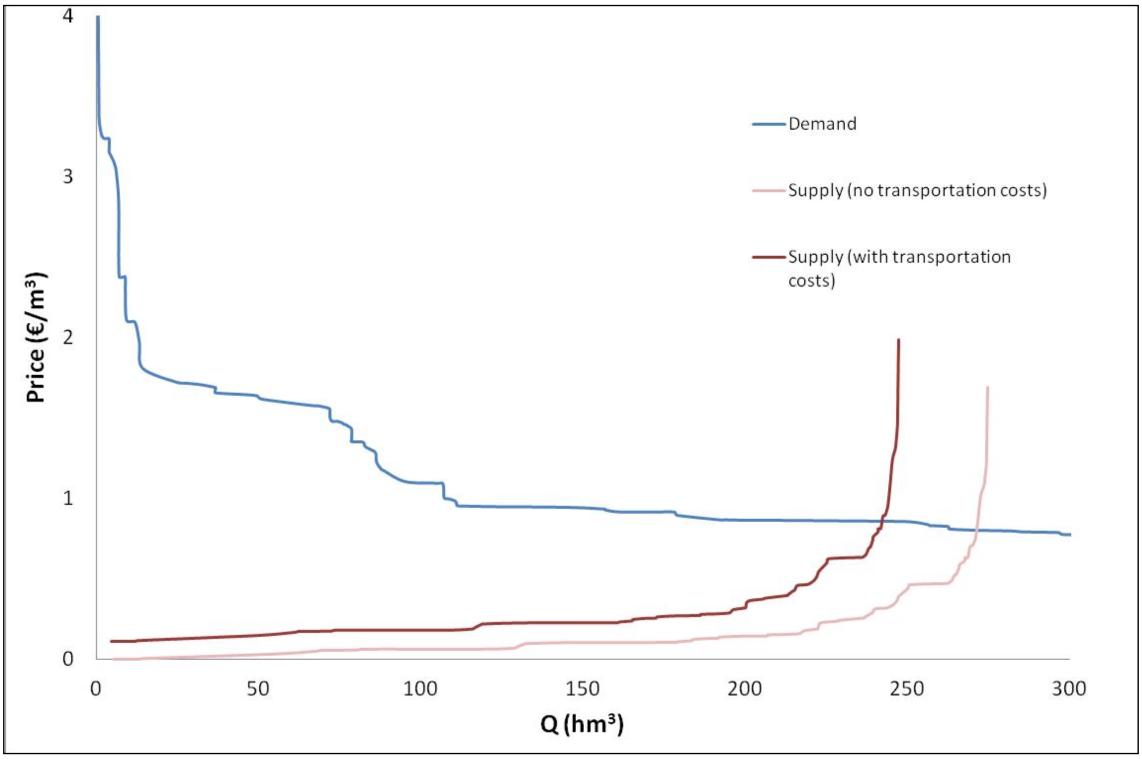
Table 5.5. Potential for water markets and income variability (TRB and SRB)

TRB Agricultural District/Variable	*Gross Margin*	*Standard Deviation*	*Standard Dev. (% of Gross Margin)*
Lozoya y Somosierra	933.1301561	52.60917499	5.64%
Área Metropolitana de Madrid	637.4626655	27.63470416	4.34%
Campiña	576.5913718	26.8561077	4.66%
Vegas	1368.222446	51.63776068	3.77%
Alcarria	659.9760032	22.62828597	3.43%
Serranía Media	435.2368487	62.39946369	14.34%
Campiña	800.9282342	51.2970032	6.40%
Sierra	930.4770215	46.29160108	4.98%
Alcarria Alta	846.1684166	46.46231338	5.49%
Molina de Aragón	421.8345528	25.41634989	6.03%
Alcarria Baja	656.8012819	20.54046945	3.13%
Sur-Occidental	373.5147269	129.9868658	34.80%
Torrijos	507.645917	179.3875049	35.34%
Sagra-Toledo	743.3472651	55.93768454	7.53%
La Jara	620.4041162	74.3388198	11.98%
La Mancha	2131.364431	493.5353738	23.16%

SRB Agricultural District/Variable	*Gross Margin*	*Standard Deviation*	*Standard Dev. (% of Gross Margin)*
Sierra Segura	1620.641479	328.9164021	20.30%
Hellín	611.2140933	255.7818196	41.85%
Vinalopó	693.2616484	296.0439814	42.70%
Meridional	3431.351966	316.239065	9.22%
Nordeste	2795.976772	179.0038606	6.40%
Campo de Cartagena	5513.459331	305.4642384	5.54%
Noroeste	1869.176296	332.681858	17.80%
Centro	3719.413585	418.003498	11.24%
Río Segura	4904.293267	351.0465563	7.16%
Suroeste-Valle Guadalentí	3602.125941	407.6655353	11.32%
Vélez	1552.393492	138.1463201	8.90%
Bajo Almanzora	5418.540949	274.9256857	5.07%

Source: Own elaboration from MARM (2009)

Figure 5-7. Water supply and demand in an inter-basin water market and the role of operational costs



Source: Own elaboration from MARM (2009)

However, the previous analysis also considers market opportunities that might fall in the best interest of the parties involved in trading. Nonetheless, from a social perspective the key question to be solved is what is in the best interest of contracting parties is also in the best interest of all the potential people affected by the spatial reallocation of water.

