EPI WATER

Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

WP3 EX-POST Case studies:
Water transfers in the Tagus River Basin (Spain)

Deliverable no.: D3.1 - Review reports
December 14th, 2011

Grant Agreement no. 265213
FP7 Environment (Including Climate Change)

Deliverable Title	D3.1 - Review reports
Filename	Tagus River Basin (Spain)
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Date	December 14th, 2011

Prepared under contract from the European Commission
Grant Agreement no. 265213
FP7 Environment (including Climate Change)

Start of the project:	01/01/2011
Duration:	36 months
Project coordinator organisation:	FEEM

Deliverable title:	Review reports
Deliverable no. :	D3.1

Due date of deliverable:	Month 11
Actual submission date:	Month 12

Dissemination level

X	PU	Public
	PP	Restricted to other programme participants (including the Commission Services)
	RE	Restricted to a group specified by the consortium (including the Commission Services)
	CO	Confidential, only for members of the consortium (including the Commission Services)

Deliverable status version control

Version	data	Author
1.0	November 15th, 2011	Carlos M. Gómez, Gonzalo Delacámara, Carlos D. Pérez, Estefanía Ibáñez, and Miguel Solanes (IMDEA)
1.1	November 21st, 2011	Carlos M. Gómez, Gonzalo Delacámara, Carlos D. Pérez, Estefanía Ibáñez, and Miguel Solanes (IMDEA)
1.2	December 5th, 2011	Carlos M. Gómez, Gonzalo Delacámara, Carlos D. Pérez, Estefanía Ibáñez, and Marta Rodríguez (IMDEA)
1.3	December 14th, 2011	Carlos M. Gómez, Gonzalo Delacámara, and Estefanía Ibáñez (IMDEA)

Executive Summary

Definition of the analysed EPI and purpose

This case study analyses the voluntary transfer of water use rights to guarantee drinking water security in the upper stretch of the Tagus River basin in Central Spain. The most significant and dynamic use of water in the entire Tagus river basin is represented by the demand of potable water in the Madrid metropolitan area including its sprawl eastwards, along the Henares River valley (water abstraction for water supply in Madrid accounted for 558.96 hm^3 in 2009; 55.5 hm^3 in municipalities supplied by the Sorbe Water Community). Two different experiences, corresponding to both water supply systems, are considered and compared. The former consists in the transfer from the irrigation areas of Alberche River to the Canal de Isabel II, the public water utility providing services in most of the Greater Madrid and its region. The latter consists of formal transfers from farmers in the Henares Canal to the Mancomunidad de Aguas del Sorbe (MAS) (Sorbe Water Community) to bridge the supply gap in the Henares valley.

Introduction

Population and economic activity in the Tagus River basin are concentrated in Madrid and Lisbon at both ends of the river basin. Scarcity problems are also more significant in the first of these ends. Although the quality of surface water is relatively good in the upper basin, only one tenth of rainfall (an average of 413.26 mm for the Henares corridor, in the 1953-2010 period, and an average of 1 300 mm for the Alberche river, in 1946-2010) and runoff is available to cope with more than two thirds of the demand for urban uses in the entire river basin. In clear contrast to that, the intermediate part of the Tagus River basin is dominated by the use of water for extensive agriculture. Yet, the availability of these resources is disputed by the more productive irrigated agriculture in the Segura River basin (SE Spain) close to the Mediterranean coastline and which is connected to the Tagus by a water transfer channel.

Since the mid 1970s, Madrid and its metropolitan area, to which the Henares valley belongs to, have been able to cope with a growing and more affluent population (1.5 million people increase within the last 15 years at an annual average rate of 2.04%) 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 any massive groundwater abstractions. Within the last three decades water management in Madrid provides a clear example of a progressive adaptation towards the more efficient use of infrastructures, together with incentives and pricing schemes designed to adjust water demand.

However, in the two decades before the current downturn, the mix of intense population growth, economic expansion, and rapid and extensive urban development pushed to the limit the capacity to manage an increasing water demand within the range of available resources and current water regulation infrastructures.

Legislative setting and economic background

Since the early 1990s, agreements to transfer water use rights from agriculture to urban uses appeared as an alternative to cope with the recurrent water supply deficit during a number of dry periods experienced since 1992 and this option gained social support and political acceptance since the costs of the best available alternatives already in place grew in the margin. In fact, efficiency in water treatment and distribution in Madrid is already above 80%; a high percentage of wastewater is currently being reused for gardening, street washing and to maintain environmental flows. In addition, the limited buffer groundwater stocks available (120 hm^3 of renewable resources) have only been used (when not strictly reserved) for extreme events (in drought years, abstraction can soar up to 149.7 hm^3). The construction of new infrastructures or tackling resources downstream in the Tagus has been ruled out because of its economic and political cost.

This is the context where pioneer agreements to transfer water between water utilities and irrigation districts sprung up for the first time in Spain. These were market agreements between the parties although actively supported by the water authority. Needless to say that in a drought-prone and water-scarce country as Spain, informal water transfers have always spontaneously occurred and even some important transfers have taken place amongst farmers. The exception in this case derives from the volume of trades, the parts involved in the bargaining process, the purpose of exchanges, and their importance to foster the adaptation of the institutional framework in order to allow for a wider use of water use right trades.

The first agreement considered in this case study took place in the summer of 1993 and actually involved two water transfers. To guarantee the flow of water to the Tagus in the Alberche River and subsequently the provision of drinking water to the city of Madrid (based on the public utility entitlements, 219.8 hm^3), irrigators in the Alberche accepted a water transfer from the middle Tagus (35 hm^3).

The second agreement took place in early 2002: a water right transfer (of 3 hm^3 during 2002 and 14 hm^3 during 2005-06) from the irrigators of the Henares Canal to provide water supply for domestic uses in the towns served by the MAS (of which Alcalá de Henares represents the most important one).

Both examples are connected with critical legal developments. After the severe drought of the hydrological year 2004-2005, the Spanish Government passed a decree (RDL 15/2005) including a number of urgent measures for the regulation of water right transactions to expand the scope for water markets as an economic policy instrument to prevent or tackle drought consequences. Yet, there was a previous record of legal measures to foster water markets in Spain, dating back to the drought of the early 1990s; that is actually the focus of this *ex post* assessment.

Brief description of results and impacts of the proposed EPI

Nowadays both transfers are deemed successful examples of drought adaptation. They fed up the process of institutional developments that have moderately boosted the use of voluntary transfers of water use rights as a water security mechanism avoiding other costly or politically challenging alternatives such as new water infrastructures or new expensive water sources.

Conclusions and lessons learnt

The emergence of water markets, as many other once innovative EPIs, is a gradual adaptive and learning-by-doing process that must be judged by its ability to push water institutional development rather than by the failure or success of the experience itself. The water transfer from the Alberche River although useful to manage the supply deficit in the 1990s would not be an alternative in 2011 anymore and many doubts exist as to the real prospect of repeating the 2002 water trade from the Henares Canal to the MAS in the same formal terms. The actual value of these examples is in the lessons that can be drawn and its importance to furthering agreements on reallocating water use rights as an instrument for water security.

Both examples also illustrate the critical importance of managing water use conflicts. It is well known in economic analysis that water management is essentially conflict management. In fact, according to the Spanish law, households have a priority over irrigators in water use, and there is no need for a voluntary agreement to take water away from farms in order to guarantee a sufficient supply of drinking water in dry periods. The real buffer for drinking water in Spain is the irrigated agriculture whose use rights are defined every year depending on the rainy season. Moreover, instead of just taking water or forcing farmers to let water flow, the agreement is easier to reach if alternative resources are available, the harvest is protected and third-party effects are avoided.

This is the real meaning of the 2002 transfer. The existence of these alternative resources is precisely what makes the replication of this trade almost impossible in 2011 (as there is evidence of overallocation or water rights in the middle Tagus river). Nevertheless, lessons learnt can be important to understand how, instead of paying for water, agreements might be easier to reach, in some cases, when alternative sources are provided to guarantee existing uses, particularly in irrigated agriculture. Nowadays, alternative resources can either come from re-used or desalinated water.

Water trading also faces some important challenges. Allowing transfers from agricultural to urban uses may bring to the negotiating table water resources that are not being effectively used. In fact, given the low quality of soil in the Madrid area, agriculture is a receding activity and in some areas water allowances are higher than the effective demand for irrigation water. Paradoxically, once subsidies from the Common Agricultural Policy have been phased out and agricultural markets have been liberalized, the irrigation sector in some areas may be in excess water supply. The fact that farmers in the Henares valley accepted to give their water up at a price lower than one eurocent per cubic meter is but an indication that probably those water resources were not being used for crops. Hence, water trading might not be a means to reduce water scarcity but rather to increase it and would not be instrumental to reallocate water but to effectively increase its use. This would be a real risk should water saved after the publicly supported shift towards more efficient irrigation systems, becomes part of the water trading system rather than being left in already degraded aquifers.

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List of Acronyms

AEMET: Met Office (Agencia Estatal de Meteorología)

BOE: Official State Bulletin

CAM: Madrid Regional Government

CHT: Confederación Hidrográfica del Tajo (Tagus River Basin Authority)

CLC: Corine Land Cover

CPI: Consumers price index

CYII: Canal de Isabel II public utility

EPI: Economic Policy Instrument

ETI: Scheme of Important Issues (previous step to a new hydrological plan) (Esquema de Temas Importantes)

GDP: Gross Domestic Product

GVA: Gross Value Added

INE: National Institute of Statistics

MARM: Ministry of Agriculture and Marine Affairs

MAS: Sorbe River Water Community (Mancomunidad de Aguas del Sorbe)

MMA: Ministry of the Environment

PIAM: Water comprehensive plan in Madrid Region (Plan Integral de Agua en la Comunidad de Madrid)

RBAs: River Basin Authorities

RD: Royal Decree

RDL: Royal Decree Law

TRBA: Tagus River Basin Authority (Confederación Hidrográfica del Tajo, CHT)

TRBD: Tagus River Basin District

TRLA: Consolidated Water Law (Texto Refundido de la Ley de Aguas)

Tagus Case Study

Transfer 1: Alberche Canal - CYII

1953 – Irrigation District of Lower Alberche Canal foundation
3 000 commoners and 4 municipalities
Nowadays:
75 hm^3/year of water demand for irrigation (water abstraction:75 hm^3; physical losses: 49.5 hm^3)
They do not hold water rights but they are beneficiaries of a public irrigation assignment
10 000 ha of irrigation land

1967 – Pumping stations of Picadas and Colmenar del Arroyo are built

Drought 1991-1992 to 1994-1995

1991 – Connection Las Parras stream – Lower Alberche Canal: infrastructure to provide water for irrigation from middle Tagus

Hydrological year 1993-94 – Reservoirs of Alberche system under 128 hm^3: of which **119.8 hm^3 were allocated for Madrid's supply**

January 15th, 1993 – The expansion of the connection between San Juan (Alberche) and Valmayor (CYII) is approved
Cost: 10 000 million pesetas (approx. 67 million ECU of 1993)

March 11th, 1993 – The Board of the Irrigation District of Lower Alberche river held a meeting to analyse solutions to provide water for irrigators

November 1993 – New connection between San Juan and Valmayor started working

1993 – Las Parras (middle Tagus) – Alberche connection starts working to guarantee the irrigation season
Capacity of the transfer: 75 hm^3
Flow rate: 5 m^3/s
Volume transferred: 35 hm^3
CYII paid 50 million pesetas (approx. 335 000 ECU of 1993) for the energy cost of pumping

Reduction of 23.1% in historical average rainfall. Regarding contributions, decrease of 78,5% (1991-92), 73.3% (1992-1993), 83.7% (1994-1995), and an average drop of 50.5% for the period

1996 – UNION FENOSA claims a payment of 1 000 million pesetas (6.7 million ECU of 1993) arguing lost profits

20 July 2001 – RD 1/2001 decree – approves the consolidated text of the Water Act (TRLA): Water transfer contracts (art. 67)

2004 - 2005 – Over-exploitation of Alberche River's resources: due to the lack of a formal previous agreement with the irrigators of the Alberche Canal to replace water from Alberche River with water from the Middle Tagus sub-basin hampered the correct operation of Las Parras-Alberche Canal connection

December 2005 – **RDL 15/2005 decree** including urgent measures for the regulation of water right transfers to expand the scope for water markets as an EPI to prevent drought consequences

2006 – CYII water rights from Alberche river are augmented in 100 hm^3 **(total rights 219.8 hm^3)**

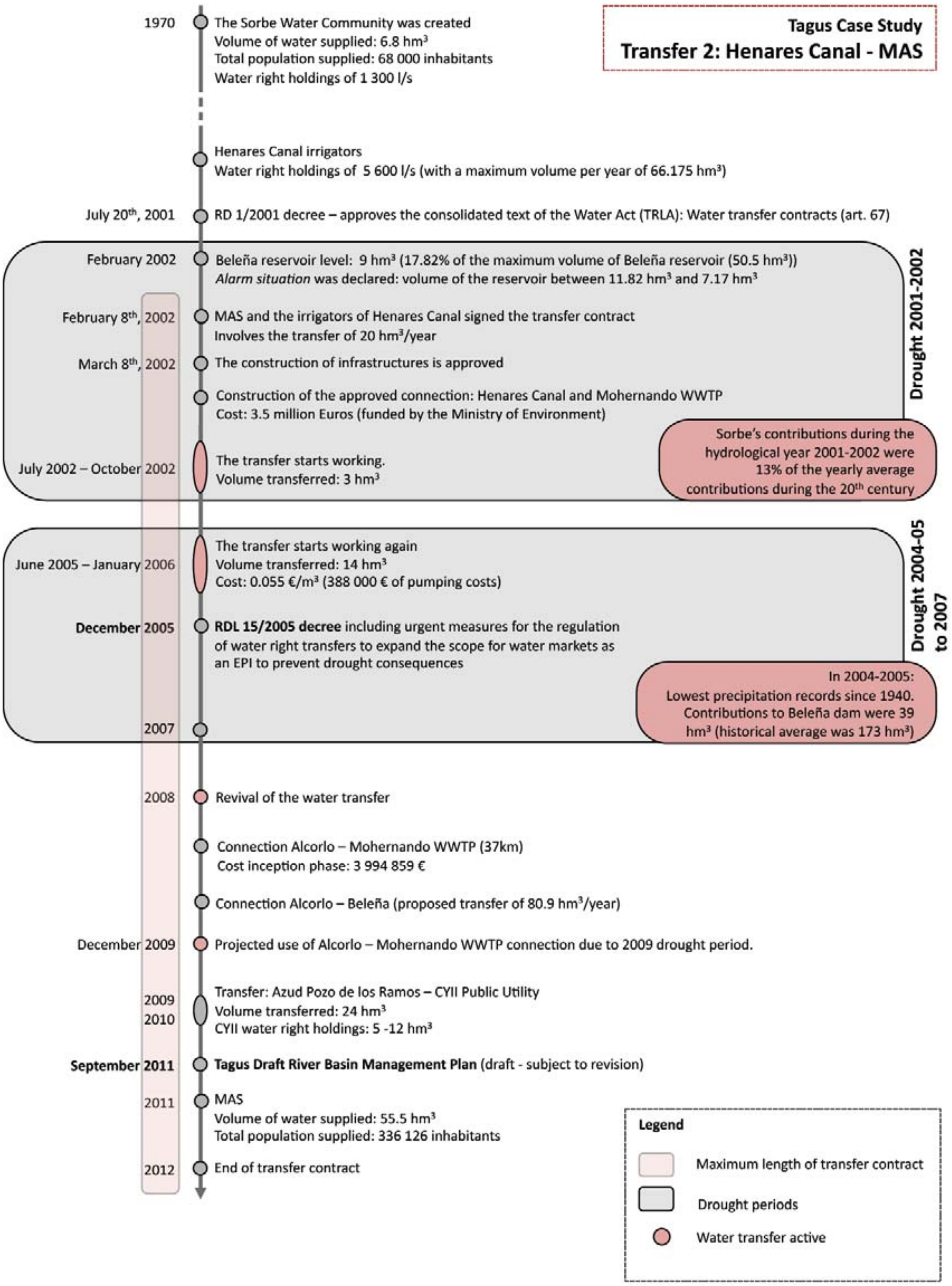
2006 – Increase in the capacity of the Las Parras – Canal de Alberche water transfer: up to 7 m^3/s
Cost: 2 million Euros

2008 – The transfer Las Parras-Alberche is used again due to water scarcity in Alberche river

December 2009 – Reactivation of Las Parras – Alberche connection due to the 2009 drought

September 2011 – **Tagus Draft River Basin Management Plan** (draft - subject to revision)

Legend
- Drought periods (grey box)
- Data related to water transfer between Alberche and CYII (pink circle)
- Data related to Las Parras Stream – Alberche transfer (grey circle)


Tagus Case Study
Transfer 2: Henares Canal - MAS
1970
The Sorbe Water Community was created
Volume of water supplied: 6.8 hm³
Total population supplied: 68 000 inhabitants
Water right holdings of 1 300 l/s
Henares Canal irrigators
Water right holdings of 5 600 l/s (with a maximum volume per year of 66.175 hm³)
July 20th, 2001
RD 1/2001 decree – approves the consolidated text of the Water Act (TRLA): Water transfer contracts (art. 67)
February 2002
Beleña reservoir level: 9 hm³ (17.82% of the maximum volume of Beleña reservoir (50.5 hm³))
Alarm situation was declared: volume of the reservoir between 11.82 hm³ and 7.17 hm³
February 8th, 2002
MAS and the irrigators of Henares Canal signed the transfer contract
Involves the transfer of 20 hm³/year
March 8th, 2002
The construction of infrastructures is approved
Construction of the approved connection: Henares Canal and Mohernando WWTP
Cost: 3.5 million Euros (funded by the Ministry of Environment)
July 2002 – October 2002
The transfer starts working.
Volume transferred: 3 hm³
Sorbe's contributions during the hydrological year 2001-2002 were 13% of the yearly average contributions during the 20th century
Drought 2001-2002
June 2005 – January 2006
The transfer starts working again
Volume transferred: 14 hm³
Cost: 0.055 €/m³ (388 000 € of pumping costs)
December 2005
RDL 15/2005 decree including urgent measures for the regulation of water right transfers to expand the scope for water markets as an EPI to prevent drought consequences
In 2004-2005:
Lowest precipitation records since 1940.
Contributions to Beleña dam were 39 hm³ (historical average was 173 hm³)
2007
Drought 2004-05 to 2007
2008
Revival of the water transfer
Connection Alcorlo – Mohernando WWTP (37km)
Cost inception phase: 3 994 859 €
Connection Alcorlo – Beleña (proposed transfer of 80.9 hm³/year)
December 2009
Projected use of Alcorlo – Mohernando WWTP connection due to 2009 drought period.
2009
2010
Transfer: Azud Pozo de los Ramos – CYII Public Utility
Volume transferred: 24 hm³
CYII water right holdings: 5 -12 hm³
September 2011
Tagus Draft River Basin Management Plan (draft - subject to revision)
2011
MAS
Volume of water supplied: 55.5 hm³
Total population supplied: 336 126 inhabitants
2012
End of transfer contract
Legend
Maximum length of transfer contract
Drought periods
Water transfer active

1. EPI Background

1.1 Rationale

A popular science book (*The God Particle*), written in 1993 by Nobel Prize-winning physicist L. M. Lederman and science writer D. Teresi added the following sub-heading to their book: "If the universe is the answer, what is the question?" Paraphrasing that witty title, one may wonder: if water transfers were the answer, what was the question?

