Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

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Voluntary intersectoral water transfer at Llobregat River Basin.

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Executive Summary

Definition of the analysed EPI and purpose

The voluntary intersectoral water transfer is focused on water management. By the use of reclaimed water by farmers, freshwater can be released and used for the higher quality urban supply. In this way, the availability of water is guaranteed for irrigation purposes and in the metropolitan area of Barcelona. Since intersectoral water transfer is integrated in a broader context (integrated water resources management) it also enables the water quality of the Llobregat aquifer to be improved and domestic water consumption decreased.

The main objectives of the instrument are: (i) to ensure the supply of water for urban and agricultural demands and so enabling increased economic activity; (ii) improve river flow, the creation of a hydraulic barrier against seawater intrusion and maintenance and restoration of wetlands; and (iii) increased income for farmers. No specific quantitative targets were defined.

The research interest in this case is based on:

- The potential of extrapolation to other EU areas in which there is a growing water demand with different quality requirements while facing droughts.
- Demonstrating that if institutional and regulatory frameworks are adequate, it is possible to reach agreements among water users for improving the management of the water resources available in an area.
- Providing an example in which transaction costs are affordable since negotiation benefits all water users.

The implementation of the EPI started in 2009 after the adoption of the Catalonian Water Reuse Program. No assessments of the outcomes of implementation have been made until now. The current version of the EPI is the result of a well designed and planned process.

Introduction

The EPI has been implemented in the Llobregat Delta which is located in the NE of Spain. It is an area with endemic water shortages and includes the Barcelona metropolitan area, the second largest city in Spain. The need to improve the availability of water was highlighted during the severe drought of 2007-2008.

Voluntary intersectoral water transfers was considered as the cheapest alternative to guarantee the water availability for irrigation and domestic purposes and also to improve the water quality of the Llobregat aquifer.

After the implementation of the instrument, and as a consequence of the important environmental education campaign carried out, domestic water consumption in the city of Barcelona in the period 2000-2010 has decreased from 133 to 107 litres per capita per day and the seawater intrusion in Llobregat aquifer has decreased noticeably. As regards economic impacts, the income of farmers has increased as a consequence of the abandonment of rain-fed agriculture and the use of reclaimed water for irrigation. The water supply company has saved costs since it has been able to avoid water transfer from remote sources.

This instrument can be considered relevant as it can be adopted in other areas with water scarcity problems, because it is adaptable to local circumstances and can be modified ex-post implementation.

Legislative setting and economic background

Because the instrument is based on negotiation and cooperation between farmers and the water administration it was not adopted by legislation; although the adoption of the Catalonian Water Reuse Program was key for the development of the EPI.

For the success of the instrument it is not necessary to consider and compensate external impacts although some of the benefits derived from the implementation of the EPI are environmental. However, these benefits have not been quantified and included in the economic assessment.

Voluntary intersectoral water transfer is affected significantly by institutional constraints. National and regional legislation relative to wastewater reuse imposes the quality criteria that regenerated water must meet. Hence, the cost of reclaimed water, and therefore the economic assessment of the instrument is indirectly determined by legislation. Information also plays an important role since to increase the willingness of farmers to use reclaimed water, they had to made aware of the advantages and disadvantages of its use.

The EPI has been introduced in the context of an economic crisis. Hence, it was essential to ensure cost recovery. The cost of regenerating the water is paid by for by domestic users in application of the polluter pays principle. However, the cost of distributing the regenerated water is paid by farmers since they profit from its use. In this way, the cost recovery of the process is ensured.

The farmers affected by the instrument do not obtain agricultural subsidies, therefore, there are no economic distortions in the implementation of the EPI and no vested interests.

Water rights were not well defined in the area. Traditionally farmers can draw a fixed quantity of water (1.5 m^3/s) in normal periods, and in periods of water shortage this volume was reduced (0.8 m^3/s). The water administration was aware that this was an inconvenience for farmers because crops were not guaranteed. Moreover, if

severe droughts occurred in the future, the water flow for irrigation could be further restricted because domestic use has priority.