Experience with water trading shows that finding the answer to this question is challenging as it requires knowledge of all the likely effects and their welfare outcomes over the so called third parties. Reviewing the existing experiences with water trading would serve only to ratify that these effects have not been always taken into account. Rather, they are often ignored (along the environmental impacts of water use right trades).

It is also well known that although all water rights are legally defined, norms don't have a full picture of all the possible contingencies and all the ways decisions over water use and diversion might affect others' opportunities and all the environmental services potentially provided by the water ecosystems along the entire river basin[22].

[22] In the absence of convincing information of third party effects the changes observed in the river basin might plausibly be attributed to the decision to transfer water (this is, for example, what happened with the severe reduction in base flows in Ciudad Real at the time when a transfer to the Segura was allowed in...). This possibility, along with the conviction that the government where not completely committed to avoid the negative consequences of the transfer (as

None of these problems (be it transport cost or he potential third-party effects) are important when water is traded on a local basis among users of the same kind, as it might happen when all farmers within the same irrigation district negotiate the individual rights received so that the more productive ones can get a higher proportion of water instead of the quota given by the water authority. This guarantees a better allocation of the overall water available without transactions being conditioned by significant transport costs or any relevant third party effects.

Experience shows that although water trading (rather than water use right trading) is not expressly permitted farmers are willing to engage spontaneously in such kind of bargain (Estevan and Lacalle, 2007; WWF, 2006). Evidence does exist that informal water markets may be trading substantial amounts of water in the Segura every year (Hernández-Mora and De Stéfano, 2013). Since these transactions are uncontrolled, illegal trading might be putting in the market water resources in excess of allowed quotas and this might be one of the emerging factors driving overexploitation of groundwater.

If this is the case, water trading might be based on the capacity of some farmers to obtain additional (ground) water in excess of what they are permitted to use, instead of in their willingness to use smaller amounts of water than those specified in their water entitlements.

Informal water transactions in the SRB may be trading significant amounts of water at the highest prices in Spain: evidence collected by Hernández-Mora and De Stefano (*ibid.*) shows that water prices during drought events hit 0.70 €/m^3 in the agricultural district of Campo de Cartagena (SRB).

This analytical approach to the opportunities of water trading consists in identifying the maximum amount of water that can be traded in a scenario where only the financial interest of the trading parties is considered (Figure 5-7).

Following a similar reasoning one can also build an extremely conservative scenario to consider the maximum water that might be traded if any possible provision to avoid detrimental environmental impacts or third-party effects.

This case occurs when potential sellers of water cede all their water use right but all the physical returns to the environment (whatever its form) remain in the area and only depletion (instead of water use) can be transferred.

With data available from our simulation models it is easy to perform such kind of analysis (see Figure 5-8). The reduction in water use that would need to be taken to allow one unit of depletion to be transferred would depend on the technical efficiency with which water is used in the ceding basin and, in economic terms, this will result in an increase in the cost of the water effectively transferred. The effect of taking this kind of caveats over water costs will be higher the lower the technical efficiency.

The average technical efficiency in the agricultural areas of the TRB connected to the water transfer is estimated at 39.9%, meaning that 60.1% of the water is "lost" and either returns to the

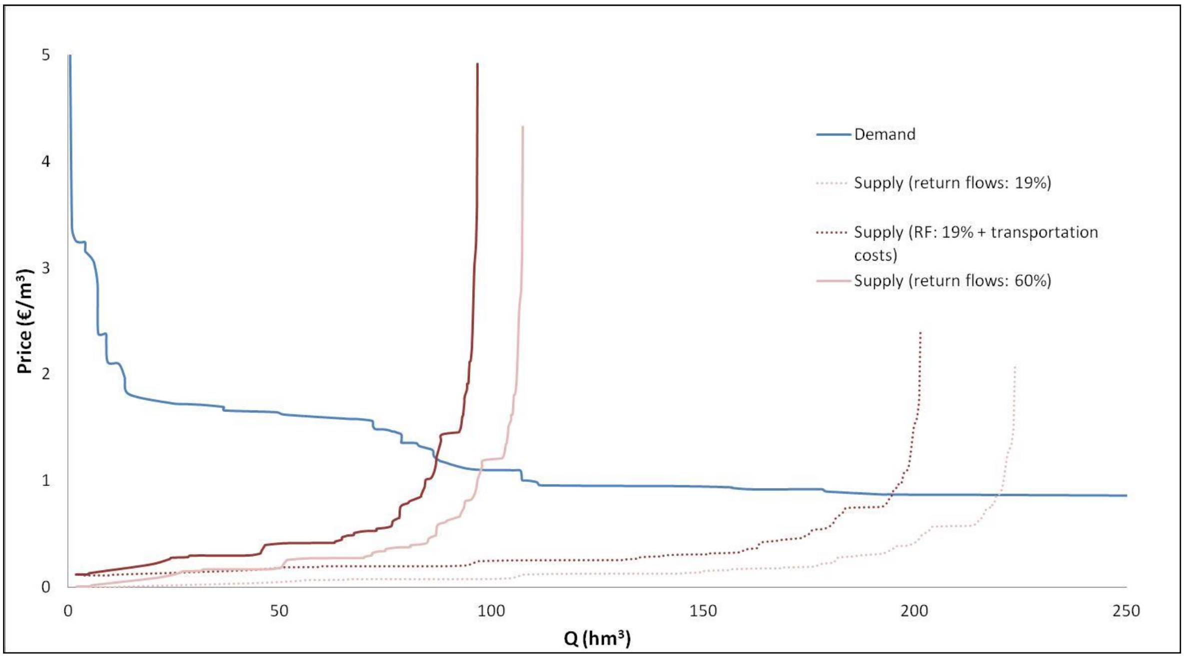
they may make reaching an agreement less likely) might live longer in the collective memory and result in a serious drag to make water transfer socially acceptable in the future.