Two drought events (1990-1991 to 1994-1995, and 2004-2005 to 2007) outline the main background for the implementation of these EPIs.

The drought of the beginning of the 1990s in the Tagus River Basin District (TRBD) is recalled for its long duration and intensity. Comparing annual rainfall average with the historical average, there was a reduction of 23.1% for the 5-year period. Regarding net contributions, and comparing same groups of data, the reduction for the period was 46.6% (see Annex I: Additional information for sections 1 and 2).

In turn, the average annual precipitation for the hydrological year 2004-2005 was 344.5 mm (and 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 39 hm^3 (see Annex I: Additional information for sections 1 and 2).

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 by socio-economic drivers, such as demographic growth, ill-defined planning some decades ago, and economic development patterns, amongst other things.

Regarding the **first transfer**, the Alberche Canal irrigation area spreads out in 9 260 ha, to which 740 ha of the elevation of the right bank of the river must be added. This irrigation land demanded around 75 hm^3/yr., roughly corresponding to an allocation of 7 500 m^3/ha per annum. Due to the joint effect of scarce contributions and consumption rises in the preceding years, the water supply for the city of Madrid could have become uncertain.

In March (hydrological year 1993-1994) the level of the reservoirs of the Alberche system was less than 128 hm^3, which was almost the volume of Alberche River flow allocated for Madrid's supply (119.8 hm^3). Given the hierarchy of uses in the Spanish Water Law (i.e. the priority of domestic supply), and the right endowment of the public water utility (*Canal de Isabel II, CYII*) in the Alberche, this implied that irrigation crops (the above-mentioned 10 000 ha) depending on the water of the Alberche Canal would not have been enough for the season (TRBA, 2007). CYII used their entitlement (approx. 120 hm^3) to supply Madrid city; a water transfer was approved from the middle stretch of the Tagus River to the Alberche (for irrigation purposes).

As to the **second transfer**, the *Mancomunidad de Aguas del Sorbe* (MAS) (Sorbe River Water Community) was created to supply water to the towns of Alcalá de Henares and Guadalajara and other municipalities of the Henares River valley, downstream from Beleña's reservoir, total population supplied was 68 000 inhabitants (CYII, 2007), and the volume of water used was 6.8 hm^3 (MAS, 2011). The project for the aggregation of water and sanitation services in the area included growth projections that have been largely exceeded. These included a maximum population for Alcalá de Henares and Guadalajara of 100 000 inhabitants each and 25 000 for the other municipalities at stake for the purposes of this assessment. Nowadays, total population supplied by MAS is 363 126 inhabitants (INE, 2010) (which includes the seven original municipalities and other six that joined later) plus 20 000 inhabitants from municipalities which are not MAS members. In terms of supply for water and sanitation services, that can be translated into an increase of the total needs of water, that in 2005 were 46 hm^3 (MAS, 2011).

MAS hold water rights for 1 300 l/s and the Beleña dam, as above, has roughly 50.3 hm^3 of effective capacity (CYII, 2007). The river had an average contribution of 168.68 hm^3/yr. (CHT, 2005). Sorbe River's system demands an average of 75 hm^3 per annum from Beleña dam, out of which 51 hm^3 are for domestic supply, leakages amount to 12 hm^3 on primary and secondary pipes, 9 hm^3 help maintain the environmental flow and the remaining water goes to filtration and evapotranspiration (CYII, 2007).

Before 2001-2002, MAS managed to provide services to all municipalities every year. However during that hydrological year, Sorbe's contributions were 13% of average levels during the 20th century. At the beginning of February 2002 the reservoir level was under 9 hm^3, equivalent to two months of consumption. Given the risks for spring and summer seasons, and at the request of the TRBA, MAS contacted the irrigators of the Henares Canal to negotiate the purchase of a certain amount of water, within the framework of article 67 of the Water Law.

The Henares Canal has a total irrigation area of 7 500 ha placed in 15 municipalities at South-eastern Guadalajara. It holds water rights accounting to 5 600 l/s from the Henares River and a maximum of 66.175 hm^3/yr. An additional advantage was that the canal is parallel to MAS pipes and is just 2 km away from the Mohernando wastewater treatment plant (WWTP).

1.2 EPI objectives and description

This case study aims at showing a diversity of water transfer arrangements in which economic incentives were used to tackle challenges posed by drought events. As a matter of fact, three different transfers are to be assessed: the CYII taking water (for which they hold rights) from the Alberche River to supply Madrid city's domestic uses;

the water transfer from the middle Tagus to the Alberche Canal to ensure irrigation for agricultural production; and the water right transfer from the Henares Canal irrigators to the MAS to supply water and sanitation to different towns in the Henares' corridor. Each of them is full of nuances and different features, which will shed light on formal and informal practices of water exchanges.

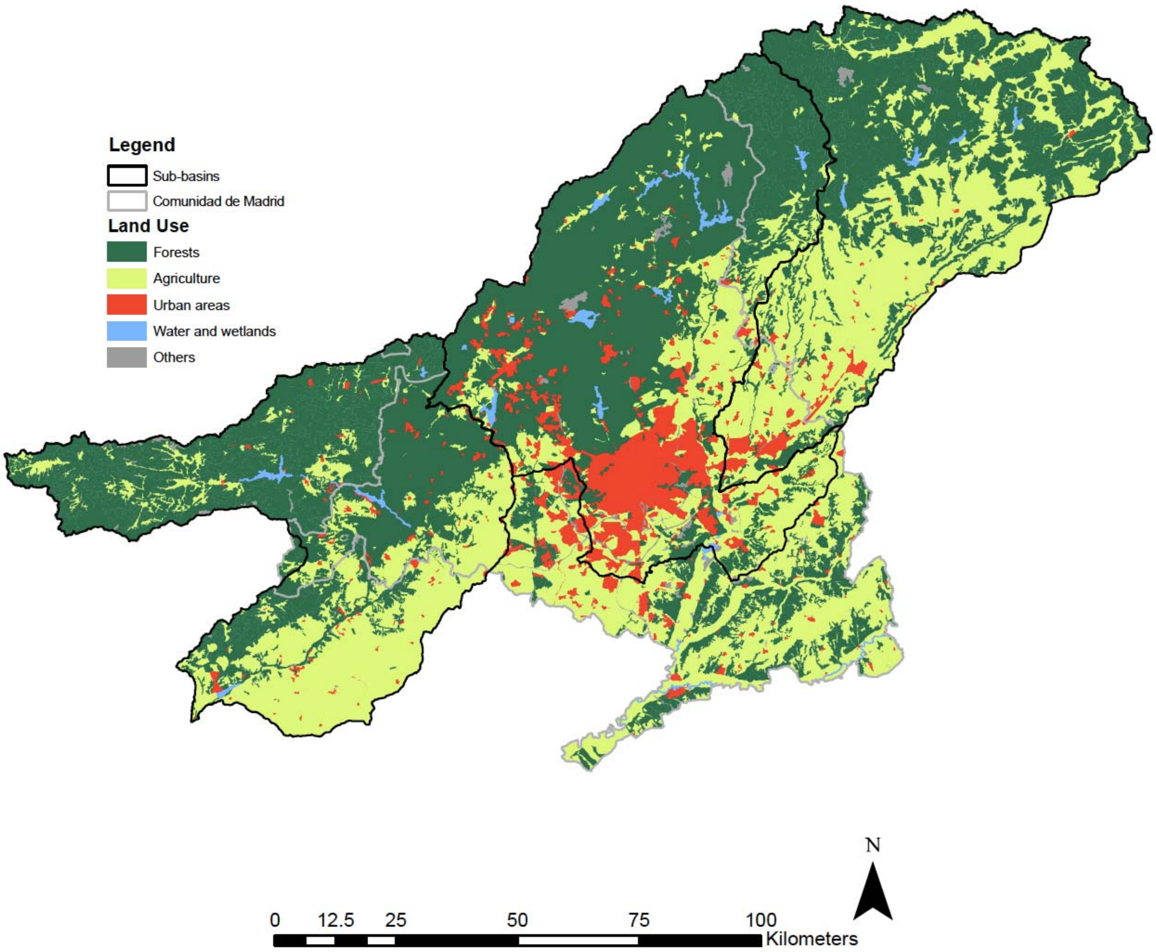
Sharp increases in water demand revealed the need for a more flexible approach (the Spanish model is based upon a concessional regime, not a water market at such), so that users could meet their demand but not necessarily at the expense of a higher use of the resource. This was even more compelling considering that water administrative mechanisms to re-allocate water (such as administrative procedures for water rights expiry, water concession audits, etc.) proved to be ineffective. For instance, the river basin authority would take a year and a half to process water right applications, even when water was available. Transfer contracts (*contratos de cesión)*, on the other hand, allow water users to get exclusive water rights in just two months (Vázquez, 2010).

2. Characterisation of the case study area

2.1 Environmental characterization

2.1.1 Land use

The study site is located in the upper section of the Tagus River watershed and includes parts of the Alberche, Jarama and Guadarrama river sub-basins (these are three of the main tributaries of the Tagus) with an area of 8 022 km^2 (see Map 2.1). Regarding economic activities involved, the study area includes the densely populated Madrid metropolitan area (6 271 000 inhabitants; EUROSTAT, 2011) and its sprawl along the Henares' corridor, where most of the urban water uses are located, and the two irrigated areas involved in the assessed water transfers. These include the irrigation communities in the Alberche sub-basin and on the banks of Henares River (see Map 2.1). 90.1% of the study area splits between agriculture and forests although this percentage has been steadily declining since 1990 (when these two land uses meant 94% of the total area, see Table 0-1 in Annex I: Additional information for sections 1 and 2). Land use dynamics in the area are nonetheless dominated by urban growth: the area devoted to urban uses has doubled since 1990, currently covering 8.3% of the area.

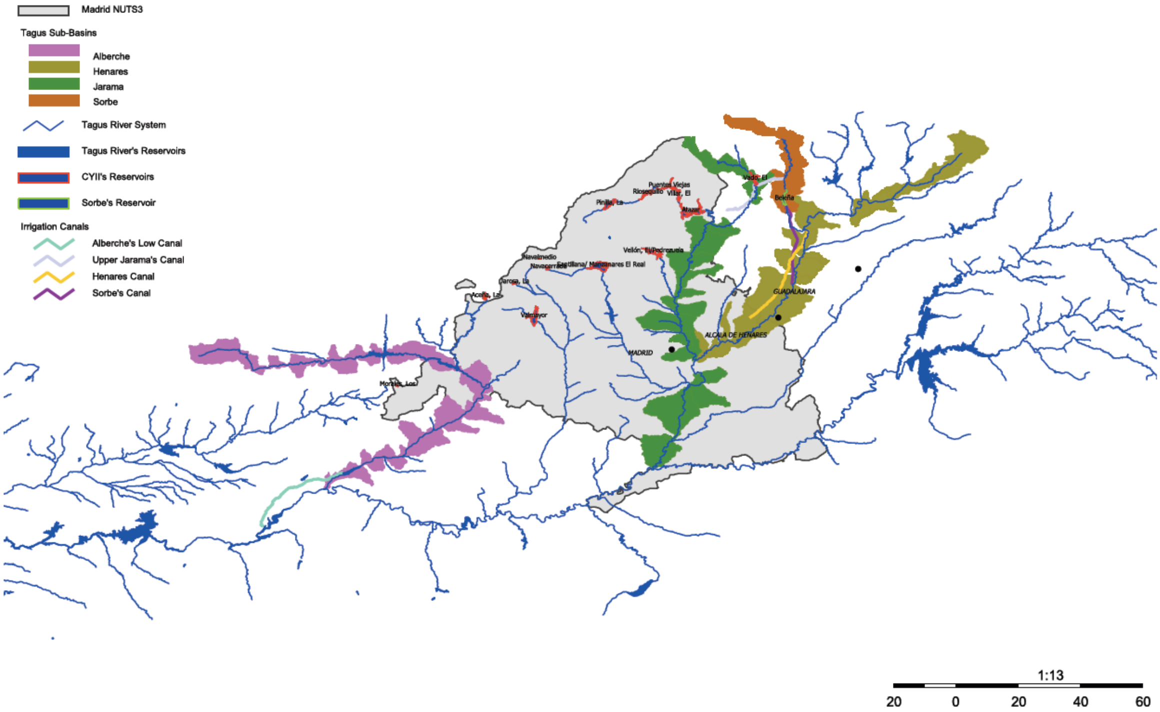


Map 2.1 - Land use in the study site (2006)

Source: Own elaboration from Corine Land Cover (CLC) 2006 and Tagus River Basin Authority (2011)

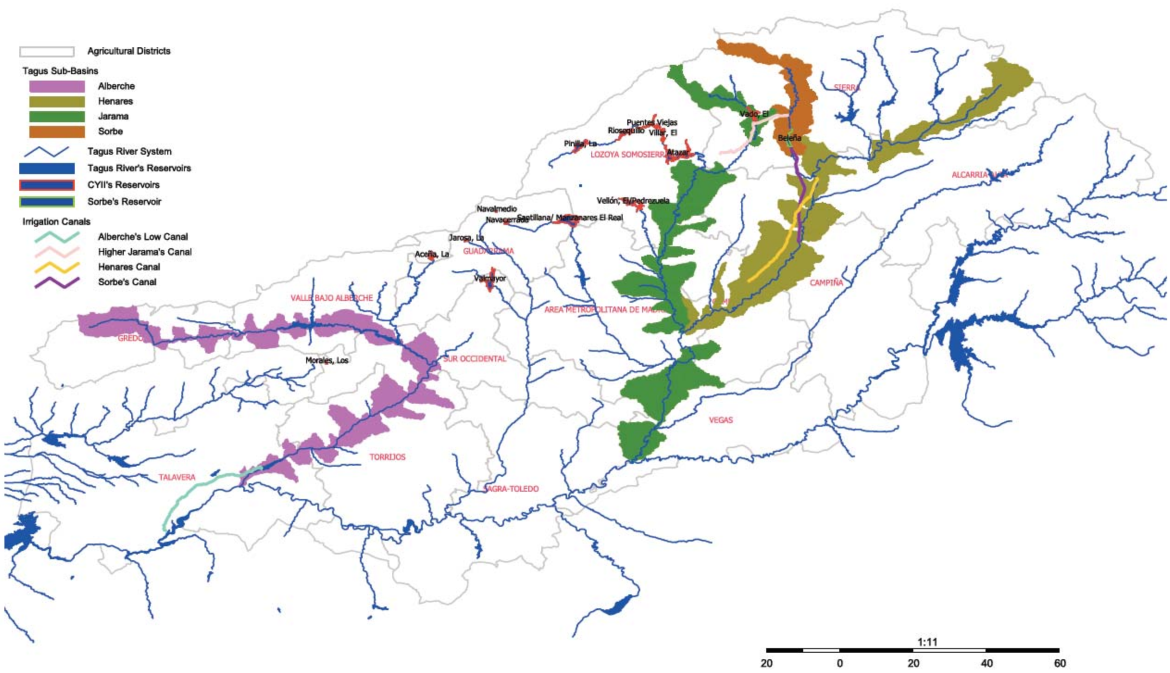
The Alberche Canal provides irrigation for an agricultural area located in the Talavera's agricultural district (province of Toledo). Irrigated land in that area reaches 14 406 ha (26.94% of total agricultural land). 10 000 ha of those are located in the Alberche Canal (69.42%). Main crops in the irrigation district are oats (25.05%), wheat (18.97%), olive trees for olive oil production (16.54%) and corn (10.74%).

The Henares Canal, in turn, is an irrigation channel that flows through the right bank of the Henares River, from Humanes (province of Guadalajara) to Arroyo de las Monjas, in Meco (Madrid). It has a length of 40 km and supplies water to 7 800 ha of irrigated land. The dams of Palmaces (with a total maximum storage capacity of 31 hm^3), Alcorlo (180 hm^3), and El Atance (35 hm^3) regulate the canal (see Map 2.2 and Map 2.3).



Map 2.2 - Detailed Tagus River sub-basins

Source: Own elaboration from Ministry of the Environment (2011) and Tagus River Basin Authority (2011)



Map 2.3 - Detailed Tagus River sub-basins and agricultural districts

Source: Own elaboration from Ministry of the Environment (2011) and Tagus River Basin Authority (2011)

2.1.2 Description of the hydrology

The hydrology[1] presents some remarkable differences in the two areas assessed for its potential to supply additional resources to meet urban demand.

In the context of the second transfer, average rainfall (1953-2010) in the Henares' corridor was 413.26 mm (AEMET, 2011), around 35% lower than the TRBD average for the same period (633.57). The high rainfall variability, with a standard deviation close to 100 mm, makes the area prone to extreme events such as droughts (TRBA, 2010), and translates into the severe variability of the volume of water stored in the basin (due to its low regulation capacity with respect to yearly water demands – see below).

Compared to that, rainfall in the Alberche (and the Guadarrama River), from where the second transfer assessed was implemented, is more abundant (1 300 mm/year on average for 1946-2010 in the headwaters of Guadarrama); despite an akin variability (standard deviation of 320 mm) the available storage capacity (close to 80% of the average runoff per year: 1 150 hm^3) makes water supply more steady and predictable than in the lower section of the Henares sub-basin (TRBA, 2010; AEMET, 2011).

2.1.3 Analysis of pressures and impacts

The study site[2], with only 15% of the area, must supply 88.5% of water demand for urban and industrial uses in the whole Spanish part of the Tagus basin. In the Upper Tagus (up to Talavera), 45% of water resources are available (85% of consumption, which implies average flows below 2 m^3/s in July of several years, quality problems, and degradation of the riverbed and banks).

This demand grew at an average rate of 4.2% from 1997 to 2006. Nevertheless, according to the most up-to-date available data (CYII, 2011), the Alberche and the Henares sub-basins only provide 26 and 56 hm^3 respectively out of the 913 hm^3 withdrawn to satisfy the demand for urban and industrial uses, the bulk of raw water being obtained from Jarama and Guadarrama sub-basins.

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[1] Headwater resources 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 stream-flow gaging stations), was 1 457 hm3/yr. From 1980-81 to 2005-06 the average volume has fallen to 773 hm3/year. This means that headwater resources have dropped by 47% with a breaking point in the trend since 1980.

[2] The Alberche system accounts for a total of 163 withdrawals 114 (69.94%) of which are related to irrigation and other agricultural uses, 34 (20.86%) with urban supply and the remaining ones with economic activities such as energy generation (3.08%), industry (3.68%) recreational uses (1.22%), and others (1.22%). As to the Henares system, irrigation and other agricultural uses account for 300 withdrawals out of 402 (74.62%), urban supply has 30 (7.46%), energy production 15 (3.73%), industry 7 (1.74%), and 50 for other uses (including recreational) (12.44%).

2.2 Economic characterization

Main drivers of water use in the study area are the result of the combined outcome of the scale effects of economic and population growth, plus the combination of income increases and changes in the economic structure (urbanization and tertiarization being important trends in water use).

In the region of Madrid population has grown by almost 1.5 million people within the last 15 years, from 5 022 000 inhabitants in 1996 to 6 458 000 inhabitants in 2010, at an average annual rate of 2.04%. Population density has also risen from 625 to 805 inhabitants/km^2. The attracting power of the Madrid area is explained by the rapid economic growth at an average rate of 3.28% until the end of 2007 (a few months before the current economic 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 and is actually still growing more than average, with a current share of *circa* four fifths of the regional GDP.

Agriculture has never been an important source of growth in Madrid and its contribution to the overall added value is declining, representing less than 0.6% of GDP (see Figure 2-1). The other potential 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).