Brief description of results and impacts of the proposed EPI

The EPI has succeeded because since farmers have started to use reclaimed water, and so freshwater has been released. Hence, the availability of water for the Barcelona metropolitan area has improved and for irrigation has been guaranteed even in summer so the income of farmers has increased. Moreover, water consumption for domestic use has decreased and the water quality of the Llobregat aquifer has improved. All of these outcomes have been achieved by employing the cheapest alternative.

Concerning the economic efficiency, the use of water regenerated in the Sant Feliu del Llobregat WWTP has increased the income of farmers by 20%. The item that most contributes to this increase is the abandonment of rain fed agriculture, and the use of reclaimed water for irrigation. In this case, the investment of one euro in the use of reclaimed water creates an income increase in agriculture of approximately EUR 1.6.

In the case of El Prat de Llobregat, there are no changes in yield and sales revenue in spite of the improvement in water availability. The use of regenerated water enables farmers' income to increase by 5%. The most important cost saving is associated with the avoidance of pumping surface and groundwater. The investment of one euro in the use of reclaimed water yields an agricultural income of 1.9 euros.

The total net profit of water transfer when considering the farmers and the city is around EUR 16 million per annum and this shows that despite the fact that the water reclamation costs are not offset by the added values in agriculture (farmers´ cost savings and increased sales revenues), the use of reclaimed water in agriculture is economically efficient due to high level of profits resulting from the intersectoral water transfer.

Regarding the environmental sustainability, an improvement in the aquifer for all parameters related to seawater intrusion has been verified. Moreover, indirectly the implementation of the EPI has involved a decrease in domestic water consumption as a consequence of the increased level environmental awareness by users.

From the social point of view, the main stakeholders in the project were farmers, the water company of the metropolitan area of Barcelona, the water administrations (at regional and local level), and the environmental administration. Because the intersectoral water transfer was made between farmers and the city, a cooperation and negotiation process between farmers and the water supply company was essential.

The implementation of the EPI has not altered the employment levels for farmers although their income has increased. As a key actor, farmers have actively participated in the decision-making process, and feel that the administration has

taken into account their interests before adopting final decisions in the framework of water management.

The second main stakeholder in the process was the water administration at regional and local levels. Both administrations cooperated in the design and implementation of the instrument. Once it has been implemented, the local administration is responsible for monitoring since it has powers for urban water supply and for wastewater treatment.

When the EPI was being designed, the environmental and economic outcomes were vaguely defined and had no quantitative target. Hence, it is impossible to quantify the difference between the intended and actual outcomes.

Conclusions and lessons learnt

The main lessons learnt from this instrument are as follows: (i) the implementation of the voluntary intersectoral water transfer has enabled users to be made aware citizens about water scarcity problems. Significant water savings have been produced as a consequence of their behaviour; (ii) the EPI was designed in order to increase the benefits for both farmers and municipalities. It has been proved mutually beneficial. This issue was one of the key aspects for the success of the instrument; (iii) considering the opinion of farmers from the beginning of the process and not trying to impose any policy was key for the success of the EPI; (iv) the institutional framework for developing the instrument is wide. The careful definition of regenerated water uses and quality criteria has eased the design and implementation of the EPI; (v) voluntary intersectoral water transfer is a flexible instrument because it enables negotiation between the parties involved in the agreement and adaptation to local circumstances including ex post adaptations; (vi) the ex-ante transaction costs are the costs associated with the negotiation between the parties. The ex-post costs are associated with the monitoring of the quality of the reclaimed water. Both types of transaction costs are insignificant; and (vii) the uncertainty is mainly associated with the environmental outcomes derived from the implementation of the EPI.