watercourse or evaporates. The TRBA estimates return flows at 19% (TRBA, 2010). However, water trading is carried out on the basis of water entitlements, which include the actual water consumption at a plot level and these water "losses".

Under these conditions, water trading ends up reducing water flows and aquifer seepage in the TRB and may limit water availability for other consumptive uses downstream. An environmentally neutral water market needs to anticipate these effects so that water trading does not have any impact over the environment. Including return flows into the equation reduces the amount of water delivered at destination (SRB) as compared to the water bought in the TRB, increasing water costs as well.

Considering the 19% return flows estimated by the TRBA, the potential for water trading would be reduced by 19.6% (from 240 to 193 hm³/year), while prices would be 3.7% higher. If we consider a maximum guarantee scenario in which return flows are 60% (precautionary principle), water trading potential would fall by 65% (to 84.5 hm³/year) and water prices would rise more than 40%.

Figure 5-8. Focus on the environment: water trading in environmentally neutral markets



Source: Own elaboration from MARM (2009)

This analysis has important consequences over the possibility of opening the option to trade with water as an incentive to enhance water efficiency. In fact the water saved by installing more efficient devices (such as modern irrigation systems) might reduce water use but will not result in reduced depletion, which at best will remain constant. If the number of tradable water rights issued after a user (e.g. a farmer) proves to have upgraded the technology she uses are equal to the (actual or presumed) reduction in water use this might be an effective way to put more water into the market.

But if the criterion to issue tradable water rights is the change in depletion then efficiency will never be a means to put more water into trade. This is but one example of how the criteria of expanding water trade as much as possible might be in contradiction with the criteria of guaranteeing that any water transaction should have at least a neutral effect over the water environment.

6 Making it happen – Transaction costs of adapting institutions to enable EPIs and make them effective, implementable and politically acceptable

6.1 The EPIs’ ex-ante assessment and design: a transaction-cost perspective

The previous chapter presented the three economic policy instruments with the higher potential to make a significant contribution to curb water scarcity down, to reduce exposure and to increase drought resilience. In this chapter we will go one step further and try to understand the EPIs as part of an overall change in the institutions governing water.

For that purpose, we make the connection between the assessed EPIs and the institutional set-up under which they are expected to operate and deliver results.

This analysis is important for the following reasons:

- On the one hand, it creates conditions to analyse the current institutional setting in order to discuss whether the enabling conditions required are already in place or the existing institutional framework needs to be modified somehow to make EPIs implementable and to enhance their effectiveness. In this section we don´t take institutions as given and unalterable but rather as something that, under certain limits, need to be adapted.
- Yet, not only the institutional set-up needs to be modified to pave the way to enabling conditions required for EPIs implementation but also EPIs themselves need to be improved in their design so as to enhance their effectiveness and to reduce their implementation costs.
- The institutional change required and the potential effectiveness of the proposed EPIs are also critically dependent on its social acceptability which, for the sake of this analysis depends of the shared perception that the change represents a real break up with respect to current practice: the instruments proposed might deliver the expected environmental outcomes within affordable costs and in an equitable manner.

In line with the recent advances in the analysis and discussion of water policy reform we follow a transaction-cost perspective (Ostrom, 1990, Krutilla and Krause, 2010; McCann and Easter, 2004; Easter and McCann, 2010, Garrick *et.al*. 2013). One basic idea is that water policy reform will only occur when its transaction costs are lower than the opportunity cost – or foregone benefits – of maintaining the *status quo* (Saleth and Dinar, 1999).

As below, walking on the current path in water use scarcity will worsen the risk of drought. Current trends can explain how water becomes more valuable with scarcity and users are willing to accept paying higher prices. At the same time security becomes more important and charging higher prices in exchange of a more secure water supply is more likely as long as water users are willing to find alternatives to secure their incomes (e.g. by insuring against water shortages). In parallel, the cost of misallocating water appears as more evident and permitting water trading might become an acceptable and promising adaptation alternative. All these processes are factors enabling institutional change.