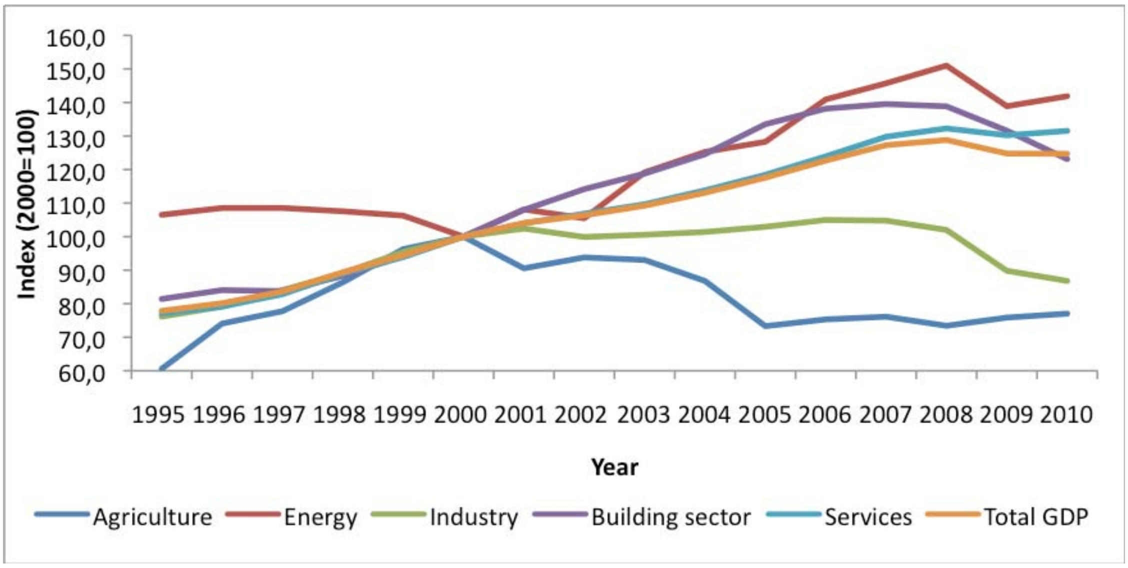


Figure 2-1 - Total GDP growth and sectoral evolution (1995–2010), chained indexes (2000=100)

Source: INE (2010)

Similar trends can be identified for the area covered by the MAS outside the region of Madrid (41 municipalities of Guadalajara). Its population has steadily grown as a consequence of urban growth and the access to membership of new municipalities from 111 000 inhabitants in 1971 to 384 000 in 2008 (MAS, 2011), which has resulted in increased pressure on water resources. Yet, agricultural uses have not been expanded and the global economic crisis (from 2007) has left the service sector as the most dynamic.

3. Assessment Criteria

3.1 Environmental outcomes

3.1.1 Drivers of water use

The rapid economic growth over the last 15 years has intensified pressures on water resources in the Region of Madrid and the River Sorbe Water Community (INE, 2011) and has posed new challenges to water management, with available water resources already at its limits during drought periods (TRBA, 2010; Alcolea and García, 2006), which has shifted attention to other sub-basins such as Alberche and Sorbe.

The public water utility (CYII) providing water and sanitation services in the Greater Madrid and most of the Madrid region obtains bulk water mostly from surface resources through a system of dams with an overall storage capacity of 945 hm^3. The last of these dams was built in 1991 and no significant increase in storage capacity has taken place since 1976 when the Valmayor dam (124 hm^3) entered the system. Groundwater sources serve to meet only a marginal part of urban water demand (20 hm^3 on average between 1995 and 2006) and are used as buffer stocks during drought periods when abstractions 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. As it can be inferred from above, Madrid has been able to guarantee a rapidly increasing water demand mostly with the same infrastructures to manage surface water and with a degraded marginal supply from groundwater sources. Efficiency gains and management improvements have been critical to meet water demands so far.

On the other hand, the overall 47 hm^3 required to meet urban water demand in the 42 municipalities supplied by the MAS (study site of the second transfer) are mainly obtained from the Sorbe River and the Beleña dam (50.3 hm^3), in the Sorbe itself. As urban and industrial development in the area have overcome initial forecasts (TRBA, 2010; MAS, 2011) resources have fallen behind the increasing water needs. This demand has increased from less than 7 hm^3 in 1971, when the MAS was founded, as new municipalities joined the system and with the population growth and urban development mainly along Henares Valley (when the MAS was constituted and the Beleña dam was built), a maximum population of 225 000 to be supplied was estimated; in 2009, population in the MAS area exceeded 384 000 inhabitants) (MAS, 2011). Total runoff in the Sorbe is high enough to satisfy water demands but its variability and the small regulation capacity of Beleña dam translates into a lower guarantee of supply and drought vulnerability, which is likely to increase due to population growth.

Water abstractions for agricultural demands in the study site were less important in absolute terms and declining; they represent about 30% of the agricultural water demand of the Spanish part of the Tagus (510 hm^3 as compared to 1 715 hm^3 in 2005). Almost half of these abstractions took place in the Alberche and Henares irrigated areas (160 and 106 hm^3 respectively in 2005; to 175 and 117 hm^3 respectively in 1998) (TRBA, 2010; Ministry of the Environment, 1999).

In the period 1996-2008 Madrid increased its real GDP by more than 50%, its number of employed people by more than 1.25 million and its real GDP per capita from EUR 19 755 to EUR 23 636, thus generating a pull effect which increased population even during the first year of the current economic crisis (INE, 2011).

The municipalities of the MAS, with most of its served population and industry located in the Region of Madrid, show a very similar trend, with high economic growth in the towns and villages of the Henares Corridor and a significant increase in demand both due to demographic growth (mainly in Alcalá de Henares and Guadalajara) and the accession of new municipalities to the MAS (see *Section 2*).

Furthermore, legal reforms and new household structure patterns have contributed to increase pressure on water resources in the areas of the two water transfers analysed under this case study. In 1998, the Land Act (BOE, Ley 6/1998, April 13th) converted into land suitable for development all non-urban areas, which were not subject to specific legal protection, thus abruptly increasing the amount of main residences and secondary dwellings. During the building-boom years that came thereafter and lasted until the very beginning of the crisis, the construction of new houses grew at such a rate that would have made it possible to duplicate the number of dwellings in the whole country in just 35 years; Madrid was amongst the regions with highest annual growth rates (2.2% and 4.72% for main and secondary residences, respectively; 2.15% and 3.63% for the whole river basin area) (Ministry of the Environment, 2008). On the other hand, the number of members per household in the region of Madrid decreased from 3.29 in 1991 to 2.79 in 2005 (INE, 2008), thus also increasing water needs (*ibid.*).

3.1.2 Demand for water services

As a result of this context of economic and population growth and urban sprawl, urban water demand in both areas sharply increased during the first years of the economic boom (1996-2003). However, over 2004-2009 this trend was partially reversed in the Region of Madrid; in spite of the high economic (accumulated 9.34% for this period) and population growth (667 990 new inhabitants overall), urban water demand in 2009 had decreased to levels similar to those of 1997.

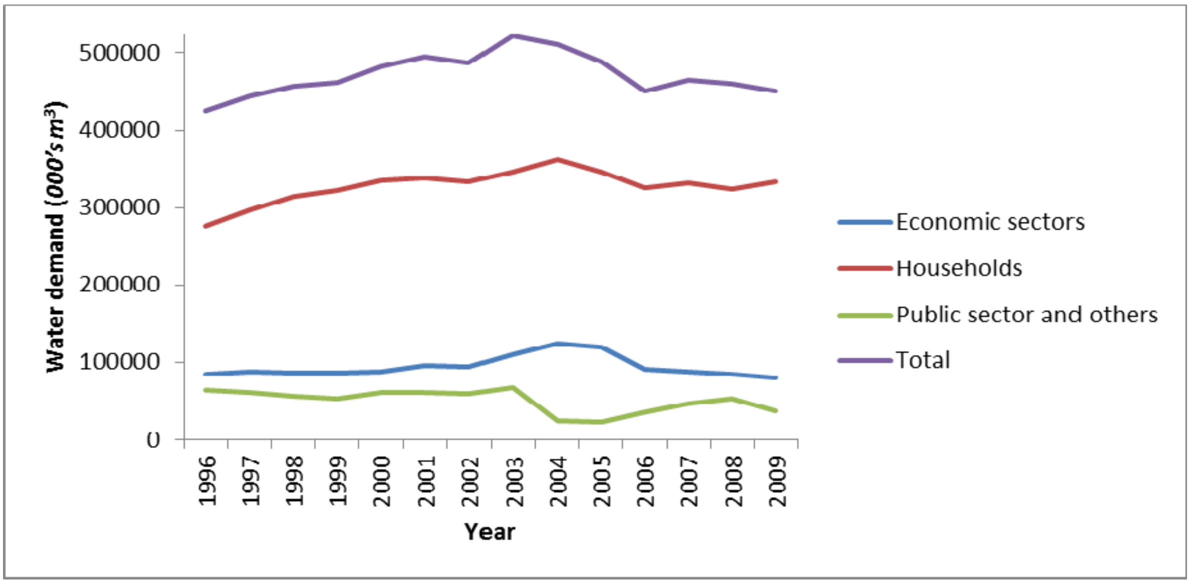


Figure 3-1 - Urban water demand in the Region of Madrid (000's m³), 1996-2009

Source: INE, 2011

The trend in Madrid from 2004 onwards can be explained by high productivity gains in the urban areas by most water users, especially in the building sector (with the highest productivity gain) and the service sector (highest share of GDP), but also in the manufacturing sector; in addition, it can also be explained by a remarkable decrease in domestic water demand.

Table 3-1 - Urban water productivity (€/l) by economic sector, Region of Madrid, 1997-2006

Year	*Agriculture*	*Manufacturing*	*Building*	*Services*
1997	130.46	1 097.16	5 624.69	811.92
1998	141.21	1 408.54	6 747.99	930.67
1999	141.75	1 361.16	7 249.74	971.24
2000	195.34	1 355.94	7 552.11	1 074.64
2001	178.73	1 338.81	7 375.10	1 058.29
2002	158.80	1 329.32	7 995.81	1 162.42
2003	141.92	1 109.71	8 057.79	1 084.63
2004	110.77	902.06	7 432.37	1 044.58
2005	116.23	1 007.91	8 682.36	1 145.94
2006	118.73	1 448.41	13 340.88	1 646.56

Source: Own elaboration from INE, (2011)

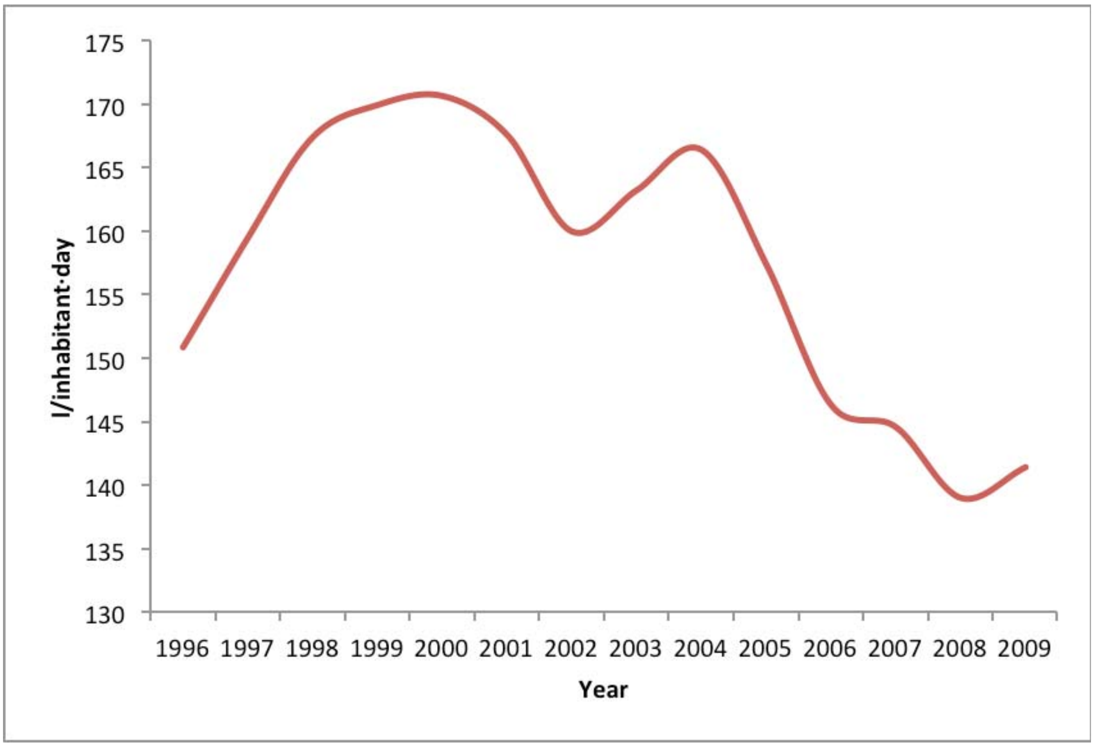


Figure 3-2 - Household water demand (l/inhabitant·day), Region of Madrid, 1996-2009

Source: Own elaboration from INE, 2011

Within the context of the first transfer, the Alberche Canal demands (gross demand) water for irrigation amounting to 83.04 hm^3/yr., which have remained close to this figure during the last decade (TRBA, 2007; 2010). Efficiency in water transport, distribution and irrigation is amongst the lowest of the Tagus River basin (*circa* 34%), due to the irrigation technique deployed (mostly gravitational). The Alberche River has a historical deficit (TRBA, 2010) and cannot cope with total water demand; especially during drought periods, this area is to rely on the water transfer from Las Parras stream. Hydropower generation is another relevant water use in the Alberche sub-basin. There are four dams with hydropower uses in the Alberche sub-basin, all managed by Unión Fenosa: Burguillo (75 hm^3, 48.8 MWh), San Juan (60 hm^3, 33.44 MWh), Picadas (60 hm^3, 20 MWh) and Puente Nuevo (3 hm^3, 16.2 MWh) (MARM, 2011). Although hydropower generation is not a consumptive use, it reduces control over water stocks in the river and thus water availability for other uses.

On the other hand, regarding the context for the second transfer, in the MAS there have also been significant productivity gains, although not enough to halt water demand growth in absolute terms, as it was the case in Madrid. In 1990-2000, water demand in the area grew by 11.6 hm^3, while population increased by 20 000 inhabitants. In the following decade, with a population growth over 100 000 inhabitants, water demand just grew by 3.8 hm^3 (MAS, 2011; TRBA, 2010). Main water demand comes from households (70%), followed by industrial uses in the Henares Corridor (22%) and the public sector (8%).

In the Henares Canal (La Campiña agricultural district) annual demand for irrigation during the last decade is estimated at 65.5 hm^3/year (TRBA, 2008; 2010). Gravitational irrigation systems prevail and efficiency is very low (38%), so that just 25 hm^3 effectively contribute to satisfy agronomic requirements. Water demand is expected to decrease as irrigated land in this area is progressively being switched to other land uses, mainly urban and industrial (TRBA, 2010), and the irrigation system is being improved.

3.1.3 Pressures on water resources

Total water abstractions for urban water supply in the Region of Madrid in the period 1996-2009 follow a similar trend to that of water demand, with a sharp increase in the first years (1996-2003) followed by a continued decrease during the period 2004-2009. Surface water is the main water source, as it represents an average of 93.5% of total water abstractions. In average, groundwater represents 6.5% of total water abstractions and acts as a buffer stock in drought years, when abstractions can soar up to 146.7 hm^3, 23% of total withdrawals (INE, 2011). There are no other sources of water in the region, and overall losses are estimated to be 12% of total withdrawals (TRBA, 2010).

Table 3-2 - Water abstractions for urban water supply (hm3) by source of water, Region of Madrid, 1996-2009

Year	*Surface water*	*Groundwater*	*Total*
1996	500.10	22.21	522.31
1997	506.24	19.28	525.52
1998	514.25	30.49	544.74
1999	506.39	63.94	570.33
2000	570.34	35.26	605.60
2001	622.46	7.75	630.21
2002	561.41	59.62	621.03
2003	650.31	20.64	670.96
2004	622.81	39.37	662.18
2005	583.34	67.08	650.42
2006	489.79	146.70	636.49
2007	554.57	18.90	573.47
2008	546.71	14.30	561.01
2009	553.37	5.59	558.96

Source: INE, 2011.

Water abstraction for irrigation in the Alberche Canal is estimated in 75 hm^3/year (TRBA, 2008), 49,5 hm^3 of which are lost in water transport. This demand is met with resources coming from the Alberche River. Although irrigators of the Alberche Canal benefit from a public irrigation endowment (Estevan and Lacalle, 2007), the public water utility holds most use rights on water resources of the Alberche River (119.8 hm^3

as the initial entitlement, plus 100 hm^3 added afterwards) (TRBA, 2010). Therefore, in dry years the Alberche Canal has to rely on water resources from Middle Tagus coming through the Las Parras-Alberche Canal water transfer (with a capacity of 75 hm^3/year).

On the other hand, total water abstraction to supply the municipalities of the MAS has grown in the last decade from 51 hm^3 in 2000 to 55.5 hm^3 in 2010 (8.8% increase). 100% of the abstractions are from surface water, as they come from the Beleña dam. Although water runoff from the River Sorbe is high enough to satisfy water demand, the low regulation capacity of the dam of Beleña (50.3 hm^3) and the high runoff variability have provoked in the past some water shortages in the MAS. Also, the CYII has the right to transfer between 5 and 12 hm^3/yr. of water from the Sorbe River depending on water stored in the Beleña dam (TRBA, 2010), and this increases even more water stock variability in the Beleña dam. To overcome this storage shortage problem there are several proposals that have being analysed in the last two years to transfer water to the Sorbe River sub-basin from the Alcorlo dam (180 hm^3) in the Bornova river basin (TRBA, 2010). However, the procedure is slow and the last project proposed to transfer 80.9 hm^3/year from the Beleña to the Alcorlo dam is at a standstill due to its high environmental impact.

3.1.4 Ecological status of water resources

Traditionally water supply in the Region of Madrid has largely come from the mountains located to the North, which represent 30% (2 407 km^2) of its total area and capture the largest share of the total rainfall in the region (TRBA, 2010). Large population and economic growth and thus the need to increase the regulatory capacity on water resources, has historically led to an increase of physical capital in the upper and middle stretches of the rivers of the region: as a result Madrid is now among the regions with more heavily modified rivers in Spain (Alcolea et al., 2006) and, in turn, in the world (Gómez, 2009).

As no significant surface water supply increases can be obtained through additional human-made capital, there have not been new constructions of relevant dams since 1970s (CYII, 2011). While demand increased and surface resources grew unable to meet water demand during droughts, groundwater, as above, has been used as a buffer stock. Thus water abstractions from aquifers during these years have scaled up, exhausting groundwater resources and leading to a poor ecological status (TRBA, 2010). Under these circumstances, the solution to scarcity problems has come from the demand side, with significant increases in water efficiency that have made it feasible to decouple economic and demographic growth from water demand and withdrawal.

Within this scheme, economic policy instruments such as water rights transfers may play a key role. In this case study, the water transfer from the Middle Tagus to the Alberche Canal guarantees Madrid reserving water flows in this very river for the provision of water and sanitation to the households of the Madrid Region. However, the lack of a formal previous agreement with the irrigators of the Alberche Canal to replace water from Alberche River with water from the Middle Tagus sub-basin has hampered the right operation of Las Parras-Alberche Canal connection, as it happened in the 2004-2005 drought, thus leading to overexploitation of Alberche River's resources (TRBA, 2007).