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1 EPI Background

Taking into account the concept of Integrated Water Resources Management (IWRM) the voluntary intersectoral water exchange constitutes a key instrument to improve the water management in those watersheds where different water uses compete.

The Llobregat delta is a valuable habitat, but is also under relentless pressure from the city´s urban and industrial growth. The river has become highly polluted and degraded, and the important groundwater aquifer, is suffering seawater intrusion. However, since the Directive 91/271/ECC, the situation has been improving with a comprehensive program of wastewater treatment along the river.

To improve the water management and taking advantage of the existence of several high capacity WWTPs, the regional water authority (Catalonian Water Agency, ACA) planned to expand the use of the treated WWTP effluents in the area for agricultural irrigation and other purposes.

The use of reclaimed water in agriculture avoids the use of river water and therefore there is more river water available for domestic supply, and the conveyance of water from remote sources is avoided. In this context, the ACA decided to promote the voluntary intersectoral water transfer between farmers (who release freshwater) and cities (who provide reclaimed water).

The main objectives can be described as follows:

- Economic objective: ensure the supply of water for urban and agricultural demands that will enable an increase in economic activity.
- Environmental objective: improve the river flow, create a hydraulic barrier against seawater intrusion, and maintain and restore wetlands.
- Social objective: To increase the income of the farmers.

Taking into account the capacity of the two main WWTPs in the area it was decided that the total volume of water to be reused would be around 44 hm^3/yr. Farmers need to be convinced of the value of the exchange for themselves, the benefits of more reliable water supply, the savings of groundwater pumping, and that the nutrients in the effluent are sufficiently firm to offset the possible health hazard, the impact on local amenities, and the risk of produce restrictions.

By considering the irrigation needs and the financial constraints, the administration decided that the total volume of regenerated water for irrigation purposes should be around 20.5 hm^3/yr. Hence, it prevents a deflection of river water which can then be used for domestic water supply. To achieve the environmental objectives, 10.4 hm^3/yr of treated water is released to maintain the river stream flow, 6.3 hm^3/yr for the restoration of wetlands, and 0.9 hm^3/yr to improve the quality of the Llobregat aquifer as the regenerated water is used as a barrier to the seawater.

From an economic point of view, the voluntary intersectoral water transfer is a plausible solution. By far the largest benefit is the value of the extra freshwater made available for the city. Nevertheless, the benefit to farmers is also positive. It is important highlight that the strategy of IWRM also involves significant environmental benefits.

No safeguarding mechanisms to avoid negative side effects were considered because it was considered that voluntary intersectoral water transfer benefits all the parties involved.

The improvement in the quality of the water from the aquifer of the Llobregat as a result of its recharge with reclaimed water has only been evaluated in general terms.

The voluntary intersectoral water transfer was non-controversial since it is a cooperative mechanism between farmers, the administration, and indirectly users. The severe drought in the years 2007-2008 showed that it was necessary to take measures to improve the availability of water in the area. Farmers were aware declining to use regenerated water could mean that in the near future that they would not have enough water to ensure harvests.

In Spain, the Royal Decree 1620/2007 of 7 December, establishes a legal and compulsory framework for the reuse of regenerated water. The norm defines the parameters that regenerated water must fulfil to be used for various purposes.

However, we should take into account that the LRB is an intraregional basin and therefore the powers for water management belong to the regional government. To fulfil the objectives of the Catalonian Urban Wastewater Treatment Program of 2005, the Catalonian Water Reuse Program was adopted in 2009. The main objective of the program is to encourage water reuse as an activity in the public interest. The objective of the program is to reuse 204 hm^3 in the year 2014. To achieve this, an investment of 373 million euros was planned with annual operating costs of 12.7 million euros.

The ACA has defined a generic protocol for public participation by all interested parties which involves dissemination material and briefings with farmers, municipalities and environmental organisations.

The experience of the Llobregat delta has shown that the most successful strategy was to communicate with all stakeholders from the very start. The best communication policy was is to implement a participative strategy.