The analysis is based upon the idea that institutional change is driven by efficiency (Garrick *et al.*, 2013) but this process is far from being automatic, not even a smooth one. The change needs to overcome important barriers such as the vested interest of some important water users (asking for instance for public support to face their financial problems rather than to improve water governance and making a sustainable use of available water resources). Along the same line, the political contest, driven for instance by regional identities or environmental concerns, might also inhibit the setting up of the kind of efficiency-enhancing institutional change proposed in EPI-Water project (McCann *et al*, 2005).

The solutions proposed to face water policy challenges in the Segura and the Tagus involve significant transaction and transformation costs. However, in comparison to traditional infrastructure-driven alternatives, the choices proposed are not intensive in transformation cost (of fixed capital, operation and maintenance) but rather on transaction costs (including information, bargaining, monitoring, enforcement, etc.) (Williamson, 2000; North, 1990, 1994; and Ostrom, 1990).

In this report we consider the basic typology of transaction costs of collective action suggested by Marshall (2005, 2013) as adapted to water policy reform by Garrick (2013). Transaction costs can be grouped in the following three categories (see Table 6.1):

- *Static transaction cost* for water-related EPIs within the existing institutional framework. This cost basically includes the implementation costs of the three instruments, the support and administration of them, and compliance, monitoring and enforcement costs.
- *Institutional transition cost* linked to the institutional changes required, for instance, to enable water trading, allowing new elements in the water pricing system or the emergence of new kinds of insurance provided by the financial sector. The reform may include setting a cap and the conditions under which trading is allowed, the precise definition of the property rights that can potentially be traded, the setting up of price formation mechanisms (tenders, auctions, etc.) and the construction of new facilities designed *ad hoc* for water trades, as well as the transformation of the rules governing the use of existing infrastructures. In the case of pricing this might include the negotiation and agreement on the new rules to share the costs of water security, in particular between irrigators and households, and the revision of the prevailing hierarchy of uses. As per insurance it includes the creation of new insurance alternatives, agreements required to create a workable re-insurance system and the set up of responsibilities and duties of water users that would make the insurance system effective to discourage depleting practices.

Table 6.1. Transaction costs typologies: categories in collective action, environmental policy analysis and water markets

Collective action	Environmental policy	Water markets
Institutional transition costs	Research and information	• River basin development, planning and closure (cap) • Hydrologic and socioeconomic studies
	Enactment or litigation	• Water rights reform (adjudication, conflict resolution, rules) • Establish or reform water user associations
	Design and implementation	• Modification to storage and distribution • Licensing systems • Trading rules and registries • Price discovery (auctions/tenders/brokerages) • Water accounting system
Static transaction costs	Support and administration	• Transaction planning • Identification of buyers/sellers • Administrative review (e.g., injury analysis)
	Contracting	• Water rights due diligence
	Monitoring and detection	• Water use accounting
	Prosecution and enforcement	• Compliance monitoring and enforcement • Dispute resolution
Institutional transition costs	Adaptation or replacement	• Revise cap; adapt water rights and water user association rules; acquire water rights for the environment if cap is revised downward
Adapted from Marshall (2005, 2013-this issue)	Adapted from McCann et al. (2005), Marshall (2013-this issue)	Adapted from Garrick and Aylward (2012), McCann and Easter (2004)

Source: Garrick *et al.* (2013, p. 200)

- *Institutional lock-in costs* referring to "the additional costs imposed by current institutional choices on future efforts to reverse or alter water use patterns and infrastructures" (Garrick *et al.*, *op. cit.*). For instance, the introduction of a price mark-up to cover drinking water security might be challenged by the current rule guaranteeing urban water consumption as an absolute priority over all other uses. The implementation of a water-trading scheme might be eroded by the traditional overallocation of water use rights occurring in water scarce areas that requires setting a cap on the number of tradable rights that might not exceed the capacity of the water management system to provide them. In addition, the implementation of an insurance system might be influenced by the perception that it is redundant with the traditional loss coverage provided by the Government in dry periods.

Implementation of EPIs involves a trade-off between the different categories of transaction costs:

- For instance, when setting up water-trading schemes, savings can be realised by limiting monitoring actions just to the amounts of water delivered and received but not paying enough attention to the likely impacts of water reallocation over third parties (whose interest, for instance, is covered by the guarantee of uses as described in the RBMPs). These effects, though, cannot generally be predicted. Not only income and employment opportunities in the water exporting areas can be reduced but also effects over return flows, infiltration and other hydrological processes may entail significant environmental impacts, particularly in dry periods and in water scarce basins. Uncertainty about these effects may lead to the perception that public interest is not being adequately protected and that authorities are giving priority to the interest just of the trading parties instead. Not having any clear gain and facing an uncertain prospect, aversion to losses might dominate the social perception of water markets and make the institutional transition cost even higher. This actually has the potential of creating an institutional lock-in (forcing water trading to operate only at local scales, only in exceptionally dry periods and with high transaction costs), as it was evidenced in our stakeholder process, as reported to the EC.
- Similarly, some authors have emphasized how saving in institutional costs associated to setting up the water-trading policy framework (i.e. cap and trade) might rise static transaction costs if rights or trading rules are unclear (Garrick *et al.*, 2013). Many concerns about the potential contribution of water trading are associated with current proposals of allowing water trades in an institutional set up where most of the water resources that are being or can be potentially used are not under the control of the water authority. Under these conditions it is not impossible to have environmentally neutral transactions but the monitoring and enforcement cost of guaranteeing that markets are not putting more water into use might be unaffordable for the water authority.
- Similarly institutional lock-in may increase if property rights are defined in a way that reduces the flexibility to adapt to changing environmental preferences of rainfall variability (Challen, 2000; Young and McColl, 2009). Unbundling water property rights from land property may lead to this kind of situations as expressed in stakeholder consultation meetings jeopardising the required institutional change.