In the MAS, water demand stems from the Beleña dam, which by the end of the 1990s was already supplying water to a much larger population than originally forecasted (TRBA, 2010). In this case study, contrary to what happens in Madrid, water supply problems are related to a lack of regulation capacity as compared to increasing water demand. There have been flawed attempts to increase regulation capacity of the system, but the solution has had to come from the water right transfer from the Henares Canal (TRBA, 2010), which provides water of a lower quality than that contained for example in the Alcorlo dam. To some extent, this is an idle infrastructure, planned to transfer water to the Beleña dam in several projects (no one has been implemented so far).

The Henares Canal in turn takes its resources from the Henares River. Economic and population growth in the surrounding areas have increased water demand in the Henares sub-basin, thus leading to a reduction of water supply guarantee during scarcity junctures. As a result groundwater abstraction in the area has increased, and although the quantitative status of the Guadalajara aquifer is still fair, its qualitative status is poor (TRBA, 2008). Indeed, non-point pollution resulting from agricultural activities is a problem of major concern, also affecting the Alcorlo dam, whose resources are used for urban supply as well as the provision of amenities (TRBA, 2010).

3.2 Economic Assessment Criteria

3.2.1 Economic efficiency

In both cases, the water transfer directly responds to the need to guarantee water supply to the population, which is specified as a priority use in the Spanish Water Law. Indirectly, it also contributes to guarantee water supply to other urban uses, such as the service sector.

Economic growth in Madrid (which comprises most of the population of the MAS) until the beginning of the current world economic crisis was led by the service sector (it still is, though), which explains more than 60% of total economic growth and 93% of employment generation in the area for the period 1995-2010 (INE, 2011). The provision of the necessary inputs (such as water) to this sector has laid the foundations to generate most of the economic and employment growth, though labour productivity is currently lower (INE, 2011). Agriculture, the sector from which water rights are exchanged from, has a minor importance for employment (0.4% of total employment in the region in 2010 and even decreasing during the period 1995-2010), and output (0.1% of total GDP in 2010, also decreasing) (INE, 2010).

The guarantee of water provision through the use of EPIs such as water right transfers has contributed to consolidate economic growth in the most dynamic urban area of Spain, Madrid and its sprawl along the Henares Corridor, although it has diminished water resources for irrigation in the Alberche River basin (which are theoretically covered by the Las Parras-Alberche Canal water transfer, though it has showed some problems in its implementation) and the Henares Canal (a traditional agricultural area which is shrinking as a result of urban and industrial expansion along the Henares) (TRBA, 2010).

Apart from quantitative effects, trade also involved heterogeneous water quality. Through the Alberche-CYII water transfer Madrid obtains high quality freshwater, while irrigators from the Alberche have complained about the low quality of the water coming from Las Parras stream. In the Henares Canal-Mancomunidad de Aguas del Sorbe water transfer; the users of the urban water have also criticized the low quality of the water transferred from the Henares Canal.

3.2.2 Costs

In the first transfer assessed, CYII takes water from the San Juan dam in the headwaters of the Alberche River to satisfy priority urban uses in the Region of Madrid (mainly drinking and sanitation services). The water transfer has been working since 1967, although the expansion, which is relevant to our case study, was installed in 1993. The cost of the expansion was 10 billion pesetas (equivalent to 67 million ECU_{1993}), and after its construction the total amount of resources of Alberche River entitled to the CYII were 119.8 hm^3/yr. The Region of Madrid was responsible for the payment, which had to be effective within a period of 25 years. As above, to compensate the irrigators of the Alberche Canal an additional water transfer was built from Las Parras stream in the Middle Tagus sub-basin to the Alberche River. This water transfer had an initial capacity of 5 m^3/s and has only been used three times[3], the first one in 1993. In that year and as a result of drought, 35 hm^3 were transferred from the Middle Tagus to the Alberche Canal, and the Region of Madrid paid for the energy costs of pumping (50 million pesetas; that is, 0.335 million ECU_{1993}) (Estevan and Lacalle, 2007).

In 2006, the TRBA allocated an additional amount of 100 hm^3 of the Alberche's resources to the Canal de Isabel II water utility. This expansion is followed by an increase in the capacity of the Las Parras - Canal de Alberche water transfer, up to 7 m^3/s at a cost of 2 million Euros. An additional projected measure consists in the modernization of the irrigation systems in the Alberche Canal, with an estimated cost of 50 million Euros, which is expected to save 25 hm^3/year through more efficient irrigation.

[3] The Las Parras-Aberche Canal water transfer was built in 1991 to provide water to the irrigated areas of the Alberche Canal, suffering a severe drought by then.

In 2008, the Las Parras-Alberche had to be used again to solve water scarcity in Alberche River. The cost of the intervention was 1.48 million Euros, and the water transferred had a lower quality than that of Alberche River.

On the other hand, in the MAS, water for urban supply is taken from the Beleña dam, with a limited capacity that has motivated an agreement between the irrigators of the Henares Canal and the MAS to transfer water rights. The agreement started in February 2002 and transferred the use of 20 hm^3/yr. from the irrigators of the Henares Canal to the Mancomunidad. This agreement is extendable for 2-year periods to a maximum of ten years. The infrastructural cost amounted to 3.5 million Euros and mainly consisted in the construction of the Maluque-Mohernando connection, with a length of 2 km and a capacity of 1.3 m^3/s. The maximum flow rate is variable during the year: between September and April the transfer can work at its maximum capacity, but from May to August the maximum flow is 300 m^3/sec. The water transfer cost for the MAS is 38 000 €/year, plus EUR 0.01 for the first 4 hm^3 and EUR 0.02 from that amount onwards. During the summer months (June, July, August) each additional hm^3 is paid at 0.03 €/hm^3 (all prices are updated with the CPI) (CYII, 2007). Besides, MAS had to pay the pumping costs to the TRBA, which during 2005-2006 amounted a total of EUR 388 000.

3.2.3 Cost effectiveness

Although during the economic expansion, labour productivity diminished in the study site, this was not the case of water productivity. As it was shown in *Section 3.1* water productivity (€/m^3) during the period 1997-2006 increased in every sector except for agriculture. This included a sharp increase in water productivity in the service sector, which represents 80.5% of total GDP in the region of Madrid and more than doubled its water productivity during the period. Overall, urban water productivity has increased in the manufacturing and service sectors as GVA and GDP grew, showing a pattern, which can be described as a Verdoorn's law for water (Verdoorn, 1980).

In those sectors, the apparent productivity of water is well over 1 000 €/m^3, while in the building sector it shot up to over 13 000 €/m^3. On the other hand, the net margin of revenues over costs of irrigation water (the sector which is mostly affected by the water transfer) is under 1 €/m^3 for many crops in Talavera and La Campiña agricultural districts, and average water productivity equals 3.57 €/m^3 in La Campiña and 3.79 €/m^3 in the Talavera agricultural district (see Table 3-3 and Table 3-4).

Table 3-3 - Water productivity in agriculture. La Campiña agricultural district.

Crop	*Surface*	*Total income (€/ha)*	*Average water demand (m3/ha)*	*Water productivity (€/m3)*
Corn	2 807	2 007	9 467	4.72
Barley	2 722	873	4 590	5.26
Pea	2 304	201	N/A	N/A
Wheat	1 729	986	3 507	3.56

Sunflower	444	942	4 597	4.88
Oats	77	602	2 275	3.78
Olive tree-olive oil	16	769	3 170	4.12
Pepper	14	18 186	3 315	0.18
Tomato	13	21 304	9 708	0.46
Onion	9	5 963	4 337	0.73
Garlic	7	9 834	2 409	0.24
Cabbage	7	9 225	1 714	0.19
Vineyard - wine grape	6	1 621	2 632	1.62
Vetch	5	560	N/A	N/A
Bitter vetch	3	517	N/A	N/A
Melon	2	6 988	5 332	0.76
Cauliflower	1	8 679	N/A	N/A
Lettuce	1	8 183	6 464	0.79
Total/Average	10 167	1 123	4 689	3.57

Source: Own elaboration from Ministry of the Environment, 2007

* Obtained as the net margin (revenue minus all direct and indirect costs) per cubic meter applied to the field.

Table 3-4 - Water productivity in agriculture. Talavera agricultural district.

Crop	*Surface*	*Total income (€/ha)*	*Average water demand (m3/ha)*	*Water productivity (€/m3)*
Corn	5 744	1 861	8 289	4.45
Barley	1 965	862	2 888	3.35
Oats	1 962	530	2 647	4.99
Wheat	1 517	845	3 023	3.58
Pea	649	330	1 941	5.89
Olive tree-olive oil	504	1 980	2 847	1.44
Vineyard - wine grape	447	5 305	4 606	0.87
Sunflower	375	691	4 119	5.96
Melon	338	6 054	N/A	N/A
Onion	194	9 248	N/A	N/A
Pepper	171	19 842	6 040	0.30
Cabbage	145	13 178	N/A	N/A
Cauliflower	123	11 792	N/A	N/A
Lettuce	111	12 574	N/A	N/A
Watermelon	74	5 079	N/A	N/A
Garlic	47	9 585	N/A	N/A
Bitter vetch	19	450	N/A	N/A
Vetch	17	519	N/A	N/A
Carrot	4	14 509	N/A	N/A
Total surface/Average	14 406	2 182.31	4 886	3.79

Source: Own elaboration from Ministry of the Environment (2007)

* Obtained as the net margin (revenue minus all direct and indirect costs) per cubic meter applied to the field.

In *section 3.1* it was shown that the apparent productivity of water was higher in other sectors than in agriculture, and so the potential for income generation was also higher. However, these results have to be taken very cautiously. Agriculture may be a minor sector for the aggregate of the area of the case study, but in certain rural areas it is the main activity, and less water availability can lead to substantial losses in these areas. Indeed, rainfed agriculture shows much lower income than irrigated agriculture in the two agricultural districts at stake (see Table 3-5 and Table 3-6).

Table 3-5 - Comparative income, rainfed and irrigated agriculture (€/ha). La Campiña agricultural district.

Crop	*Total income, irrigated crops (€/ha)*	*Total income, rainfed (€/ha)*
Barley	872.70	460.06
Pea	200.86	123.98
Wheat	986.33	530.84
Sunflower	941.94	316.25
Oats	602.48	375.69
Olive tree-olive oil	768.57	410.68
Vineyard - wine grape	1 620.78	1 645.69
Vetch	560.43	261.07
Bitter vetch	516.55	302.04
Melon	6 987.98	1 880.85

Source: Own elaboration from Ministry of the Environment, 2007

Table 3-6 - Comparative income, rainfed and irrigated agriculture (€/ha). Talavera agricultural district.

Crop	*Total income, irrigated crops (€/ha)*	*Total income, rainfed (€/ha)*
Oats	530.13	265.57
Wheat	845.06	325.71
Olive tree-olive oil	1 979.75	777.41
Barley	862.45	394.68
Vetch	519.30	221.10
Vineyard - wine grape	5 304.55	2 070.07
Watermelon	5 079.12	1 888.74
Bitter vetch	449.62	252.62
Melon	6 053.63	1 163.15
Pea	329.69	162.70
Sunflower	691.41	236.86

Source: Own elaboration from Ministry of the Environment, 2007

3.2.4 Risk reduction

In the Alberche-CYII water transfer, high quality water is transferred from agricultural uses in the Alberche Canal to urban uses in the city of Madrid; in both areas neither rainfall nor runoff show large variability as compared to those shown in average by the Tagus River Basin, but pressure on existent resources is very high as a consequence of economic growth in Greater Madrid. The result is a structural deficit, which makes Madrid prone to extreme events such as droughts.

The Alberche-CYII agreement aims at diminishing the likelihood of drought events in Madrid while compensating irrigators of Alberche River with water from the Middle Tagus. However, this second water transfer has not worked as foreseen and as a result the irrigated lands of the Alberche Canal are now more vulnerable to drought events (TRBA, 2010). Also when the water transfer has actually worked, water quality has been lower (TRBA, 2010).

In the Henares Canal-MAS water transfer there is not such a structural deficit, but rather a lack of regulatory capacity to supply water to a large and growing population. Rainfall and thus runoff patterns in the Henares sub-basin show large variability, which combined with low storage capacity in the Beleña dam actually increases the exposure of the area to drought events. To reduce this exposure the MAS agreed with the irrigators of the Henares Canal to transfer 20 hm^3/year from agricultural uses to urban uses.

In this case study the agreement to transfer water rights from the Henares Canal to the MAS had a minor effect upon drought risk in agricultural activities (TRBA, 2010). Indeed, irrigated land in the Henares Canal is diminishing as a consequence of land use dynamics in the Henares Corridor and urban and industrial land use expansion (Ministry of Public Works, 2011).

3.3 Distributional Effects and Social Equity

According to recent evidence (Ministry of the Environment, 2007), farmers growing irrigated crops get an average income of 1 123.06 €/ha, with important variations amongst crops. Corn, which covers the widest area, produces an average income of 2 000 €/ha while barley obtains less than 900 and peas less than 200. These three crops share 95% of the study site area; the rest is covered by some more profitable as well as more water demanding vegetables. As an indicator of the value of water, it can be said that the average income obtained per cubic meter amounts to EUR 0.19, but 23% of the irrigated area using 30% of the water might be generating an income lower than 0.04 €/m^3.

The importance of water for irrigation can be observed if comparing the previous figures with those of rainfed agriculture, covering around 120 000 hectares and earning 490 €/ha on average. For example, as to the most common crop, both under irrigated and rainfed agriculture, irrigation facilities and water represent a shift from 460 to 2

000 €/ha of income and an increase from 2 300 to 11 000 kg of average yield. From a social viewpoint, water does actually make a difference in the study site.

The average income obtained in the Talavera agricultural district in the Alberche is about twice that of the Henares (2 180 €/ha) and although cereals still account for three quarters of the irrigated area, crops are more diversified than in the Henares. Average income per cubic meter is 0.32 € with lower variations than in the Henares. The dominant crop is also corn, which covers 40% of the irrigated area, uses 45% of the water, and obtains an estimate of 0.22 €/m^3. This may imply significant equity concerns linked to economic losses in the water exporting area, but since the transfer does not threaten water availability for agriculture in this area, the social impact is not critical at all.

Hence, the assessed water transfers have not had significant impacts on material living standards, since water was guaranteed for both water supplying irrigation districts holding stakes. From the consultation process, we have inferred that the irrigators of the Henares Canal did not suffer noteworthy losses (in the second transfer assessed). The fact that farmers in the Henares valley accepted to give their water up at a price lower than one eurocent per cubic meter is but an indication that probably (at least part of) those water resources were not being used for crops.

As to the first one, though, the irrigators from the Alberche Canal complained about the low quality of the middle Tagus water (received via Las Parras stream). A study carried out by the public utility (CYII, 2007), states that the conductivity of the Tagus River up to Talavera can reach 2 000 microSiemens/cm, which basically means that it is semi-brackish water. This does not seem to have led, though, to critical production losses or major protests.

This idea that no major equity impacts were found is reinforced by the fact that compensation payments were implemented in both water transfers (in the Henares – Sorbe transfer, as part of contractual explicit clauses).

In 1993, CYII offered a payment of 50 million pesetas (approx. 0.335 million $ECUS_{1993}$) to cover the pumping costs in which the irrigators would incur to bring the water from the Tagus River to the Lower Alberche Canal trough the Las Parras stream. In the agreement the irrigators did contract the energy supply, which was thus partially paid by the CYII. Despite a number of interviews with stakeholders (representatives from the River Basin Authority, on one side, and CYII water public utility, on the other) no significant evidence has been obtained as to why this compensation was implemented in spite of the utility holding water rights in the Alberche. It seems part of a compromise between the company and the basin authority.

In November 1996, the energy company Unión FENOSA, claimed the payment of 1 billion pesetas (6.7 million $ECUS_{1996}$) from CYII arguing that some production losses would occur after the transfer from the Picadas dam (in the Alberche) to CYII, built to increase water supply in Madrid. Since the transfer started working, Unión FENOSA considered that its water concessional rights were being affected. The transfer reduced the volume of water that the company could process in the turbine, and hence, its capacity to generate electricity. These damages were estimated in roughly 1.2 billion pesetas. CYII managers argued that they were acting under the safeguard of the water rights they held, granted by the TRBA, in which there was neither specific constraints to the transfer nor compensations to other third-party agents.

In terms of positive equity impacts, local communities served by MAS and benefitting from the water transfers from the Henares River, managed to elude water restrictions. There are records of some complaints regarding the quality of water, but this was always in accordance with regulations. MAS, on the other hand, does not only supply households but also industries; for some of them water is an essential input.

Regarding the transfer from the Alberche to supply Madrid city, households did not face an increase in water tariffs due to additional expenses for the public utility (power for pumping).

3.4 Institutions

In Madrid, socio-economic drivers, such as population growth, a lack of past planning, and economic development patterns (building as a critical sector, subsidised agriculture, etc.), amongst other things, can explain the threat of water shortages.

Intense industrialization during the 1990s and the prolific development of real estate resulted in an increase of water demand. Concessions to market forces became necessary, to facilitate transfers amongst uses and reallocate already used waters, without increasing total water withdrawals.

After centuries of enforcement of the appurtenance principle4 a number of factors led to the transfer of water rights among users. Economic development and urban growth, as well as droughts themselves, could no longer be managed within the limits imposed by a water law based on the needs of a formerly agrarian society and the constraints of traditional administrative systems. As a result of these parallel developments Spanish water legislation was amended (1999) to allow for the transfer of water rights. Cession contracts, as defined in the Spanish legislation, allow transfers to operate, amongst others, under these conditions:

1. Transfers can only take place between and among present right holders. A newcomer having no right to the use of water would not be able to purchase a right (art. 67. 1 TRLA).
2. Transfers are to be temporary (art. 67.1 TRLA). What is transferred it not the water right itself, but the use of water, subject to the original conditions imposed on the original right holder (Vázquez, 2010).

[4] Permanent and rigid attachment of water to a piece of land and a single use, preventing exchanges and reallocation.

3. Transfers are restricted to same-level and higher-ranking uses. Thus, irrigation may transfer water to urban water supplies (as in the assessed transfers) or other irrigators only, and not to industry and energy (art. 67.1 TRLA).
4. Transfers cannot take place between non-consumptive and consumptive uses (art. 67.1 TRLA).
5. Most importantly, transfers must be approved by the administration (art. 67.1 TRLA). There is a maximum period of time for the administration to approve or reject a transfer (one month within the same organization of users, two months otherwise). Should the term expire without a decision, the rule of silence procedure applies, and the transfer is in fact approved by default, without a formal decision (Decree 606/2003, art. 347.2, art. 68.2 TRLA). Transfers can be rejected by RBAs, which must justify the reasons for its rejection. Grounds for refusal include injury to the rights of third parties, negative impacts on water regimes, injury to environmental flows, and damage to water ecosystems. Transfers can also be refused for non-compliance with legal conditionalities. RBAs have a preferential right to acquire the volumes to be transferred (Art. 68.3 TRLA).
6. The amount of water to be transferred is not the nominal entitlement of the right holder, but the amount actually and effectively utilized by the assignor (Art. 69. 1, TRLA) as averaged in the 5 years preceding the transfer. The actual amount of water to be utilized by the beneficiary can be adjusted by the RBA according to the basin plan, minimum flow requirements, beneficial water use, and hydrological situation (Art. 345 Decree 606/2003). Cessions can have a pecuniary consideration, which may be subject to a ceiling by the administration (art. 69.3 TRLA).