There were no unexpected events that influenced the performance of the instrument.

2 Characterisation of the case study area (or relevant river basin district)

The LRB is situated in the NE part of Spain adjacent to Barcelona (Figure 9.1). The basin covers an area of 4 948 km^2, and is about 156.5 km in length. The river Llobregat has two main tributaries, the Cardener River and Anoia River, and all three receive effluent from various wastewater treatment plants (WWTPs). Nevertheless, this study is focused on the delta of the Llobregat River which lies to the south of Barcelona city and covers about 100 km^2. In spite of its close proximity to the city, it is a valuable natural habitat and its wetlands are of international importance for wildlife. The delta aquifer is one of the most important freshwater resources for Barcelona region, with a groundwater capacity of 100 hm^3/yr, and is used by numerous industries, agriculture, and the metropolitan area of Barcelona.

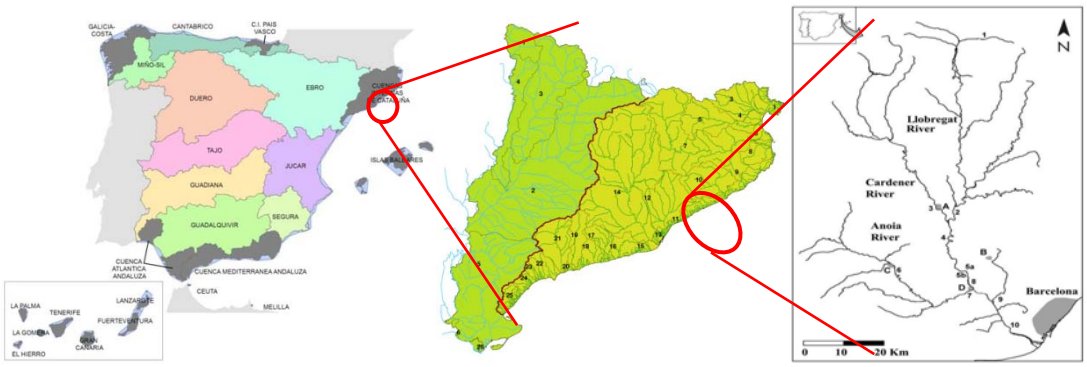

Figure 9.1- Location of Llobregat River Basin

Source: Catalonian Water Agency (ACA), 2011

Since the 1960s, the delta has been under constant pressure from Barcelona´s urban and industrial expansion. In this context, less than 5 % of the original wetlands in the area now remain and in some municipalities half of agricultural land has been lost in the last decade.

By the end of the 1980s, the Llobregat River was one of the most polluted and degraded in Western Europe. The river experiences periodic floods and droughts which lead to frequent morphological variations in the river bed.

The Llobregat River is the main source of irrigation water, via the Canal de la Dreta, which provides water extracted from the middle course of the river to horticulture (19 hm^3/yr), and a small amount via the Canal de la Infanta. Normally, the limit for agricultural use of water from the Llobregat river is 1.5 m^3/s, but in periods of water shortage this use is reduced to 0.8 m^3/s. At such times, the farmers are obliged to use treated wastewater.

At present, during drought conditions, the extraction of the Llobregat aquifers exceeds the natural recharge of 5.6 hm^3/yr. This over-exploitation has led to a new

policy aimed at restoring the river basin´s natural state and this policy is based partly on the reclamation and the reuse of treated wastewater.

In the study area there are two main wastewater treatment plants (WWTPs): the Sant Feliu de Llobregat WWTP and El Prat de Llobregat WWTP, both with tertiary treatment. A third WWTP operates on the western edge of the delta at Gavà-Viladecans (see Figure 9.2).