– Alike, saving in institutional set-up costs of the drought insurance system (which implies monitoring yields and income losses before issuing a damage indemnity) might erode the effectiveness of the insurance system itself, as farmers may want to protect themselves by obtaining water from uncontrolled sources while receiving the compensation for drought. This will likely be the case unless a complex monitoring system is put in place (e.g. to control all groundwater wells) incurring in high static transaction costs.

Interactions between direct, institutional transition and institutional lock-in costs in incentive-oriented water policy reform need to be taken explicitly into account when assessing the alternative strategies and courses of action. In other words, the *ex-ante* assessment of the alternatives to implement EPIs not only requires a cautious consideration of direct (transaction) costs but also a thorough analysis of the sequence and alternatives to promote the institutional change with the better potential to enable the implementation of the proposed policies and to reduce its direct transaction costs while avoiding or minimizing the costs of institutional lock-in.

Summing up, different from traditional water policy alternatives that are intensive in infrastructures and direct costs, EPIs belong to a class of water management options which cost effectiveness can only be obtained by:

– Improving its design (in order to reduce the direct transaction costs while delivering effectively).

– Identifying and sequencing its implementation strategy (in order to minimize institutional transition costs).

– Designing the better strategies to minimize the burden of institutional lock-in so as to improve the implementability of the instruments as well as its social and political acceptability.

In addition to that, synergies within a set of instruments (such as the ones proposed in this case study) can be exploited in the design phase in order to improve a joint contribution to cope with overall water policy challenges.

Four strategies can then be followed to enhance the (overall) cost-effectiveness of EPIs: improved design of each particular instrument in order to minimize direct transaction costs, sequencing its implementation, coupling it with the overall water management reform as a way to reduce the institutional transition cost, finding the best strategy to overcome institutional lock-in so as to avoid negative path-dependency trends and, finally, packaging different instruments to take advantage of their mutually reinforcing effects.

In what follows we summarise the EPIs proposed from the viewpoint of each of these four perspectives.

6.2 Improved design to reduce direct transaction costs

Outcome-oriented pricing schemes such as the proposed in this case study need to be tuned up along its implementation in order to guarantee the proper coordination of the intended objectives. Security mark-ups in both drinking and irrigation water must insure buffer stocks in the short term, through guaranteeing the financial sustainability of non-conventional water. At the same time this might allow excess supply of non-conventional water available in non-dry periods to replace over-depleted groundwater sources, which means making prices competitive and providing guarantee in such a way that farmers would voluntarily renounce to groundwater and the water authority might save monitoring and enforcement costs.

Besides providing water security for dry periods the pricing scheme must be seen as an instrument towards matching water demand and long-term renewable supply as well as towards a more efficient way to ensure this water supply in the long term. Besides making non-conventional water available, the pricing scheme to promote this transition might include a variety of pricing delivery mechanisms such as performance-oriented subsidies (demonstrated improvements in water tables might be compensated by guaranteed access to alternative resources), payment for environmental services (linking water policy with rural development objectives), etc. Alternative pricing schemes, including subsidies, payment for environ. In a similar sense, outcome-oriented prices allow for on-going assessment and monitoring, providing the information required to adapting the entire scheme.

Drought insurance design would also need to be adapted to guarantee its implementability within the range of an acceptable transaction cost. Drought risks are almost perfectly correlated both among farmers and river and irrigation districts and this correlation is high among river basins. Although reinsurance systems do exist in the private sector this may imply and important increase in risk premiums with important consequences over both the number of farmers and the risks covered by the insurance. There is room for public intervention to back up the system against systemic risk, as demonstrated by other agricultural insurance in place. Moreover the objective of public support must consist in guaranteeing positive net revenues can compensate the functioning of the system in the long term, such as losses in dry years in the normal ones, and not in subsidizing the insurance or in assuming public costs that need to be covered by the financial system.

Dealing with moral risk and adverse selection is easier the larger is the proportion of farmers covered by the insurance system. To be effective the insurance must cover the farmers exposed to drought risks but most importantly it must also cover those farmers with the ability to protect themselves (e.g. by using groundwater). Hence, to avoid insured farmers selling water to uninsured neighbours in dry periods, all farmers in the same area must be under the same insurance system. These objectives can be simultaneously obtained by a careful design of the insurance system and besides guaranteeing the efficiency of the scheme will result in substantial reductions in monitoring and enforcement costs.