A significant number of institutions were involved in the implementation of the two analysed water transfers. Following Williamson (2000), different levels of the institutional setting have been identified.

The first transfer (that from the Henares Canal to the MAS), in the early 1990s, describes a situation in which the transfer itself was formally feasible. The other (CYII using their entitlements in the drought of the mid 2000s to supply Madrid with water from Alberche River, and the Alberche Canal irrigators being compensated with water from the Middle Tagus), is an example of a situation where the water transfer is viable but only under more specific circumstances. The former is a case in which a water right transfer is performed in strict sense. The latter, on the contrary, is an example of a water right holder (the public water utility) using their rights and the affected irrigators being compensated through a decision by the TRBA.

Level 1: Informal

At an informal level (in terms of water rights), the Irrigation District of the Lower Alberche Canal started working in 1953, with 3 000 commoners and 4 municipalities[5]. Historically they have mainly grown corn and the most used irrigation technique is gravitational, although there is currently a modernization project planned for the whole irrigation system.

The irrigators of the Alberche Canal do not hold rights although they are beneficiaries of the allocation of public water flows for irrigation. These farmers have not been granted a formal entitlement and thus their rights are not registered, which implies that they cannot be part of a water transfer contract. Nevertheless, as an exception, the RDL 15/2005 allowed water users adjoin to public irrigation land to sign transfer contracts provided some conditions were met.

Resources allocated for this irrigation area (hydrological plan, 1999) were 7 500 m^3/ha· year. In the ETI (the *Scheme of Important Issues*, previous step to a new river basin plan), a reduction of allocated resources is set: 6 191 m^3/ha· year.

It is interesting to point out that in the transfer from the Henares to the Sorbe, although in the two situations in which water right transfers were needed these were implemented following the conditions required by the MAS, the contract did not include a single obliging clause for the Henares Canal irrigation community to set aside water resources for water transfers; neither did it contain any provision that could shed light on the relative priority of water leasebacks or trades over the Canal users' risks (CYII, 2007).

Level 2: institutional environment. Formal rules (constitutions, laws, property rights).

In Spain, the Water Law of 1879 (fundamental law of June 13th, 1879, Gaceta 19-06-1879) established a public domain status for part of its surface water resources. The Spanish Constitution, dating back to 1978, set in his article 128 that the wealth of the country was subordinated to the public interest. According to this, the Water Law 1985 (Law 29/1985, BOE 8-8-1985) included all surface and groundwater as public domain goods; the Water Framework Directive (Directive 2000/60/CE), of 2000, reinforced the public nature of water resources and established a common legal framework for all types of water bodies (surface and groundwater, coast water and transitional waters).

As above, the reform of the Water Law in 1999 (Law 46/1999, BOE 14-12-1999) introduced the so-called water transfer contracts (*contratos de cesión*) and transfer centres[6] (*centros de intercambio*) that eased certain transfers of water rights for a given period of time including a pecuniary compensation. The transfer contract for exclusive

[5] San Román de los Montes, Pepino, Talavera de la Reina, and Calera y Chozas.

[6] The transfer centres are defined as institutions or measures that allow the River Basin Authority to offer the purchase of water rights, that may be subsequently transferred to other users, via payment compensation. The set up of these centres is either related to emergency situations or to the concurrence of exceptional situations.

water use rights on public-domain waters is regulated under articles 67 and ulterior ones of the Consolidated Water Law, approved by RDL 1/2001, of July 20th, 2001 (Vázquez, 2010).

After the drought of 2004-2005 the Government passed a decree (RDL 15/2005) including several urgent measures to regulate water right transactions. Both, the Law 46/1999 and the RDL 15/2005, were designed in a drought context and as reaction to it, firstly in 1990 and thereafter in 2004-2005.

Level 3: Institutions of governance

The **CYII** was created in 1851 to provide drinking water and sanitation services to the city of Madrid, with both private and public capital and depending on the Ministry of Public Works. In 1971, after its operational area was extended to the whole province (which is also a region itself) and other neighbouring towns, it turned into a public utility dependent on the Ministry of Public Works and Urban Planning. The affiliation to Madrid Regional Government (CAM) was implemented back in 1984 (RD 1873/84, September 26th), and the regulatory framework for water and sanitation services (in the CAM) was set with the Law of December 20th, 1984 (CYII in an exception as it is a regional company and not a municipal one). With the so-called PIAM (*Plan Integral de Agua en la Comunidad de Madrid*), CYII took responsibility for sanitation and river conservation, beyond water supply services (Alcolea y García, 2006).

CYII is also related to the second transfer (see below) due to the transfer between Azud del Pozo de los Ramos and Madrid, that transfers a minimum volume of 5 hm^3 and a maximum of 12 hm^3.

In 1993, CYII held rights in Alberche River (119.8 hm^3), which were increased in some additional 100 hm^3 by decision of the TRBA of April 12th, 2006. This increase should have only been a fact after additional regulation in the river (which did not actually happen) and subject to compensation to the parties (i.e. the hydropower operator, Unión FENOSA).

Regarding the transfer from the Henares Canal, during the drought of 2002, the **Ministry of the Environment, Rural and Marine Affairs** (MARM) (just Ministry of the Environment in 2002) thought the TRBA had requested the MAS to contact irrigators of the Canal to negotiate the purchase of a certain amount of water rights. The *Confederación Hidrográfica del Tajo (CHT)* is the River Basin Authority, which is mainly responsible for water administration in interregional basins (article 19 and subsequent of the Water Law). Regarding services, municipalities are responsible for water supply and sanitation (including wastewater treatment) (articles 25 and 26 of the Law 7/1985, April 2nd, of Local Administration), providing the service directly, as a commonwealth of municipalities (i.e. the MAS) or through a public or private company, via public procurement procedures. In the second transfer analysed in this case study, as an irrigated area of public initiative was involved in the process, the transfer should have been issued to the Ministry of Agriculture, Fishing and Food Affairs, which in the exercise of its competencies, could have informed about the use change. Actually, this was stated as a mandatory step in the regulatory process.

In 1970, **MAS** was created to supply water to the towns of Alcalá de Henares and Guadalajara and other 5 municipalities of the Henares River valley. Nowadays, MAS supplies water to 13 municipalities as well as other 42 that are not official members. MAS held water rights for 1 300 l/s and Beleña dam has 50.3 hm^3 of effective capacity (CYII, 2007). The hydrological plan sets in 7 100 m^3/ha and year the resources allocated for irrigators.

3.5 Policy Implementability

Current water legislation and institutional arrangements promote water use efficiency (art.14.1 TRLA). They also separate water management, which is entrusted to non-sectoral RBAs, from sectoral functions such as irrigation, and power generation. The institutional arrangement seeks to ensure that water will not be managed and allocated according to the functional vocation and constituencies of sectoral organizations (lobbies). In so doing, it reflects international experiences and developments.

However, the depth and extent of the operational activities of RBAs may make them prone to structural, rather than to economic instruments, since they are charged with project preparation, construction and exploitation (art. 23 TRLA)[7].

Official initiatives regarding market instruments, such as water right exchanges, seem to have been *ad hoc* responses to crises, rather than part of the instruments to be compulsorily considered when managing water.

The emergence of water markets, as many other once innovative EPIs, is an adaptive process itself, one that allows for learning-by-doing practices. Both water transfers can be judged, from a policy implementability perspective, not so much for their failure or success but rather for their ability to refine water institutional development. To some extent, water transfer examples in Spain are not only observed concerning their flexibility to be potentially adapted to local particularities elsewhere in the country but also, to some extent, as an benchmark for the potential development of water markets in other European countries. Cession contracts, as such, are very specific of the Spanish legal approach to water transfers but conceptually (in nature), rather flexible as an instrument (as discussed in other sections of the case study, i.e. institutional settings).

The water transfer from the Alberche River, although valuable to manage water shortages in the 1990s, might well not be an alternative in 2011 anymore and many doubts exist as to the real prospect of repeating the 2002 water trade from the Henares Canal to the MAS in the same formal terms (that is, beyond the agreement expiring in

[7] Awareness of structural biases has prompted planning proposals in other countries (such as the USA) establish that at least one alternative with non-structural measures shall be formulated and identified as the primarily nonstructural alternative. This should lead to the combination of structural and non-structural elements to ensure the best alternative is identified.

2012), due to legal changes. This has nothing to do, though, with overallocation problems or social response, but rather with a more systematic approach to water transfers, which suggests that water transfers will not necessarily adopt such an interim fashion. The actual value of these examples, though, is in the lessons that can be drawn and its relevance to furthering agreements on reallocating water use rights as an instrument for water security.

The Spanish system accepts the transfer of water rights, but it faces important restrictions. One of them is that transfers can only take place between and among uses of similar or superior ranking in the order of preferences[8]. The ranking of preferences of the TRLA is based on tradition, which at present does not necessarily fit into any actual social and economic imperatives, with the exception of water supply and sanitation. In that sense, the limitation of the TRLA hampers the efficiency gains that may be obtained through markets, since it does not take account of water productivity in different alternative uses.

The constraints of the system are best illustrated by the fact that legislation issued to cope with droughts, and related emergency measures, include variances and exceptions to the order of preferences of the TRLA. If exceptions are needed for the system to perform there is an indication that structural, permanent rules, may need some revision.

Whilst the coordination between parties (the public water utility and the irrigators from the Alberche Canal, on one side, and the MAS and the irrigators from the Henares, on the other), was reasonable[9], especially for the facilitating role of the Tagus River basin authority, some flaws can be observed regarding the implementability of these transfers in other contexts. Under current water legislation and institutional set-up, request for a transfer may be approved by default, if the administration does not approve or refuse it within one or two months, depending on the reach of the transfer (within or outside the same community of users). That legal provision provides a powerful incentive for administrators to reject transfers outright should they be complex and time consuming.

Water trading, as assessed in these two water transfers, may face additional challenges. Allowing transfers from agricultural to urban uses (as in the two cases that have been

[8] The ranking of preferences set in the TRLA priories urban use, in which low water consuming industries located near urban areas and connected to municipalities are included. Second use is water for irrigation and other agricultural uses. Third, industrial use for electric energy production. Fourth other industrial uses not included in previous categories. Fifth Aquiculture. Sixth, seventh and eight, recreational uses, navigation and other transport and other uses, respectively.

[9] River basin organizations (RBOs) in Spain are responsible for the administration, management and control of water resources, the preparation of water plans, the operation of common works, and the preparation, construction and exploitation of water projects (art. 23, TRLA). They grant water rights, except for matters of public interest, and look after demand management, with a view to promote water savings and environmental and economic efficiency. Water management and administration must be separated from other functions or RBA's (art. 24.a), d), g) TRLA). The TRBA, along this line, played a critical role in both transfers.

assessed) may bring to the negotiation process water resources that are not being effectively used, unless strict monitoring provisions are implemented.

In fact, given the low quality of soil in the region of Madrid, agriculture is a waning activity and in some areas water allowances are higher than the effective demand for irrigation water. Paradoxically, once subsidies from the Common Agricultural Policy have been phased out and agricultural markets have been liberalized, the irrigation sector in some areas may be in excess water supply.

Both water transfers were the result of measures to cope with droughts. Because of this, all procedures and public works were executed on an emergency basis, which hampered whatever participation process. This lack of participation, though, does not seem to have damaged the acceptance of water transfers, nor has it conditioned its design. Yet, these instances have created a favourable context (built on protocols and formal procedures), which opens up space for further transfers. Time laps between decisions and effects were 8 months for the 1993 transfer, and 3 months for the 2002 one.

Despite the fact that no participation took place regarding the assessed transfers, there have been ulteriorly consultation processes within the context of the water planning drafting stages. As part of those, a number of potential conflicts were identified (regarding the ecological status of river Tagus, as pacing the town of Talavera; the availability of water resources in the Alberche – mainly water for irrigation; the use of Sorbe's resources; etc.).

3.6 Transaction Costs

There is no explicit definition of transaction costs in the literature developed around this case study. This is not to say, though, that there were no transaction costs in the water right transfers analysed.

It should be clear that water transfers create benefits and costs relative to what the situation would have been in the absence of these transfers. If stakeholders had not been aware of those impacts and there had been no compensation for those bearing negative impacts, there would have been a clear economic incentive to politically contest these water transfers. Being that the case, the effort that stakeholders would have devoted to influence decision-making should have been added to the explicit costs of the EPI implementation; these costs are generally assumed away. Yet, there was compensation in both cases, as it has been explained in previous sections.

Section 3.4 details the most relevant institutions involved. Some of these institutions held a number of meetings which entail non-negligible transaction costs:

- For the transfer between the Alberche and the CYII, the Board of the Irrigation District of Alberche River held a meeting to discuss about feasible solutions to guarantee the irrigation season in the Alberche River once the transfer between Alberche and CYII to supply Madrid city was in place. Furthermore, the

Directorate General for Public Works (on behalf of the Spanish Administration) was in charge of doing and financing the building work.

- For the transfer between the Henares and the MAS water community, the agreement was signed between the irrigators of Henares Canal and the Sorbe River Water Community, but the TRBA was the authority requesting such an agreement.

For the first transfer, in March 11th, 1993, the above-mentioned Board held a meeting to analyse alternative solutions to provide water for irrigators of the Lower Alberche Canal. Because of the urgency in building the connection between Picadas dam (Alberche) and Valmayor dam, the transfer started working in November of that very year.

As per the 2002 transfer, the agreement was signed in February 8th, 2002 and in July of the same year it started working for 4 months. The connexion between the Canal and Mohernando's treatment plant did not work again until June 2005 for a period of 8 months (up to January 2006). The fact that it took less time to implement the second transfer is an indicator of lower transaction costs, due to the prior effort, which provided some institutional assets for ulterior water trades.

There is no evidence of the time devoted to these meetings, since, as above, these two water transfers were designed as *ad hoc* urgent measures to tackle drought consequences. However, despite this emergency feature, the process was longer (and consequently transaction costs higher), that one could infer. Once irrigation was established in the Alberche, different drought periods threatened water availability for farmers. This motivated, in 1991, the construction of an emergency infrastructure, thanks to an intake from the Tagus. This means that although no significant transaction costs may be linked to the decision to transfer water in 1993, some *ex ante* costs may need to be taken into account (no available information has been found), regarding the construction of the infrastructure for water transfers.

No specific decision-support tools where used to make decisions and no *ex ante* studies have been identified, beyond analyses by the TRBA for wider planning purposes. Both transfers were designed, as emergency measures, for severe drought situations that threatened water supply of important cities and towns such as Madrid, Alcalá de Henares or Guadalajara. It is therefore evident that a more systemic consideration of non-structural alternatives to water management in Spain, rather than a drought-based-emergency resort to market-like solutions, may be requested under the duty of economic efficiency imposed to RBAs under art 24 J of the TRLA.

3.7 Uncertainty

3.7.1 Environmental objective

The objective of the EPI under assessment was to guarantee urban water supply in the capital city of Madrid and the Mancomunidad de Aguas del Sorbe (MAS), and the outcomes to be assessed were qualitative. In the case of Madrid city, there was no deadline for the EPI (the increase in the number of water rights of the CYII held in Alberche River and the compensation paid by the CYII in the form of pumping cost payment for the Las Parras-Alberche water transfer had no time horizon). It was therefore conceived as a permanent arrangement. In the case of the Henares Canal-MAS water transfer, the water right transfer was set to be finished in 2012. In both cases the outcome of the EPI has been assessed in terms of water provision for households, urban economic sectors and agriculture (from where water rights were transferred) for the period 1993-2009.

Indicators for water demand from households, agriculture and urban economic sectors used in the assessment rely on official data obtained from large and precise water demand surveys (INE, 2011) and show that the EPI has achieved its main goal of guaranteeing urban water supply. The efficiency of the policy is also analysed through the water apparent productivity evolution during the years considered, which is also obtained from publicly conducted surveys on water use of large samples and high accuracy (INE, 2011). The analysis of distributional effects is based upon the comparison of income under two alternative agricultural regimes: rainfed agriculture and irrigation. Data in this case is obtained from estimations from large samples in the relevant agricultural districts and has a good fit.

Urban water quality information is obtained from different official and unofficial records that acknowledge a decrease in water quality levels when it is supplied from agricultural districts instead of traditional sources; in this case the precision is lower but still offers a good fit. For the quantitative status of surface and groundwater resources, the results are the official ones: the method follows the best available practice and uses large samples, so the measure is robust.

Finally, financial results are obtained from different official sources that record the series of costs stemming from the implementation of EPI. The sources are from public national macroeconomic accounting and the results are accurate.

3.7.2 Performance of policy instruments

Both water transfers were aimed at guaranteeing urban water supply in urban areas with not enough resources, for different reasons, to cope with water demand. In the case of Madrid, the scarcity problem is related to the overexploitation of traditional water sources (surface and groundwater), while in the MAS the problem is related with the lack of water infrastructure. The performance of the EPI has been assessed using official and reliable data, except for the case when this was not available (as it is the case in agricultural districts where the Henares Canal and the Alberche Canal are located.

4. Conclusions

4.1 Lessons learned

The emergence of water markets, as many other once innovative EPIs, is a gradual adaptive and learning-by-doing process that must be judged by its ability to push water institutional development rather than by the failure or success of the experience itself. The water transfer from the Alberche River although useful to manage the supply deficit in the 1990s would not be an alternative in 2011 anymore and many doubts exist as to the real prospect of repeating the 2002 water trade from the Henares Canal to the MAS in the same formal terms. The actual value of these examples is in the lessons that can be drawn and its importance to furthering agreements on reallocating water use rights as an instrument for water security.

Both examples also illustrate the critical importance of managing water use conflicts. It is well known in economic analysis that water management is essentially conflict management. In fact, according to the Spanish law, households have a priority over irrigators in water use, and there is no need for a voluntary agreement to take water away from farms in order to guarantee a sufficient supply of drinking water in dry periods. The real buffer for drinking water in Spain is the irrigated agriculture whose use rights are defined every year depending on the rainy season. Moreover, instead of just taking water or forcing farmers to let water flow, the agreement is easier to reach if alternative resources are available, the harvest is protected and third-party effects are avoided.

This is the real meaning of the 2002 transfer. The existence of these alternative resources is precisely what makes the replication of this trade almost impossible in 2011 (as there is evidence of overallocation or water rights in the middle Tagus river). Nevertheless, lessons learnt can be important to understand how, instead of paying for water, agreements are easier to reach when alternative sources are provided to guarantee existing uses, particularly in irrigated agriculture. Nowadays, alternative resources can either come from re-used or desalinated water.

Water trading also faces some important challenges. Allowing transfers from agricultural to urban uses may bring to the negotiating table water resources that are not being effectively used. In fact, given the low quality of soil in the Madrid area, agriculture is a receding activity and in some areas water allowances are higher than the effective demand for irrigation water. Paradoxically, once subsidies from the Common Agricultural Policy have been phased out and agricultural markets have been liberalized, the irrigation sector in some areas may be in excess water supply. The fact that farmers in the Henares valley accepted to give their water up at a price lower than one eurocent per cubic meter is but an indication that probably those water resources were not being used for crops. Hence, water trading might not be a means to reduce water scarcity but rather to increase it and would not be instrumental to reallocate water but to effectively increase its use. This would be a real risk should water saved after the publicly supported shift towards more efficient irrigation systems, becomes part of the water trading system rather than being left in already degraded aquifers.