Figure 9.2- WWTPs located in Llobregat River Basin

Source: Cazurra et al., (2008)

Effluent from the Sant Feliu de Llobregat WWTP is around 19 hm^3/yr and can be used for irrigation purposes on the right side of the Llobregat delta. The Prat de Llobregat WWTP generates 40 hm^3/yr of treated wastewater that can be used to supply the ecological flow of the lower part of Llobregat river, and to provide water for agricultural irrigation and to the wetlands in the delta areas. An important part of the reclaimed flow is also used to create a hydraulic barrier to seawater intrusion in the Llobregat lower delta aquifer. The treated effluent from the Gavà-Viladecans WWTP is channeled to local farmers who pump it for their own purposes. This effluent is not used directly for irrigation, but is used for stabilizing the hydrological balance in this area. Some of the effluent is also used to recharge wetlands.

From an administrative point of view, the delta of the Llobregat river contains two districts: Baix Llobregat and Barcelonés. The main municipalities of the Baix Llobregat are San Viçent dels Horts, El Prat de Llobregat, Sant Feliu de Llobregat, and Gavà. Barcelona is the most important city of the Barcelonés. Therefore, the economic characterisation of the area of study will focus on these main municipalities.

The total population of the area is around 2 000 000 inhabitants. The average population density is around 14 617 inhabitants/km^2. As is shown in Table 9.1, Barcelona city is mostly responsible for the high population density. Because of this, there is a high demand for water in the area mainly for urban use, but also for environmental and agricultural uses.

Table 9.1- Population and population density in the main municipalities of the Llobregat delta

Municipality	Area (km^2)	Population (Inhabitant)	Population density (Inhabitant/km^2)
Gavà	30.8	46 386	1 508.4
El Prat de Llobregat	31.4	63 434	2 019.5
San Viçent	9.1	28 024	3 072.8
San Feliu	11.8	43 112	3 647.4
Barcelona	101.4	1 619 337	15 977.7
TOTAL	184.5	1 800 293	

Source: Catalonian Statistical Institute, (idescat) 2011

The main economic activity in the area of study is services since approximately 75% of the gross value added is generated by this activity. Agriculture has a very small weight in the gross value added. Table 9.2 shows that the trend is an increasing importance for the sector services, especially for Barcelonés district.

Table 9.2- Gross value added at market prices by sector in percentage

District	Year	Agriculture	Industry	Services
Baix Llobregat	**2001**	0.2	40.9	59.0
	2006	0.2	39.2	60.6
Barcelonés	**2001**	0.0	25.1	74.9
	2006	0.0	20.7	79.2
TOTAL	**2001**	0.1	26.6	73.3
	2006	0.1	22.6	77.3

Source: Catalonian Statistical Institute, (idescat) (2011)

To conclude the economic characterisation of the area, Table 9.3 shows the gross domestic production for years 2001 and 2006. The difference in the GDP per capita for Barcelonés and Baix Llobregat districts was unchanged in the study timeframe since for both years Barcelonés showed a GDP per capita that was 10% higher than Baix Llobregat.

Table 9.3- Gross domestic production for the districts of the Llobregat delta

District	Year	GDP (Million EUR)	GDP per capita (EUR/person)
Baix Llobregat	**2001**	19 263.1	26 235
	2006	21 576.4	28 000
Barcelonés	**2001**	63 215.3	29 021
	2006	68 068.4	30 700
TOTAL	**2001**	82 478.5	28 741
	2006	89 644.8	30 429

Source: Catalonian Statistical Institute, (idescat) (2011)

3 Assessment Criteria

3.1 Environmental outcomes

The year 2000 marked a turning point in the evolution of water demand in the municipal networks of the metropolitan area of Barcelona. In the period 1994-2000 urban water consumption increased by around 10% even though the population remained almost constant. From the year 2000 this trend was reversed, so that despite a population growth of about 115 000 people in the period 2000-2010, water demand was reduced by a 13.5%. Urban water use (Figure 9.3) fell from 133 to 107 litres per capita per day, as a result of user awareness and improved efficiency in the distribution networks.