6.3 Sequencing to minimize institutional transition costs

No one of the instruments proposed in this study can be implemented without some important changes in the regulations in place. Phasing up the legal reform and sequencing the setting up of the EPI might be the key to water reform success. As an example, there is no provision in the current financial legislation to put a price on the means chosen in this study to provide water supply security. When security is provided by additional infrastructures cost recovery provisions are enough to finance the system but this is not sufficient to finance alternative security means such as demand management, maintaining excess capacity or promoting the recovery of groundwater bodies. Promoting good practices and substitution of water sources also needs a stepwise approach in order to gain broad political and social support. Some small-scale demonstration projects would help demonstrate that expected benefits in avoiding overexploitation are for real and not just another alibi for rent seeking.

Furthermore, starting in some properly chosen locations and gradually extending the system as "learning by doing" can gradually increase the value of the insurance system and its effectiveness and foster network economies to make the option affordable to other crops and areas. Experience shows that the best candidates are those areas where farmers have fewer options to change decisions in dry periods, with ligneous rather temporary crops, profits and then WTP for water security are higher, as in the many parts of the SRB, and groundwater sources are already over exploited, so that the demand for outside insurance is higher. Success in this scenario may be the key to demonstrate how the drought insurance may be in the best interest of farmers and might also work to allow the recovery of water sources.

6.4 Dealing with lock-in in order to gain social and political acceptability

The state of the art documents how past institutional choices influence strongly the cost of changing institutions and the technologies adopted under the existing institutional frameworks. The original works of Douglas North (1950) have been extended to the discussion of environmental governance (McCann *et al*., 2005) and more recently to water management (Garrick *et al*, 2013).

The implicit risk of allowing water trading has been repeatedly highlighted. For example, Heinmiller (2009) demonstrated how the once for all allocation of water use rights (following apportionment rules) decided early in the Murray-Darling (Australia), The Colorado (USA) and the Saskatchewan-Nelson (Canada) is now the main constrain that needs to be overcome in adapting water governance to give a greater priority to environmental objectives. The same have happened in Chile (Donoso and Just, 2011) and some authors (Marshall, 2009 and 2011) goes back to the nineteen century to date the institutional choices that organized the vested interest propelling infrastructure development as the preferred option to irrigation salinity problems in the Murray- Darling in spite of the availability of more effective soft options such as re-vegetation of the catchment. An important element in this discussion is the still remaining preference for paternalistic approaches to enhance irrigation systems or improve farming practices in spite of the severe fiscal constraints and the limited resources available to subsidize new infrastructures or behavioural changes (Marshall, 2013).

The implementation of water pricing schemes needs to overcome the current institutional set up that distribute drought risk asymmetrically among urban uses (with the high priority of supply) and other uses (such as irrigation which play the role of buffer stocks). Droughts are associated with the perception that risk-bearing distribution is unfair and, under this context, droughts have more severe impacts on the rural sector, and the agro-food industry, and may result in additional social conflict. Under the present distribution of risk paying for buffer stocks to cope with droughts in the short term and to allow water security in the long term seems unfeasible as additional costs are not affordable without substantial losses in production and employment while, as shown in this study, all this will become relatively easy to implement by reforming urban water pricing.

Almost by definition innovative policy instruments require innovative implementation. Social acceptability obviously depends on political will and on the ability of the political system to create a common perception of the problems and to deliver convincing arguments in support of the solutions at hand. But in the end only instruments that work are socially acceptable and the careful implementation of the insurance system is the key to induce further progress towards less scarce areas, temporary crops and all this will allow building the information (and decision-support) systems, the expertise and the business networks that will pave the way for a meaningful and better social acceptance of the scheme.

As to water trading, they are associated with a major risk of lock-in. Decentralization of property rights would reduce quasi-option values and thus increase institutional lock-in costs (Challen, 2000). The concentration of property rights from smaller groups (small farmers) to larger groups (e.g. the State) can also increase quasi-option values and thus reduce institutional lock-in costs. The basic point is that, if change in the property right distribution is considered an important element of adapting governance, then option values and lock-in costs are higher the more decentralized the distribution of property rights is (Cundill and Fabricius, 2010).

6.5 Packaging EPIs: taking advantage of synergies between EPIs

The effectiveness of pricing and water trading are linked to each other. None of the instruments proposed alone represents a workable solution to any water policy challenge. The actual effectiveness of each instrument depends on the proper implementation of more than one.

- This is precisely why trading and pricing schemes are not alternative responses to the same problem but mutually reinforcing EPIs. Synergies between both instruments do exist for good, as both instruments reinforce each other’s effectiveness, but also for bad as one instrument (trading) might erode the potential of the other.
- On one side, it seems that the potential of water trading to make a relevant contribution to reduce scarcity and perform as an adaptive mechanism relies on the promise of water trading to reveal the scarcity price of water. Through its spontaneous and decentralized way of setting prices, bargaining with water might become a powerful mechanism to show how water is valuable in its marginal uses and how far potential users are willing to pay before abandoning such a valuable but scarce production factor. Markets do have an important virtue that governments lack or cannot have without paying substantial transaction costs (including the cost of information): setting the scarcity cost of a given supply of water available for its use in the economy.