4.2 Enabling / Disabling Factors

To some extent, it seems that the Spanish legislator was of two minds when incepting water markets into water legislation. On the one hand, they were accepted (adopting quite a sound model, as internationally compared). On the other, they were encumbered with some structural restrictions and conditionalities. These conditionalities of the system on the one hand block economic agents, and on the other deter them.

At the same time RBAs have little operational obligations forcing them to seriously consider water markets, and other non-structural measures, when planning for, and managing, water.

Transfers are mostly related to emergency situations, with legal exceptions promoted by the administration at times of crisis, rather than being an essential feature of both, public and private water management.

5. References

CYII, 2011, Canal de Isabel II - Infraestructuras de Captación. (http://www.cyii.es/cyii.es/web/gestion_agua/captacion.html) accessed 14 September 2011.

EC, 2000, Directive 2000/60/CE, the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (OJ L 327, 22.12.2002, p.1)

Estevan, A. and Lacalle, A., 2007, *Transferencias de Derechos de Agua entre Demandas Urbanas y Agrarias - El Caso de la Comunidad de Madrid*, Cuadernos de I+D+I, Canal de Isabel II.

Ley de Aguas de 1879, 13 June 1879, Gaceta 19-06-1879.

Ley 29/1985, Ley de Aguas de 1985, BOE núm. 189, 8-8-1985, 2 de agosto de 1985.

Ley 46/1999, de 13 de diciembre, de modificación de la Ley 29/1985, de 2 de agosto, de Aguas. BOE núm. 176, 14-12-1999, 13 de diciembre de 1999.

MAS, 2011, *Mancomunidad de Aguas del Sorbe* (http://www.aguasdelsorbe.es/web/) accessed 14 September 2011.

Ministry of the Environment, 1999. BOE 30/8/99. Normative determinations of the Hydrological Plan of the Tagus River Basin, August 30th, 1999.

Ministry of the Environment (MMA), 2007, Plan Especial de Sequía de la Cuenca Hidrográfica del Tajo, Anejo III - Análisis de sequías históricas.

Ministry of the Environment, 2008. Libro de Usos del Agua. Madrid, 2008.

RDL 1/2001, Real Decreto Legislativo 1/2001, de 20 de julio, por el que se aprueba el texto refundido de la Ley de Aguas. BOE 24-07-2001.

RDL 15/2005, Real Decreto-Ley 15/2005, de 16 de diciembre, de medidas urgentes para la regulación de las transacciones de derechos al aprovechamiento de agua. BOE núm. 301, 17-12-2005.

Tagus River Basin Authority, 2005, Protocolo de actuación de sequías, tomo I (memoria y anexos) y II (documento de operatividad), Ministerio de Medio Ambiente, Secretaria General para el Territorio y la Biodiversidad, Dirección General de Agua.

Tagus River Basin Authority (TRBA), 2007. *Plan Especial de Alerta y Eventual Sequía en la Cuenca Hidrográfica del Tajo.* (http://www.chtajo.es/DemarcaTajo/SequiasyAvenidas/Paginas/Pes.aspx) accessed 14 September 2011.

Tagus River Basin Authority (TRBA), 2008. *Esquema de Temas Importantes.* (http://www.chtajo.es/DemarcaTajo/Paginas/default.aspx) accessed 14 September 2011.

Tagus River Basin Authority (TRBA), 2010. *Esquema de Temas Importantes.* (http://www.chtajo.es/DemarcaTajo/Paginas/default.aspx) accessed 14 September 2011.

Vázquez, D., 2010, El contrato de cesión de derechos al uso privativo del agua: otra forma de adquirir derechos sobre las aguas públicas más allá de las concesiones administrativas, Uría Menéndez.

Verdoorn, P J, 1980. Verdoorn's Law in Retrospect: A Comment. Economic Journal (Royal Economic Society) 90 (358): 382-85

6. Data Sources

AEMET, 2011, *Agencia Española de Meteorología*. Data server. (http://www.aemet.es/es/-m:i/servidor-datos/acceso-datos/listado-contenidos) accessed 14 September 2011.

EUROSTAT, 2011, Statistics. (http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes) accessed 14 September 2011.

INE, 2011, *Instituto Nacional de Estadística - INEbase.* (http://www.ine.es/inebmenu/indice.htm) accessed 14 September 2011.

Ministry of the Environment, 2007. Database MODERE for the Analysis of Water use in the Spanish Agriculture and the Art 5 Report of the WFD

Ministry of the Environment, 2011. Anuario de Aforos. (http://hercules.cedex.es/anuarioaforos/default.asp) accessed 14 September 2011

Ministry of the Environment, 2011. Sistema Integrado de Información del Agua. (http://servicios2.marm.es/sia/consultas/servlet/consultas.GlobalFilter?tipo=masiva&sid=generate) accessed 14 September 2011.

Ministry of Public Works, 2011. *Corine Land Cover 1990*. (http://centrodedescargas.cnig.es/CentroDescargas/inicio.do) accessed 14 September 2011.

Ministry of Public Works, 2011. *Corine Land Cover 2000.* (http://centrodedescargas.cnig.es/CentroDescargas/inicio.do) accessed 14 September 2011.

Ministry of Public Works, 2011. *Corine Land Cover 2006*. (http://centrodedescargas.cnig.es/CentroDescargas/inicio.do) accessed 14 September 2011.

Tagus River Basin Authority, 2011. *Información geoespacial de la Cuenca del Tajo*. (http://www.chtajo.es/Servicios/Paginas/InforGeografica.aspx) accessed 14 September 2011.

Annex I: Additional information for sections 1 and 2

Table 0-1 - Land Use and Land Use Change (1990, 2000, 2006), Tagus Watershed

Land use / Year	1990	2000	2006	Land use change 1990-2006 (%)
Agriculture	48.05%	48.03%	48.34%	1.33%
Forests	49.27%	48.82%	47.91%	-2.09%
Urban areas	1.22%	1.74%	2.13%	75.95%
Water and wetlands	0.88%	0.88%	0.88%	4.98%
Others	0.58%	0.52%	0.74%	29.79%
Total	100.00%	100.00%	100.00%	-

Source: Own elaboration from Corine Land Cover 1990, 2000 and 2006 (Ministry of Public Works, 2011)

90.1% of the study area splits between agriculture and forests although this percentage has been steadily declining since 1990 (when these two land uses meant 94% of the total area). Land use dynamics in the area are nevertheless dominated by urban growth; the area devoted to urban uses has doubled since 1990, currently covering 8.3% of the area.

Table 0-2 - Land Use and Land Use Change (1990, 2000, 2006), Henares sub-basin

Land use / Year	1990	2000	2006	Land use change 1990-2006 (%)
Agriculture	53.34%	52.17%	51.23%	-3.96%
Forests	45.47%	45.70%	46.08%	1.35%
Urban areas	0.99%	1.75%	2.27%	129.21%
Water and wetlands	0.14%	0.14%	0.14%	32.86%
Others	0.06%	0.23%	0.28%	377.63%
Total	100.00%	100.00%	100.00%	-

Source: Own elaboration from Corine Land Cover 1990, 2000 and 2006 (Ministry of Public Works, 2011) and Tagus River Basin Authority, 2011

Table 0-3 - Agricultural Land Use, La Campiña agricultural district

Crop	Irrigated (ha)	Percentage of total surface	Non-irrigated (ha)	Percentage of total surface	Total (ha)	Percentage of total surface
Barley	2 722	2.11%	62 034	48.12%	64 756	50.23%
Wheat	1 729	1.34%	23 906	18.54%	25 635	19.88%
Olive tree - olive oil	16	0.01%	17 622	13.67%	17 638	13.68%
Sunflower	444	0.34%	5 220	4.05%	5 664	4.39%
Pea	2 304	1.79%	1 911	1.48%	4 215	3.27%
Vineyard – wine	6	0.00%	3 712	2.88%	3 718	2.88%
Oats	77	0.06%	3 039	2.36%	3 116	2.42%
Corn	2 807	2.18%	0	0.00%	2 807	2.18%

Vetch	5	0.00%	714	0.55%	719	0.56%
Bitter vetch	3	0.00%	553	0.43%	556	0.43%
Melon	2	0.00%	39	0.03%	41	0.03%
Pepper	14	0.01%	0	0.00%	14	0.01%
Tomatoes	13	0.01%	0	0.00%	13	0.01%
Onion	9	0.01%	0	0.00%	9	0.01%
Garlic	7	0.01%	0	0.00%	7	0.01%
Cabbage	7	0.01%	0	0.00%	7	0.01%
Cauliflower	1	0.00%	0	0.00%	1	0.00%
Lettuce	1	0.00%	0	0.00%	1	0.00%
Total	10 167	7.89%	118 750	92.11%	128 917	100.00%

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)

Table 0-4 - Land Use and Land Use Change (1990, 2000, 2006), Region of Madrid

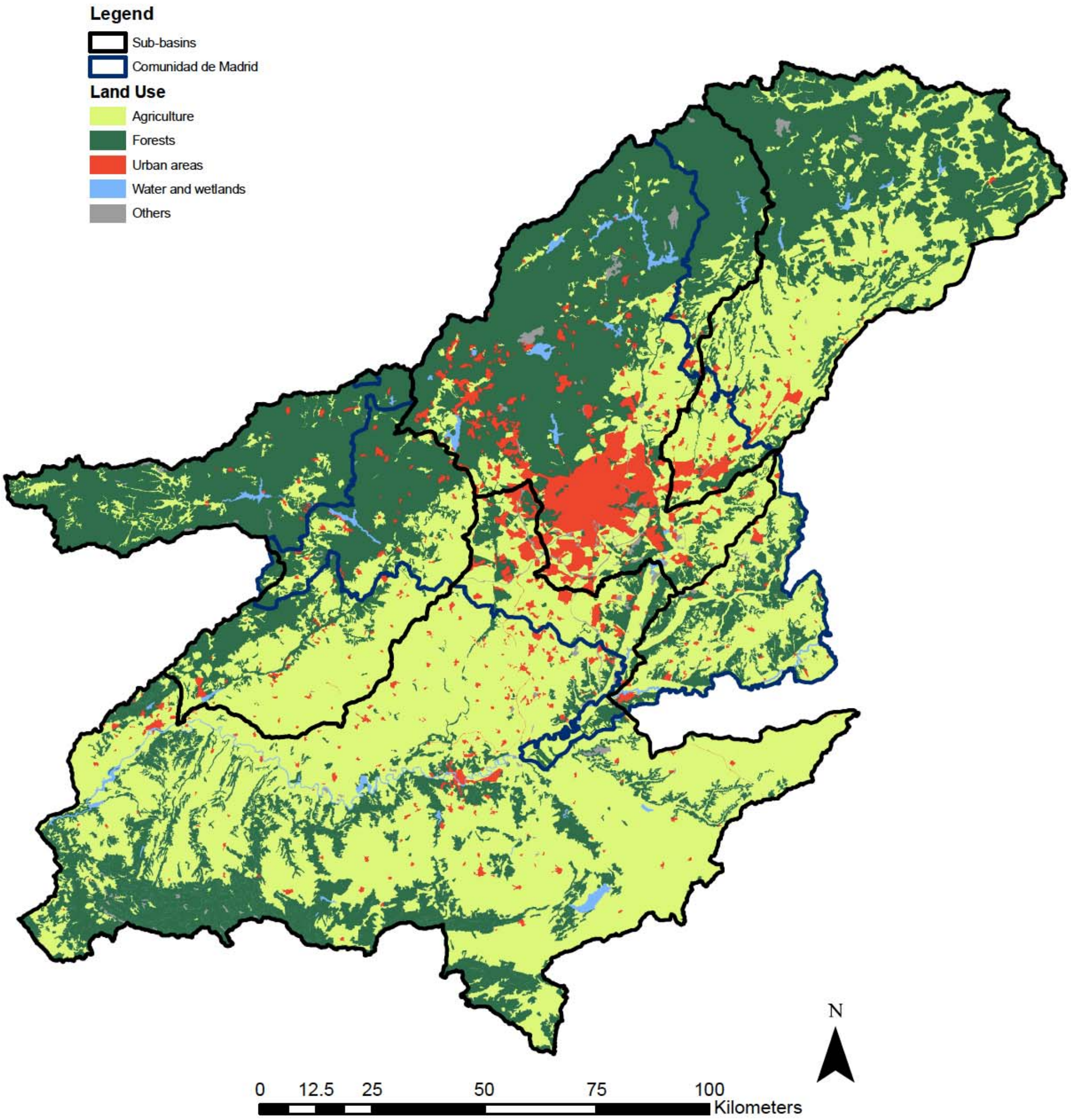
Land use/Year	1990	2000	2006	Land use change, 1990-2006 (%)
Agriculture	49.21%	48.39%	46.70%	5.1%
Forests	45.27%	43.36%	43.38%	-4.18%
Urban areas	4.28%	6.71%	8.23%	92.28%
Water and wetlands	0.61%	0.61%	0.61%	17.92%
Others	0.63%	0.94%	1.08%	71.92%
Total	100.00%	100.00%	100.00%	-

Source: Own elaboration from Ministry of Public Works, 2011 and Tagus River Basin Authority, 2011

Table 0-5 - Agricultural Land Use, Talavera agricultural district

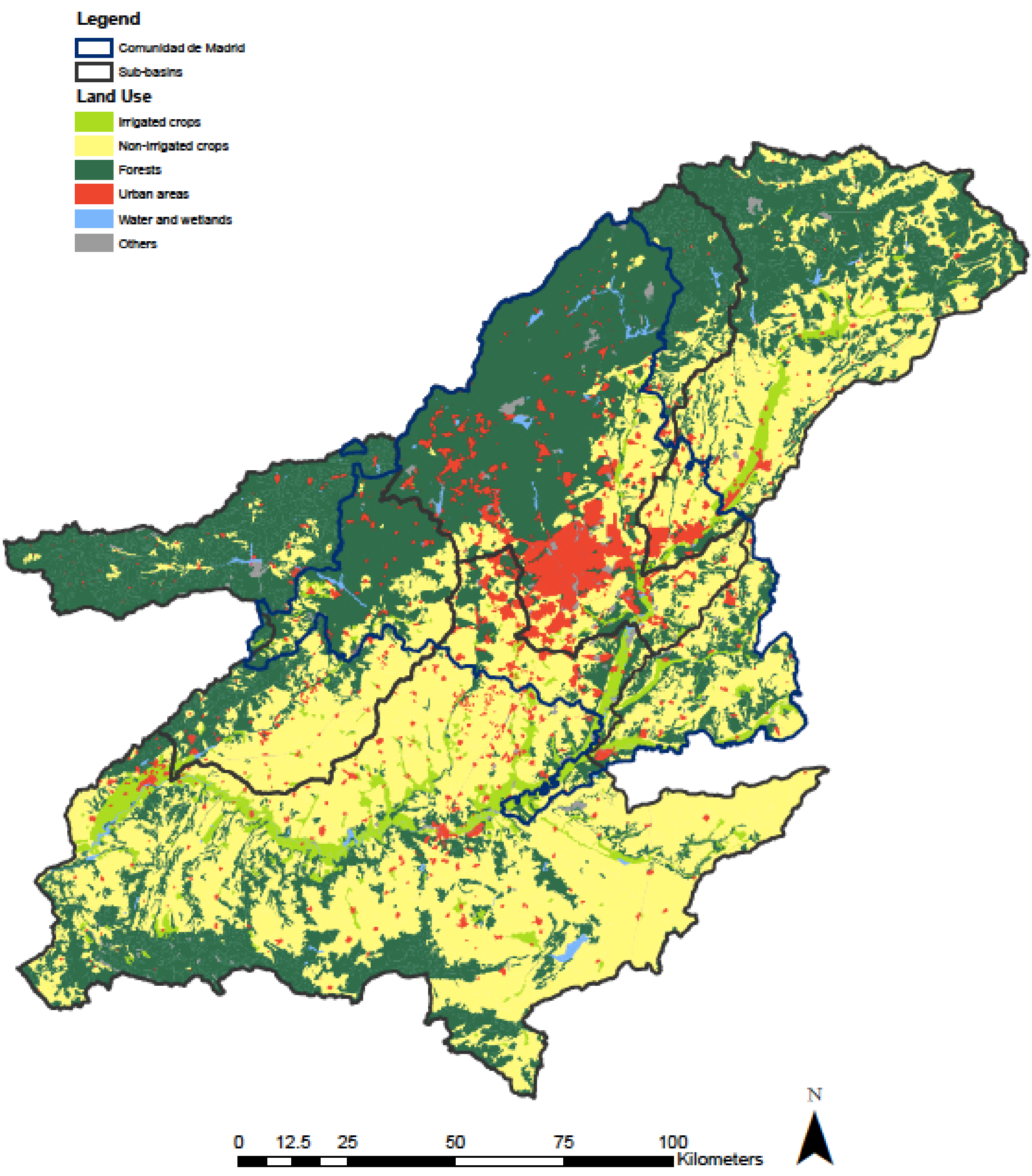
Crop	Irrigated (ha)	Percentage of total surface	Non-irrigated (ha)	Percentage of total surface	Total (ha)	Percentage of total surface
Oats	1 962	3.67%	11 433	21.38%	13 395	25.05%
Wheat	1 517	2.84%	8 624	16.13%	10 141	18.97%
Olive tree-olive oil	504	0.94%	8 341	15.60%	8 845	16.54%
Corn	5 744	10.74%	0	0.00%	5 744	10.74%
Barley	1 965	3.68%	3 365	6.29%	5 330	9.97%
Vetch	17	0.03%	2 996	5.60%	3 013	5.64%
Vineyard - wine grape	447	0.84%	2 149	4.02%	2 596	4.86%
Watermelon	74	0.14%	974	1.82%	1 048	1.96%
Pea	649	1.21%	137	0.26%	786	1.47%
Bitter vetch	19	0.04%	712	1.33%	731	1.37%
Melon	338	0.63%	228	0.43%	566	1.06%
Sunflower	375	0.70%	103	0.19%	478	0.89%
Onion	194	0.36%	0	0.00%	194	0.36%
Pepper	171	0.32%	0	0.00%	171	0.32%
Cabbage	145	0.27%	0	0.00%	145	0.27%
Cauliflower	123	0.23%	0	0.00%	123	0.23%
Lettuce	111	0.21%	0	0.00%	111	0.21%
Garlic	47	0.09%	0	0.00%	47	0.09%
Carrot	4	0.01%	0	0.00%	4	0.01%
Total	14 406	26.94%	39 062	73.06%	53 468	100.00%

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)