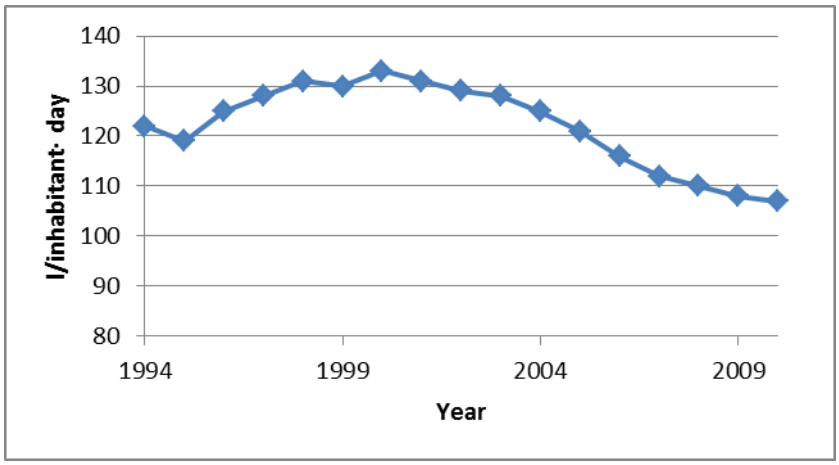

Figure 9.3 Household water demand (l/inhabitant ·day), metropolitan area of Barcelona, 1994-2010

Source: Own elaboration from Metropolitan Area of Barcelona (AMB), 2011

Despite the efforts made by the ACA, there is still a significant deficit with regard to the registration of the flows captured for agricultural uses, especially dependent groundwater. Hence, it is difficult to make an estimation of the water demand based on gauging and accountant records.

Nevertheless, it is estimated that the LRB water demand for irrigation in the last decade was 50 hm^3/yr. However, in drought periods, it was not possible to cope with total water demand. In this context, the use of 20.5 hm^3/yr of reclaimed water for agriculture has increased water security, especially in summer.

It should also be taken into account water that demand for industrial uses in 2007 was approximately 35 hm^3/yr. In the year 2011, this demand stood about 40 hm^3/yr. However, approximately 5.5 hm^3/yr of this demand was satisfied from water regenerated in the WWTP of El Prat de Llobregat.

The Catalonian Water Reuse Program adopted in 2009 by the ACA has involved significant environmental outcomes since the reclaimed water is used mainly for groundwater recharge, augmentation of rivers, irrigation of wetlands, and prevention of seawater intrusion. Hence, the use of regenerated water contributes to the restoration of aquifers and rivers, both in terms of water availability and water quality. Groundwater recharge and raising river flows by using reclaimed water results in an indirect wastewater reuse in agriculture and in an improvement in the water situation for all users in the delta.

As Table 9.4 shows, the reclaimed water from the El Prat and San Feliu WWTPs is used for several purposes. Note that reusing treated wastewater is important not only for agricultural irrigation but also for industrial water use and for enhancing water quality and wetlands.

Table 9.4- Multi-purpose use of reclaimed water in Llobregat Delta

	El Prat de Llobregat WWTP (hm^3/yr)	**Sant Feliu de Llobregat WWTP (hm^3/yr)**
Agriculture	13.09	7.36
River stream flow	10.37	-
Wetlands	6.31	-
Seawater barrier	0.91	-
Municipalities	-	0.11
Recreation	-	0.37
Industry	5.48	-
Total	**36.2**	**7.84**

Source: Cazurra et al., (2008) and Catalonian Water Reuse Program (2009)

It is remarkable that the Canal de la Dreta irrigation canal starts just before Barcelona´s main drinking water treatment plant of Sant Joan Despí. This means that the use of reclaimed water prevents a deflection of river water of around 20.5 hm^3/yr for irrigation purposes, and this water is then used for domestic water supply instead brings water remote sources such as the Ter River.