Box 6.1. Limits to water reuse

If the reuse industry were not already operating close to the limits permitted under the prevailing Spanish water reuse law, the pricing system would also be an important element explaining the scope of water trading.

Were Spanish authorities to follow the European Commission's advice by controlling illegal abstractions and applying full cost recovery pricing, an effective market for regenerated wastewater for irrigation would instantly become more realistic.

Water from the Tagus-Segura pipeline, for example, currently costs just 0.12 €/m^3, a price that fails to reflect the transmission infrastructure's capital, operational and environmental costs. At an estimated price of 0.40 €/m^3, wastewater reuse is expensive as compared with subsidized pipeline water or illegal abstractions, but cheap if compared to an estimated 1 €/m^3 for desalinated water.

Source: Paying the price for reuse in Spain (GWI, 2012)

Under this premise, water trading can become a powerful instrument to make pricing more effective.

- The higher the scarcity costs the higher the potential for sustainable alternatives available to match water demand and supply.
- The ability of water trading to put scarcity a price might result in some important positive effects that enhance the potential of the pricing system to respond to the existing water management challenges.
- For instance, the scarcity cost of water in the market might become a real opportunity to put into use non-conventional resources and make its provision financially sustainable in the long term. It may also serve to promote water recycling and the use of regenerated water instead of traded water and, in general, it can make water efficiency improvements attractive for many users in the economy.
- The potential of water trading to contribute to its primary objective of increasing water security will be reinforced through these forward linkages resulting from the adequate functioning of water trading.

Nevertheless, for many reasons water markets can also fail in (rightly) pricing water scarcity. Experience with water trading in Spain and elsewhere shows that current water markets might also perform differently than expected from competitive and well-functioning markets.

- At the end the scarcity price of water might be hidden by implicit subsidies to users that might have the option of selling the freshwater received from the Government (as it is the case when water authorities provide water services at less than full cost recovery prices). Explicit subsidies, where existing, will also result in actual prices that are lower than the real opportunity cost of water; this will happen when the Government acting as facilitator of water trading provides infrastructures for free or subsidizes the transport cost (i.e. the transfer fee in the TSWT).
- Another important reason why water trading might fail in finding the scarcity cost of water is because water trading in practice might go beyond allocating available water to its more valuable uses and, as experiences in Spain and other countries show, might also serve to

mobilize water that might have not been used otherwise without the option to buy and sell water. If this happens water trading will add to current distortions that impede prices to reveal the real scarcity of water. Apart from increasing scarcity (instead or reducing it), prices resulting for these water-trading schemes will result in lower prices and weaker incentives to go ahead with.

Synergies between EPIs are reciprocal or two-way.

- As above, water trading might fail in pricing water scarcity and this will undermine the potential of prices to improve water security.
- But when pricing fails to reflect all water costs (including not only financial costs – capital and operational costs – but also the environmental costs incurred in the provision of water) the water market potential might remain underdeveloped. Subsidized resources provided by the water authority and "self-service" groundwater might remain the preferred option instead of expensive alternatives of buying reused or desalinated water from the own basin or freshwater from abroad.
- It is not difficult to imagine a situation in which trading is only made possible with water which costs have been fully recovered so that this kind of pricey water is reserved only for exceptionally dry situations and the potential effect of markets will remain untapped.

In other words, without improvements in the way water is priced everywhere in the river basin even a well-designed market, able to price water being traded at its scarcity price, would not led to a substantial reallocation of water to its more beneficial uses. Any improvement in the pricing system will enhance the potential of water trading to attain the collective aims of water policy.

As discussed earlier in this chapter, these improvements might stem from bridging the gap between the current (financial) price and the real opportunity (economic) cost of water.

Nonetheless, rather than asking for an increase in water prices, the analysis asks for rebalancing the relative prices of water from different sources so as to reflect its particular economic cost. For the case of resources that are actually being underpriced this is equivalent to recovering capital and operational costs as well as internalizing environmental and resource costs.

- Both surface and groundwater are underpriced: the former because of the government failure to price it by its cost; the latter because of the absence of any mechanism to internalize its scarcity cost (at least while the resource is under the control of its individual users).
- The same line of reasoning would lead us to the conclusion that the so-called non-conventional sources are overpriced. In other words, contrary to freshwater, its financial cost is higher than its economic cost.
- Hence, the correct way to rebalance the water price from different water sources consists in adding to the price of freshwater the environmental costs and the scarcity cost, and in deducting from the cost of non-conventional sources the avoided scarcity costs of using it instead of freshwater sources.