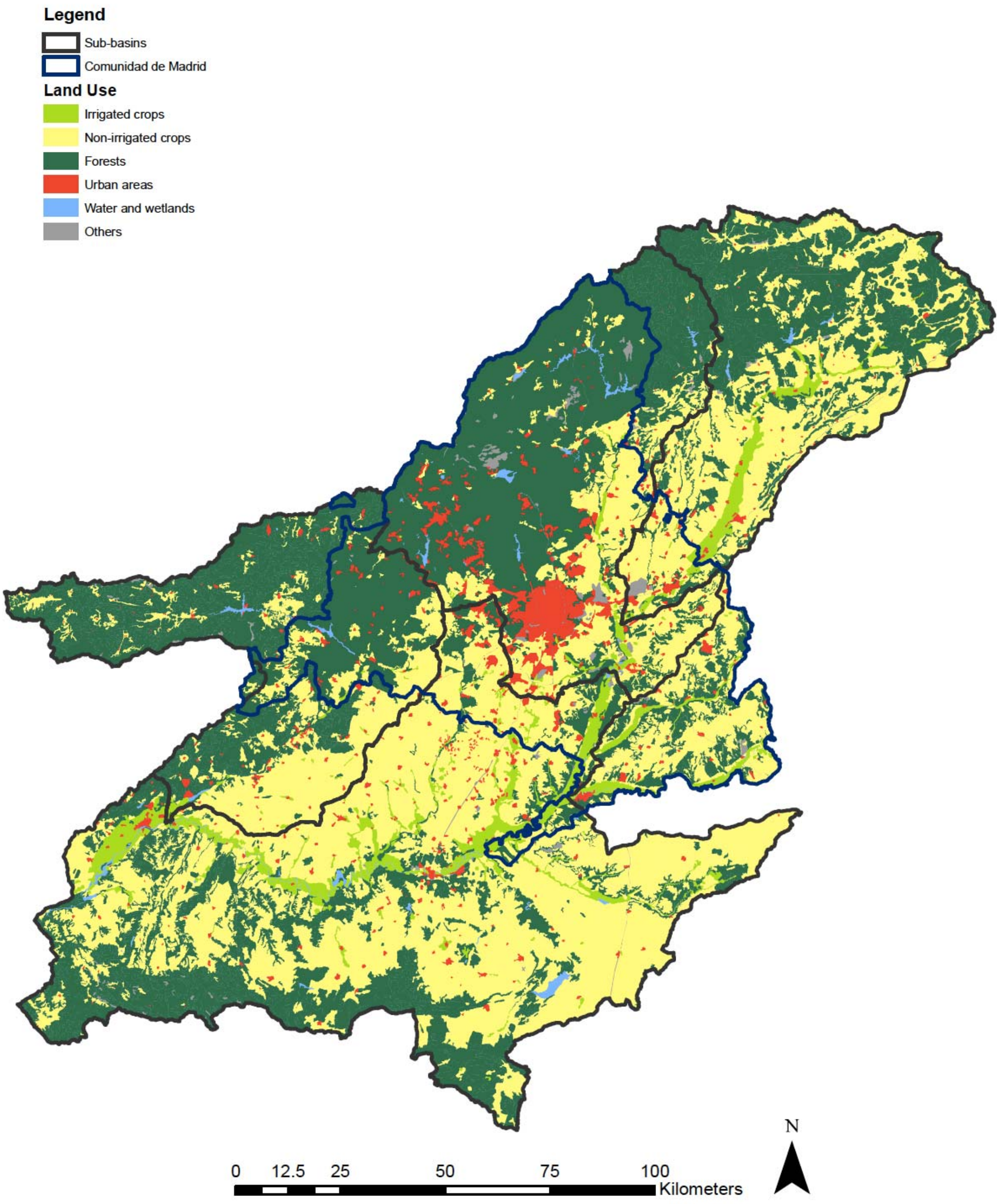
Map 0.1 - Land use in the area of study, 2006

Sources: Own elaboration from Corine Land Cover 1990, 2000 and 2006 (Ministry of Public Works, 2011) and Tagus River Basin Authority (CHT), 2011



Map 0.2 - Land use in the area of study, 2000

Sources: Own elaboration from Corine Land Cover 1990, 2000 and 2006 (Ministry of Public Works, 2011) and Tagus River Basin Authority (CHT), 2011



Map 0.3 - Map Land use in the area of study, 1990

Sources: Own elaboration from Corine Land Cover 1990, 2000 and 2006 (Ministry of Public Works, 2011) and Tagus River Basin Authority (CHT), 2011

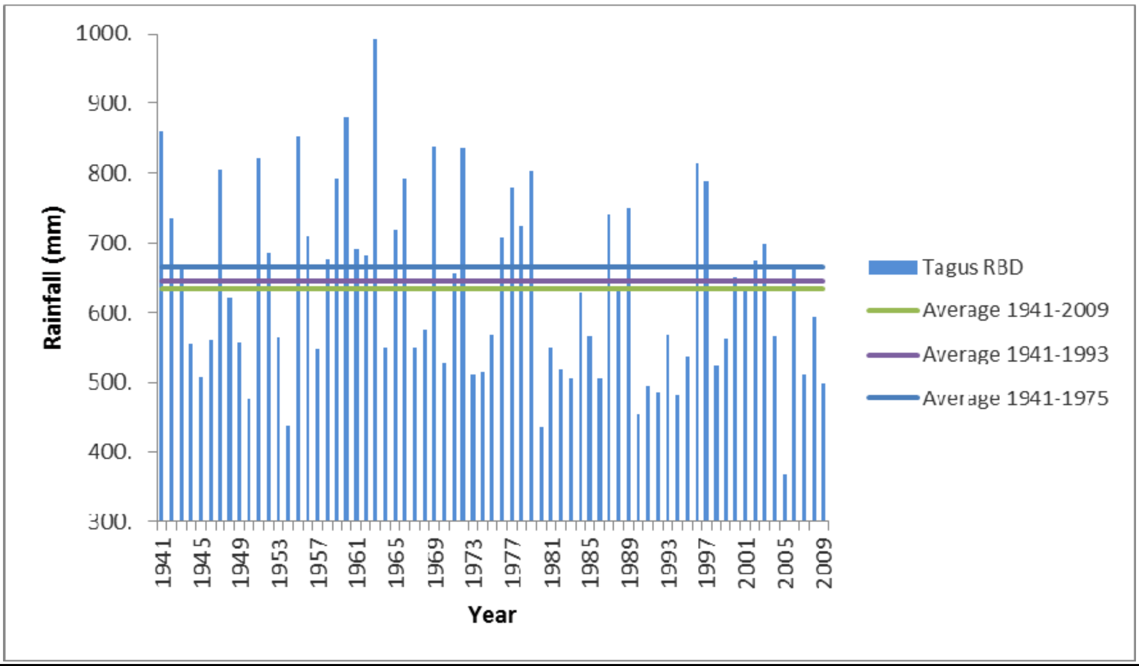


Figure 0-1 - Annual rainfall and long-term averages, Tagus River Basin (mm, 1953-2010)

Source: Own elaboration from Ministry of the Environment, 2011

As it has been said, the drought of the beginning of the 1990s in the Tagus river basin is recalled for its long duration and its intensity. Comparing annual rainfall average with the historical average, there was a reduction of 23.1% for the 5-year period. Regarding to net contributions, and comparing same groups of data, the reduction for the period was 46.6%. The first and fourth years of the period were almost normal (1990-1991 recorded a reduction of 15.1% and 1993-1994 of just 1.8%); the other three were remarkably dry (75.1%, 73.9% and 67.1% reductions, respectively). Alberche River showed a decrease of 10.8% (1990-91), 78,5% (1991-92), 73.3% (1992-1993), 6.1% (1993-1994), 83.7% (1994-1995), and an average drop of 50.5% for the period.

Regarding the drought of the hydrological year 2004-2005, the average annual precipitation was 344.5 mm (and 45% of it fell in October), the lowest record since 1940-1941. The estimated contribution for that year in the Tagus river basin was between 3 000 and 3 500 hm3 (there was only one year that recorded contributions below 3 000 hm3 and five years under 3 500 hm3).

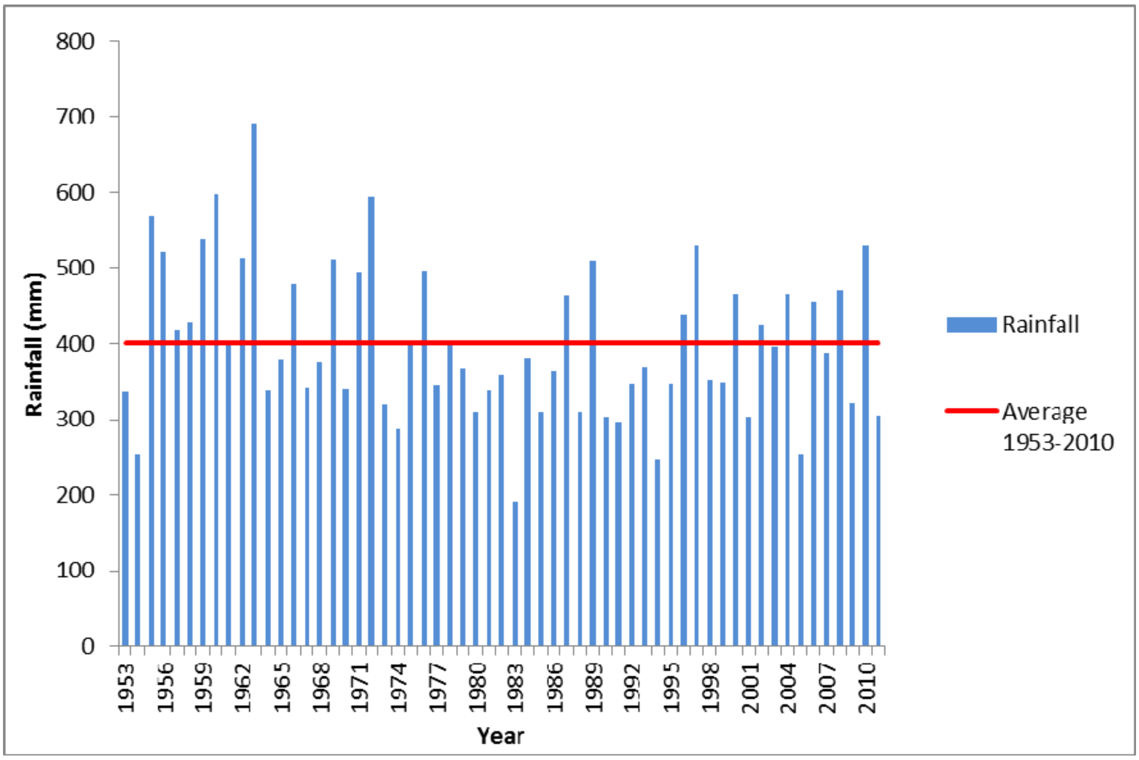


Figure 0-2 - Annual rainfall and long-term average Henares Corridor (mm, 1953-2010)

Source: · Own elaboration from Agencia Española de Meteorología (AEMET), 2011

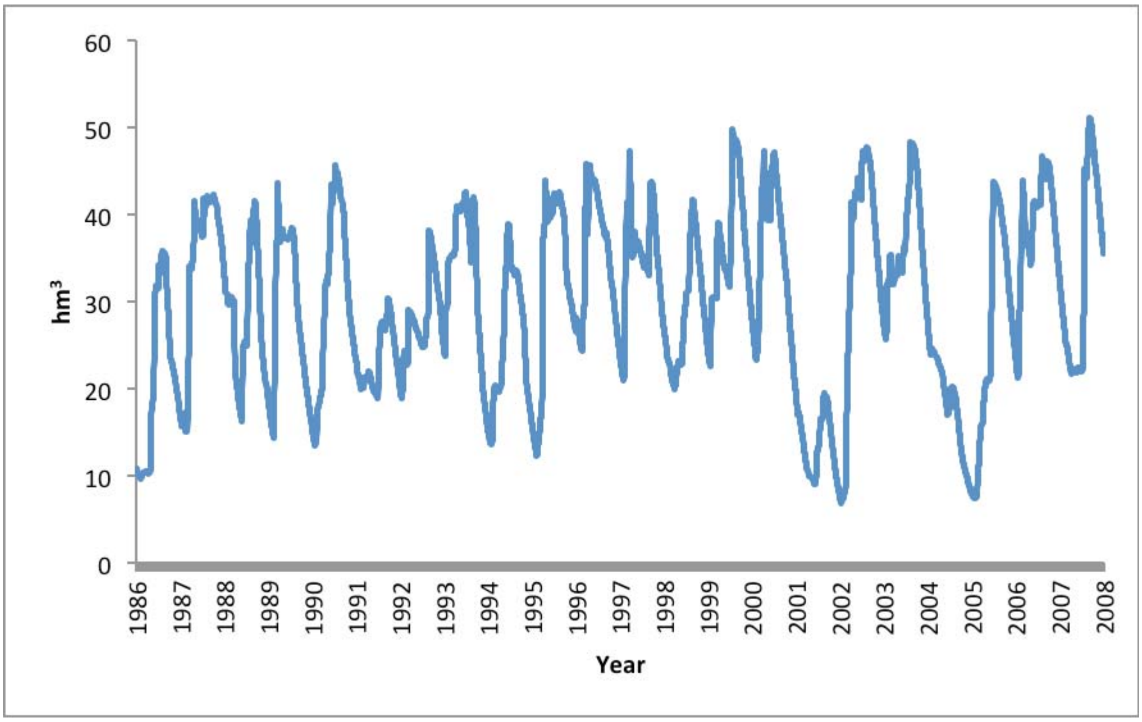


Figure 0-3 - Water stock in Beleña dam, 1986-2008

Source: Own elaboration from Ministry of Public Works, 2011

Regarding contributions to Beleña dam, the historical average was 173 hm^3 while the recorded amount for that year was 39 hm3. The TRBA defined a drought pattern in which the average contribution should be 32.52 hm3 or less. During 2004-2005 the MAS system declared pre-alert status in February, alert in May, and alarm in June, reaching a volume in September of 15.09% of the dam's capacity.

Table 0-6 · Reservoirs managed by the Canal de Isabel II 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

Notes: (1) The old dam, with a capacity of 45 hm^3, was operating from 1907 to 1969, when the new dam was built. It started operating in 1971.

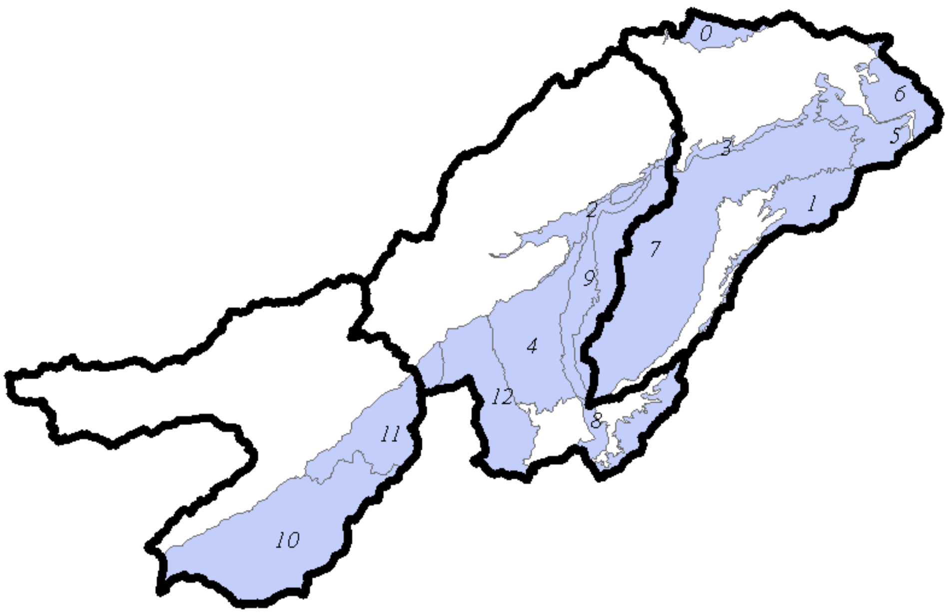
Table 0-7 · Groundwater resources, Madrid Region: qualitative and quantitative state

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

Groundwater sources serve to meet only a marginal part of urban water demand (20 hm^3 on average between 1995 and 2006) and are used as buffer stocks during drought periods when abstractions 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. As it can be inferred from above, 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.



Name	Code number
Cabecera del Bornova	0
La Alcarria	1
Torrelaguna	2
Madrid: Manzanares-Jarama	4
Jadraque	5
Sigüenza-Maranchón	6
Tajuña-Montes Universales	6
Guadalajara	7
Aluvial 3: Jarama-Tajuña	8
Talavera	10
Madrid: Aldea del Fresno-Manzanares	11
Madrid: Guadarrama-Manzanares	12

Figure 0-4 - Groundwater units: Jarama, Guadarrama, Henares and Alberche sub-basins

Source: Own elaboration from Ministry of Public Works, 2011 and Tagus River Basin Authority, 2011

Table 0-8 - Urban water demand, Mancomunidad de Aguas del Sorbe, 1971-2010

Year	Demand (hm^3)	Water demand variation (%)[1]
1971	3.3	-
1980	18.3	454.55%
1990	31.7	73.22%
2000	43.3	36.59%
2009	43.2	-0.23%
2010	47.1	9.03%

Source: Tagus River Basin Authority, 2011

Notes: (1) After its establishment in 1970, the Mancomunidad de Aguas del Sorbe supplied water to the municipalities of Alcalá de Henares, Guadalajara, Azuqueca de Henares, Yunquera de Henares, Alovera, Fontanar y Mohernando. After 1980 the following municipalities have been added to the Mancomunidad: Cabanillas del Campo, Humanes, Quer, Tórtola de Henares, Villanueva de la Torre, Marchamalo, the Mancomunidad de La Muela (21 municipalities) and the Mancomunidad de la Campiña Baja (4 municipalities). During many years the Mancomunidad de Aguas del Sorbe also supplied water for the municipalities of Meco and Cogolludo.