The use of 20.5 hm^3/yr of reclaimed water for agricultural purposes has entailed energy savings associated with the reduction of pumping groundwater. This saving can be quantified at around 4 000 000 kWh/yr which according to the Spanish national electrical production grid represents a saving of 1 440 Tn of CO_2 equivalent per year. The use of reclaimed water has led to cost savings in chemical fertilizers quantified as 2 170 Tn/yr meaning significant energy savings and an increased the availability of phosphorus – which is a non-renewable resource.

An improvement in the aquifer for all parameters related to seawater intrusion has been verified: sodium, magnesium, sulphate, calcium and potassium. Ammonium levels have also been improved. Arsenic is monitored although its mobilization is unlikely, and nitrates are slightly present in the injected water. The greatest effects of the hydraulic barrier have been detected in the Gearbox Prat well in which the conductivity has conductivity dropped progressively from 16 500 to less than 4 000 µS/cm, meaning that the content in chloride in groundwater has decreased from 6 500 mg/l to less than 1 000 mg/l. Figure 9.4 shows the evolution over time of the electrical conductivity in several wells in the Llobregat aquifer.

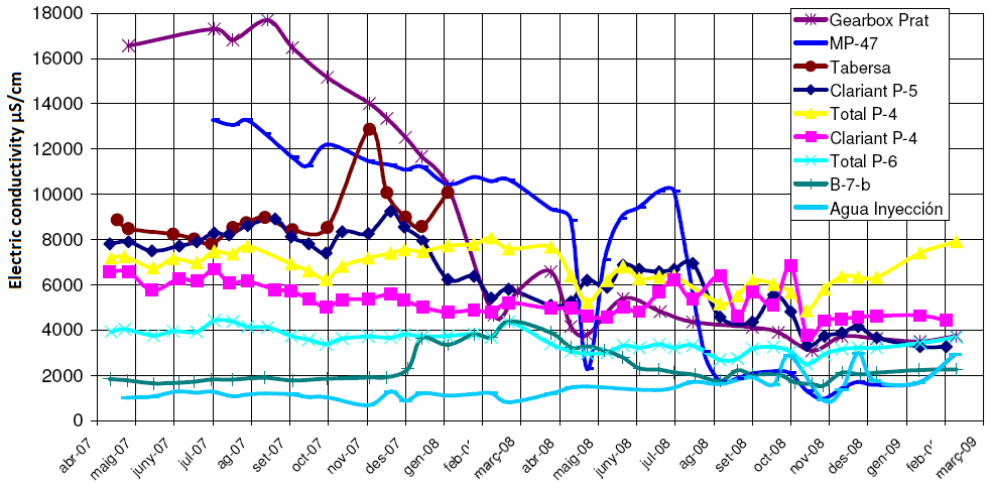

Figure 9.4- Evolution of electrical conductivity in Llobregat aquifer.

Source: Hernández et al., (2011)

Another indicator of the quality of the groundwater of the Llobregat aquifer is the concentration of chlorides. Figure 9.5 shows the differences between the concentration of chloride in May 2007 to May 2009. The water of the hydraulic barrier has travelled in a year a distance of 1 to 2 km from the injection points.

Figure 9.5- Reduction of chlorides at Llobregat aquifer (2007-2009)

Source: *Ortuño et al., (2011)*

3.2 Economic Assessment Criteria

Desalination of sea water and water transfer from other areas are the two alternatives to voluntary intersectoral water transfer to increase the supply of water. It is important to stress that as an exceptional measure due to the severe drought during the summer and fall of 2008 water transfer by boat was proposed.

Table 9.5 shows a summary of the cost of freshwater released by irrigated agriculture in the Llobregat delta. For both areas, El Prat and San Feliu, the average cost of water transfer is approximately 0.34 EUR/m³.