Progress in this direction is the result of a combination of instruments (and not only from pricing). The following three examples convey how the combination of instruments (insurance, pricing and trading) plays a critical role in rebalancing the relative prices of water:

- For instance, any improvement in bridging the gap between abstraction costs and real economic costs of groundwater can only come after putting this source under some kind of collective control able to monitor its status and control its use.
- Regarding surface water, even after financial costs are fully recovered, the main instrument to include scarcity costs is not a price itself but water trading which, if properly designed and implemented, will help reveal the opportunity cost of water in their best alternative uses.
- Finally, as explained in the previous chapter, we propose to put a price premium on all sources of freshwater under the control of the water authority in order to share the cost of infrastructures required for the more valuable users to have a buffer stock of water in dry periods. In practice, this means increasing the price of surface water (in exchange of increasing its guarantee) but also reducing the price of non-conventional water for its use in normal (non-dry periods).

An alternative way of looking at the importance of the package of incentives is through considering the risks associated to implementing just one instrument and ignoring the other two.

- Without proper pricing practices the scope for the market will be strictly reduced to situations where water is so valuable that it will only be traded in severe to extreme droughts and the room will be reduced for using markets as a means to cope with structural water shortages, if remaining at all.
- Without a proper enforcement of groundwater property rights avoiding market incentives to stimulate over-abstraction would become a difficult when not an impossible task. In fact, water trading might help put more groundwater into use after, for instance, some farmers sell out the surface water allocated to them by the Government and using groundwater in its stead.
- Last but not least, price increases required to share the costs of providing water security, when property rights are not properly defined and enforced, may enhance incentives to obtain water illegally and, as analysed in this report, might drop water tables down before non-controlled abstractions become unprofitable.

7 Synthesis of conclusions and policy recommendations

As evidenced not just in this *ex-ante* case study but also in the *EPI-Water* project as a whole, little is known about the impact of economic policy instruments for sustainable water management. There are reasonable doubts as to how they may be effectively introduced In the first place is not much is known about their design and potential impacts, for example. In addition, the scope of this research project aims to convey the idea that analyses of possible policy choices (i.e. the link of specific economic incentives to tackle critical water policy challenges), on the basis of rational criteria will inevitably lead to better-informed decisions. Ill-informed policy choices will always have unpredictable costs.

What this case study shows is that traditional policy responses to mitigate structural water scarcity and to reduce drought risk, thus increasing the resilience of the economy to react to these extreme events and policy challenges, not only have failed to provide (overall) an adequate solution; sometimes they have even brought unwanted results.

When judged separately and according to their intended technical objectives, each of the responses to water problems in the Tagus and Segura river basin districts can be said to have been a clear success. The Spanish river basin authorities are a good yardstick worldwide in many particular dimensions. Infrastructures do exist and allow for a flexible adaptation of water supply; systems in place and available skills to transport, distribute and apply water, both in urban and rural uses, are amongst are quite efficient; non-conventional water sources might provide significant and reliable water services and drought management practices have completed the transition from preceding reactive, discretionary and emergency responses to droughts to a new anticipated, contingent and planned response to water risks.

Nonetheless, as part of an overall water management strategy these measures have not resulted in a real contribution to curb down the existing negative trends towards increased scarcity and higher drought risk (and might have even contributed to reinforce them).

One basic reason behind this water governance *fiasco* is the lack of an explicit and *ad-hoc* strategy to manage standing incentives behind water demand and supply and in particular to adapt all individual decisions to collective water policy objectives, as defined by the EU Water Framework Directive and other daughter directives or ulterior policy developments.

Despite a number of opportunities what is rational for water users differs from what is sustainable from a collective perspective. Rational individual decisions may actually be leading to unsustainable outcomes, and there is in-detail evidence of that in this report. Hence, the set of EPIs proposed in this case study aim both at providing a new set of incentives, able to replace or correct prevailing ones, and to make the most out of available opportunities and technical and institutional strengths in place.

This report makes a strong case against those that see EPIs as ends rather than means of water policy. This report by no means defends a reduced role for governments in order to give leeway to markets and see synergies rather than contradictions between both of them.

Despite dealing with pricing issues, *inter alia*, the conclusions of this analysis should not lead to ask for getting the prices right because prices themselves are not right or wrong but effective or ineffective to deliver the desired objective. In addition, we explore the idea that markets can help in mitigating scarcity and managing drought without any pre-conceived idea about the superiority of markets.

Regarding public discussions our analysis suggests that the best way to push forward the role of EPIs in water management is probably through defending water prices and markets from their cheerleaders, through providing rational arguments to see the critical role EPIs may play (should be playing) but placing these instruments in the space they should fill in within water policy reform and not elsewhere.

Based on evidence we prefer to see EPIs as what they are: very insightful instruments rather than aims on their own and promising opportunities rather than panaceas.

Different policy-relevant issues have been discussed in this report: the need to link EPI design and implementation to the actual water policy challenges posed by scarcity and drought; the imperative to consider EPIs not in isolation but as part of just one set of economic incentives (i.e. packaging incentives); the complementarity of EPIs and other conventional policy instruments, which places attention where it should always be (i.e. the policy mix); the sequencing of water policy reforms; and the emphasis on synergies among the three water EPIs proposed and assessed: pricing schemes to guarantee water security, insurance mechanisms to prevent groundwater overexploitation, and water trading schemes.

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