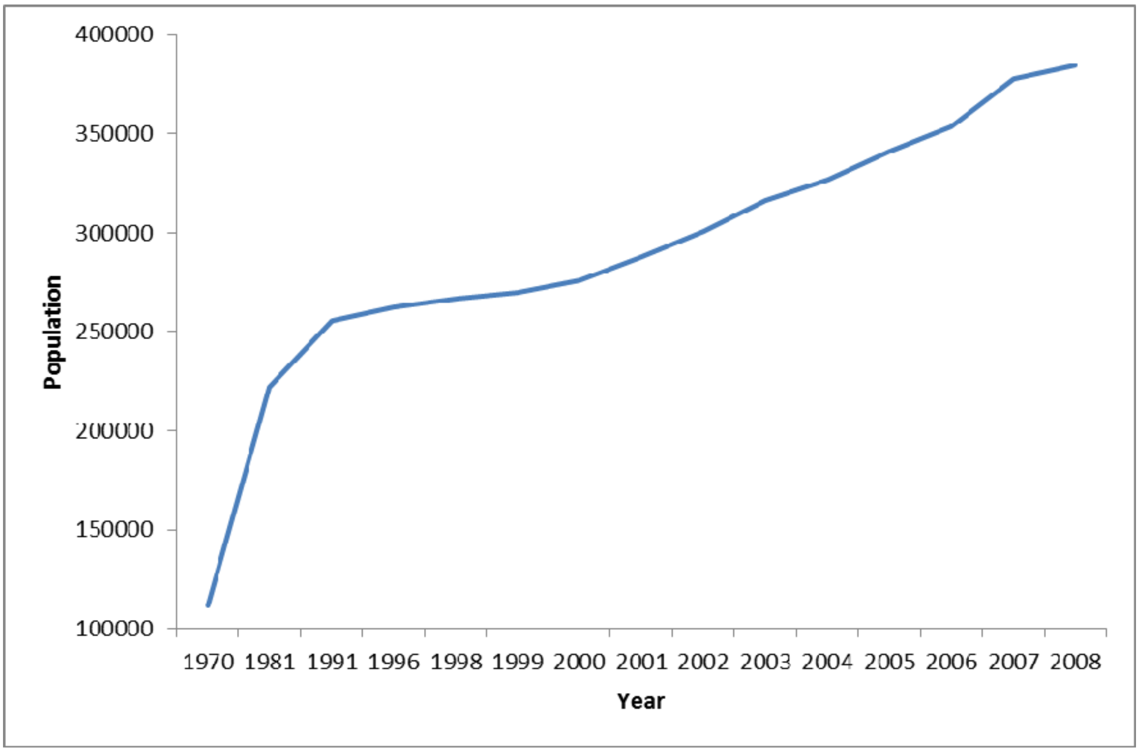


Figure 0-5 - Population growth 1971-2008, Mancomunidad de Aguas del Sorbe

Source: Mancomunidad de Aguas del Sorbe, 2011

Table 0-9 - Financial analysis of irrigated crops, La Campiña agricultural district

Crop	Surface	Total income (€/ha)	GVA[1], market prices (€/ha)	NVA [2], market prices (€/ha)	NVA[2], factor cost (€/ha)	Production (kg/ha)
Corn	2 807	2 007.16	666.56	636.61	947.32	11 034.00
Barley	2 722	872.70	72.08	42.14	384.66	3 923.50
Pea	2 304	200.86	-118.58	-148.52	-149.81	996.05
Wheat	1 729	986.33	132.65	102.71	460.91	4 135.15
Sunflower	444	941.94	71.32	41.38	473.48	2 000.20
Oats	77	602.48	-81.43	-111.37	86.65	2 927.45
Olive tree-olive oil	16	768.57	261.30	139.84	321.46	1 165.00
Pepper	14	18 186.16	16 166.11	16 136.16	16 101.19	23 315.55
Tomato	13	21 304.25	18 344.07	18 304.82	19 583.08	42 000.00
Onion	9	5 963.32	4 701.12	4 671.18	4 669.66	36 194.95
Garlic	7	9 834.20	7 468.89	7 438.95	7 636.35	9 225.45
Cabbage	7	9 225.12	8 176.79	8 146.85	8 127.10	27 980.00
Vineyard - wine grape	6	1 620.78	1 327.77	1 144.88	1 134.30	3 370.00
Vetch	5	560.43	-43.22	-73.16	171.43	1537.10
Bitter vetch	3	516.55	-137.80	-158.44	118.85	1525.00
Melon	2	6 987.98	5 393.07	5 363.13	5 360.45	23 790.95
Cauliflower	1	8 678.77	6 942.73	6 922.09	6 901.54	21 900.00
Lettuce	1	8 183.12	7 458.06	7 418.81	7 399.89	20 200.00
Total/Average	**10 167**	**1 123.06**	**2 406.01**	**995.51**	**5 068.12**	**10 617.28**

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)

Notes: (1) Gross Value Added, including depreciation; (2) Net Value Added, excluding depreciation

According to recent evidence, irrigated crops get an average income of 1 123.06 €/ha, with important variations amongst crops. Corn, which covers the widest area, produces an average income of 2 000 €/ha while barley obtains less than 900 and peas less than 200. These three crops share 95% of the area; the rest is covered by some more profitable as well as more water demanding vegetables. As an indicator of the value of water, it can be said that the average income obtained per cubic meter amounts to EUR 0.19, but 23% of the irrigated surface using 30% of the water might be generating an income lower than 0.04 €/m^3. The importance of water for irrigation can be observed if comparing the previous figures those of rainfed agriculture, covering around 120 000 hectares and gaining 490 €/ha on average. For example, for the case of the most common crop, both under irrigated and rainfed agriculture, irrigation facilities and water represent a shift from 460 to 2 000 €/ha of income and an increase from 2 300 to 11 000 kg of average yield

Table 0-10 - Water cost and consumption in agriculture, La Campiña agricultural district

Crop	% of water costs over total income	Average water demand (m^3/ha)
Corn	8.35%	9 467.16
Barley	19.30%	4 589.77

Pea	100.85%	N/A
Wheat	17.03%	3 507.29
Sunflower	18.07%	4 596.60
Oats	27.92%	2 275.25
Olive tree-olive oil	22.95%	3 170.02
Pepper	0.92%	3 314.91
Tomato	0.83%	9 708.40
Onion	2.82%	4 337.13
Garlic	1.72%	2 409.24
Cabbage	1.82%	1 713.68
Vineyard - wine grape	10.88%	2 632.35
Vetch	31.22%	N/A
Bitter vetch	30.76%	N/A
Melon	2.41%	5 331.79
Cauliflower	1.83%	N/A
Lettuce	2.16%	6 464.12
Total surface/Average	17.81%	4 688.9

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)

Table 0-11 - Financial analysis of rainfed crops, La Campiña agricultural district

Crop	Surface	Total income (€/ha)	GVA[1], market prices (€/ha)	NVA[2], market prices (€/ha)	NVA[2], factor cost (€/ha)	Production (kg/ha)
Barley	62 034	460.06	110.27	110.27	249.09	2 382.60
Wheat	23 906	530.84	108.45	108.45	267.46	2 455.45
Olive tree-olive oil	17 622	410.68	230.27	187.09	283.98	622.50
Sunflower	5 220	316.25	55.98	55.98	212.63	626.20
Vineyard - wine grape	3 712	1 645.69	1 515.08	1 393.73	1 379.16	3 421.80
Oats	3 039	375.69	61.69	61.69	185.10	1 825.50
Pea	1 911	123.98	17.41	17.41	16.72	614.80
Vetch	714	261.07	41.00	41.00	154.82	716.05
Bitter vetch	553	302.04	12.32	12.32	174.46	891.70
Melon	39	1 880.85	1 492.60	1 492.60	1 491.63	6 403.45
Total surface/Average	118 750	488.69	166.08	155.88	285.81	2033

Source: Own elaboration

Notes: (1) Gross Value Added, including depreciation; (2) Net Value Added, excluding depreciation

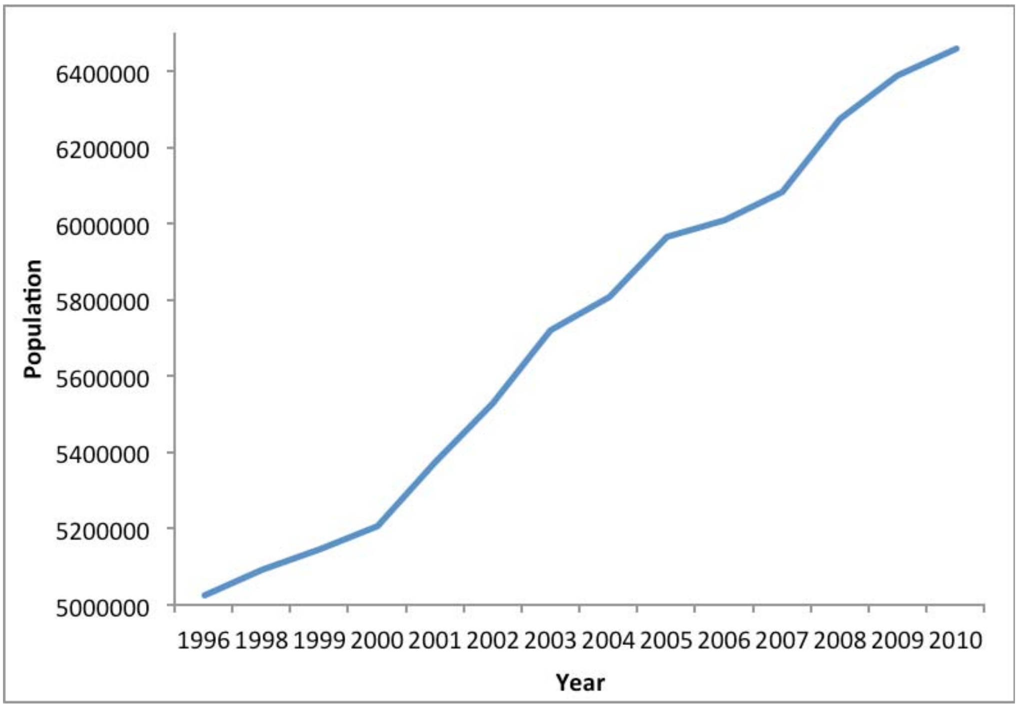


Figure 0-6 - Population growth 1996-2010, Region of Madrid

Source: INE, 2011

In the region of Madrid population has grown by almost 1.5 million people within the last 15 years, from 5 022 000 inhabitants in 1996 to 6 458 000 inhabitants in 2010, at an average annual rate of 2.04%. Population density has also risen from 625 to 805 inhabitants/km^2. The attracting power of the Madrid area is explained by the rapid economic growth at an average rate of 3.28% until the end of 2007 (a few months before the last recession started). 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).

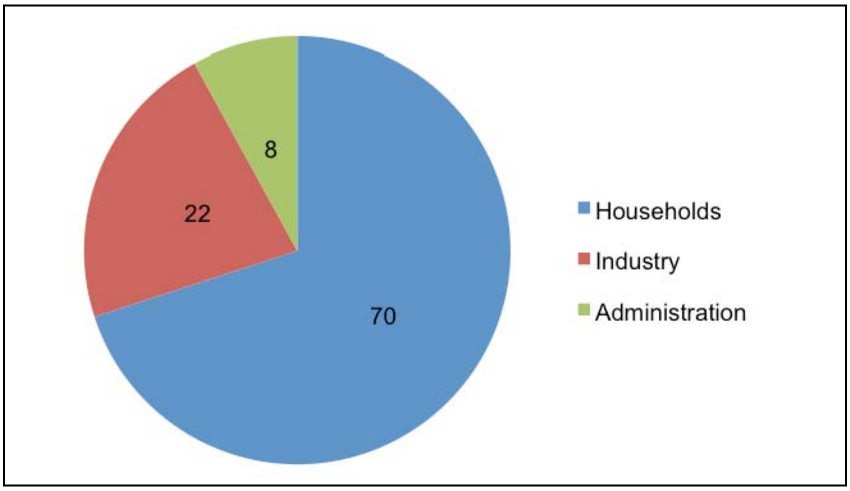


Figure 0-7 - MAS main water demand.

MAS main water demand comes from households (70%), followed by industrial uses in the Henares Corridor (22%) and the public sector (8%).

In the Henares Canal (La Campiña agricultural district) annual demand for irrigation during the last decade is estimated at 65.5 hm^3/year (TRBA, 2008; 2010), although it is expected to decrease as irrigated land in this area is progressively being substituted by other land uses, mainly urban and industrial (TRBA, 2010).

Table 0-12 - Gross Value Added (GVA) by sector and year, Region of Madrid, 1995-2010

Economic sector/Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture	0.25%	0.29%	0.30%	0.29%	0.29%	0.28%	0.25%	0.26%	0.27%	0.22%	0.19%	0.18%	0.17%	0.15%	0.15%	0.16%
Energy	3.49%	3.36%	3.16%	2.71%	2.47%	1.96%	1.93%	1.84%	2.03%	2.06%	2.32%	2.53%	2.59%	2.79%	2.80%	2.91%
Industry	14.40%	14.60%	14.80%	14.45%	14.43%	14.11%	13.53%	12.70%	12.06%	11.64%	11.28%	10.98%	10.55%	10.09%	9.07%	8.70%
Building sector	7.18%	7.10%	6.74%	6.71%	6.99%	7.33%	7.75%	8.26%	8.78%	9.39%	10.33%	10.62%	10.33%	9.95%	9.32%	8.52%
Services	74.68%	74.65%	75.01%	75.84%	75.82%	76.32%	76.54%	76.93%	76.85%	76.69%	75.89%	75.69%	76.36%	77.02%	78.65%	79.72%
GVA (1,000,000 of €)	69 023	73 221	78 228	85 239	91 781	100 670	109 609	117 366	125 081	133 881	143 866	155 614	167 256	176 707	176 418	174 231

Source: INE, 2011

Table 0-13 - Financial analysis of irrigated crops, Talavera agricultural district

Crop	Surface	Total income (€/ha)	GVA[1], market prices (€/ha)	NVA[2], market prices (€/ha)	NVA[2], factor cost (€/ha)	Production (kg/ha)
Corn	5 744	1 860.61	609.18	560.94	848.96	10 228.40
Barley	1 965	862.45	72.79	24.56	363.05	3 877.40
Oats	1 962	530.13	-88.26	-136.49	37.75	2 575.90
Wheat	1 517	845.06	93.17	44.94	351.84	3 542.90
Pea	649	329.69	-83.61	-131.85	-133.95	1 634.90
Olive tree-olive oil	504	1 979.75	963.24	703.24	1 171.06	3 000.90
Vineyard - wine grape	447	5 304.55	4 758.66	4 240.30	4 205.67	11 029.50
Sunflower	375	691.41	11.29	-36.94	280.24	1 468.20
Melon	338	6 053.63	4 653.09	4 604.85	4 602.53	20 609.90
Onion	194	9 247.75	7 386.20	7 337.96	7 335.61	56 130.10
Pepper	171	19 842.06	17 656.86	17 608.63	17 570.47	25 438.50
Cabbage	145	13 178.28	11 756.06	11 707.83	11 679.61	39 970.00
Cauliflower	123	11 792.43	9 485.34	9 437.10	9 409.18	29 757.00
Lettuce	111	12 574.46	11 567.20	11 518.96	11 489.89	31 040.00
Watermelon	74	5 079.12	3 787.26	3 739.03	3 727.07	22 599.70
Garlic	47	9 585.02	7 278.92	7 230.69	7 423.09	8 991.70
Bitter vetch	19	449.62	-145.74	-193.98	47.38	1 327.40
Vetch	17	519.30	-48.82	-97.05	129.59	1 424.30
Carrot	4	14 508.72	12 235.63	12 187.40	12 163.43	60 727.10
Total surface/Average	14 406	2 182,31	1 181,51	1 111,28	1 351,66	8 492,83

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)

Notes: (1) Gross Value Added, including depreciation; (2) Net Value Added, excluding depreciation

Irrigated lands located in the Alberche Canal area account for 10 000 ha, which is the 69.42% of the agricultural district /Talavera) that it belongs to. Main crops in the irrigation district are oats (25.05%), wheat (18.97%), olive trees for olive oil production (16.54%) and corn (10.74%).

The average income obtained in the Talavera agricultural district in the Alberche is about twice that of the Henares (2 180 €/ha) and although cereals still account for three quarters of the irrigated area, crops are more diversified than in the Henares. Average income per cubic meter is 0.32 € with lower variations than in the Henares. The dominant crop is also corn, which covers 40% of the irrigated area, uses 45% of the water, and obtains an estimate of 0.22 €/m^3.

Table 0-14 - Water cost and consumption in agriculture, Talavera agricultural district

Crop	% of water costs over total income	Average water demand (m³/ha)
Corn	8,82%	8 288,97
Barley	19,03%	2 887,64
Oats	30,95%	2 647,42
Wheat	19,42%	3 023,18
Pea	49,77%	1 941,15
Olive tree-olive oil	8,29%	2 847,40
Vineyard - wine grape	3,09%	4 605,54
Sunflower	23,73%	4 118,79
Melon	2,71%	N/A
Onion	1,77%	N/A
Pepper	0,83%	6 039,68
Cabbage	1,25%	N/A
Cauliflower	1,39%	N/A
Lettuce	1,30%	N/A
Watermelon	3,23%	N/A
Garlic	1,71%	N/A
Bitter vetch	36,50%	N/A
Vetch	31,60%	N/A
Carrot	1,13%	N/A
Average	12.97%	4 886.67

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)

Table 0-15 · Financial analysis of rainfed crops, Talavera agricultural district

Crop	Surface	Total income (€/ha)	GVA1, market prices (€/ha)	NVA2, market prices (€/ha)	NVA2, factor cost (€/ha)	Production (kg/ha)
Oats	11 433	265.57	43.61	43.61	130.84	1 290.40
Wheat	8 624	325.71	66.54	66.54	164.11	1 506.60
Olive tree-olive oil	8 341	777.41	435.91	354.17	537.58	1 178.40
Barley	3 365	394.68	94.60	94.60	213.69	2 044.00
Vetch	2 996	221.10	34.73	34.73	131.11	606.40
Vineyard - wine grape	2 149	2 070.07	1 905.79	1 753.14	1 734.81	4 304.20
Watermelon	974	1 888.74	1 446.60	1 446.60	1 441.96	8 404.00
Bitter vetch	712	252.62	10.31	10.31	145.92	745.80
Melon	228	1 163.15	923.05	923.05	922.45	3 960.00
Pea	137	162.70	22.85	22.85	21.94	806.80
Sunflower	103	236.86	41.93	41.93	159.25	469.00
Total surface/Average	**39 062**	**540.17**	**278.03**	**252.18**	**357.72**	**1 671.65**

Source: Own elaboration from MODERE Database (Ministry of the Environment, 2007)

Notes: (1) Gross Value Added, including depreciation; (2) Net Value Added, excluding depreciation

7. Annex II: Pedigree analysis

Table 8-1- Pedigree table, environmental objectives.

	Policy target[1]	Policy deadline[2]	Reference[3]
Guarantee urban water demand	Supply urban water demand	No deadline	Urban water demand, 1996-2009
Pedigree	2	3	1

Source: Own elaboration

Notes: (1) Policy target: [1] quantifiable and clearly stated, [2] measurable in principle, qualitative levels of achievements (e.g. weak, substantial), [3] vague and hardly quantifiable; (2) Policy deadline: [1] clearly stated, [2] stated in qualitative terms (short, medium, long term), [3] no statement; (3) Reference: [1] clearly stated in quantitative terms and with specific reference, [2] not stated.

Table 8-2- Pedigree table, performance of policy instruments.

	Satisfaction of domestic water demand	Satisfaction of urban water demand by economic sector	Satisfaction of irrigation water	Efficiency	Distributional effects	Urban water quality	Quantitative status - surface water	Quantitative status - Groundwater	Financial costs
EPI: Guarantee urban water demand	Population water demand evolution (Hm^3)	Urban water demand evolution by economic sector(Hm^3)	Irrigation water demand evolution (Hm^3)	Water productivity dynamics (€/l)	Rainfed agricultural income and irrigation income (€/ha)	Perception of the quality of water supplied by agents	Evolution of abstractions (Hm^3)	Evolution of abstractions (Hm^3)	Costs in €
Proxy[1]	4	4	2	4	3	3	4	4	4
Empirical[2]	4	4	2	4	4	3	4	4	4
Method[3]	4	3	3	3	3	3	4	4	4

Source: Own elaboration

Notes: : (1)Proxy: 4, exact measure; 3, Good fit or measure; 2, well correlated; 1, weak correlation; 0, not clearly related; (2) Empirical: 4, Large sample, direct measurements; 3, small sample, direct measurements; 2, modeled/derived data; 1, educated guesses/rule of thumb estimate; 0, crude speculation; (3) Method: 4, Best available practice; 3, reliable method commonly accepted; 2, acceptable method, limited consensus on reliability; 1; preliminary methods, unknown reliability; 0, no discernible rigor.

8. Annex III: Contributors to the report/ Acknowledgments

This report has been produced with substantive contributions from Carlos M. Gómez, Gonzalo Delacámara, Carlos D. Pérez, Estefanía Ibáñez, and Miguel Solanes (all researchers at IMDEA).

We would like to acknowledge valuable comments from Davide Viaggi and Laura Sardonini from UNIBO with relevant questions on economic outcomes, Christophe Viavatanne and Joanna Pardoe from MU (on distributional effects and social equity), David Zetland from WU (on institutions and transaction costs), Hans-Peter Weikard also on transaction costs, Jennifer Möller-Gulland and Manuel Lago from Ecologic (on policy implementability and the overall approach to the assessment), and Jaroslav Mysiak (on uncertainty). We also thank Mikael Skou Andersen his comments to the executive summary.

A consultation process with key stakeholders was carried out. We acknowledge insightful contributions from Bernardo López Camacho, Director of Water Planning of the Tagus River Basin Authority and Jose Antonio Iglesias, Head of the Groundwater Prospecting Division of the CYII public utility.