Table 9.5- Cost of freshwater released by irrigated agriculture at Llobregat delta

Annual cost intersectoral water transfer	
El Prat de Llobregat area	5 245 000 EUR/yr for 13 hm³/yr
Sant Feliu de Llobregat area	1 607 000 EUR/yr for 7.3 hm³/yr
Total annual cost	6 852 000 EUR/yr for 20.3 hm³/yr
Average unit cost of water release	**0.34 EUR/m³**

Source: FAO (2010)

The average unit cost of water release may be compared with the unit cost of desalination from seawater that ranges between 0.45 and 1 EUR/m³. Regarding the second alternative, although it was considered only as exceptional measure, its cost was 8.38 EUR/m³ (Correira et al., 2011). Taking into account the cost of the alternatives, the EPI represents the cheapest option and its choice was obvious.

The cost-effectiveness of the water reclamation at Sant Feliu del Llobregat area shows that this strategy has lead to significant savings in groundwater and surface water pumping costs (62 672 EUR/yr) and in fertilizing (10 419 EUR/yr). The abandonment of rain-fed agriculture and the use of reclaimed water for irrigation also has meant a positive change of sales revenue (388 139 EUR/yr) (Table 9.6). These figures verify that even paying the conveyance cost of 208 390 EUR/yr, the income of farmers has increased significantly by 252 840 EUR/yr, i.e. a 20% increase. The investment of one euro in the use of reclaimed water creates an income increase in agriculture of approximately EUR 1.6.

Table 9.6 shows that there are significant positive economic effects in agriculture. Nevertheless, even if there are not, benefits for other water users and the environment should be considered, such as those due to the release of freshwater for cities or due to the lessened discharge of effluents into rivers. As shown below, these benefits can be considerable. They make water reclamation a promising undertaking even if there are no economic benefits (or even losses in agriculture). The consideration of the beneficial impacts going beyond agriculture is subject of the evaluation of intersectoral water transfer between farmers and cities as discussed below.

Table 9.6- Economic impact of the use of reclaimed water for agriculture at Sant Feliu area

	EUR/yr
Change of surface water and groundwater pumping cost	-62 672
Change of fertilizing cost	-10 419
Change of sales revenue	-388 139
Cost of conveying reclaimed water	208 390
Change of irrigation cost	145 718
Change of farmers´ income	**252 840 (20%)**

Source: FAO (2010)

Unlike the Sant Feliu de Llobregat area, in the case of El Prat de Llobregat area there are no changes in yield and sales revenue despite the improved water availability. The saved pumping costs associated with not using surface water and groundwater are 321 177 EUR/yr and saved fertilizer costs 30 017 EUR/yr. Taking into account that the cost of transporting the water is 120 066 EUR/yr, the farmers income increased by around 231 128 EUR/yr or 4.9%. An investment of one euro in the use of reclaimed water yields an income increase in agriculture of 1.9 euros (Table 9.7).

Table 9.7- Economic impacts of use of reclaimed water for agriculture at El Prat area

	EUR/yr
Change of surface water and groundwater pumping cost	-321 177
Change of fertilizing cost	-30 017
Change of sales revenue	0
Cost of conveying reclaimed water	120 066
Change of irrigation cost	201 111
Change of farmers´ income	**231 127 (5%)**

Source: *FAO (2010)*

To assess the economic efficiency of water exchange between farmers (who release freshwater) and cities (who provide reclaimed water) a broader perspective at watershed level is needed. This assessment is to be based on the concepts of IWRM that consider, as far as possible, all water-related issues and their interdependencies.

The IWRM of the ACA concept is embedded in the Catalonian Water Reuse Program in the context of the overall Catalonian Hydrological Plan for internal basins. The Catalonian Water Reuse Program foresees a total budget of 323 million euros and a 31% reuse of the total treated wastewater, amounting to 204 hm^3/yr. The Llobregat Delta is one of the major areas in which IWRM actions have been planned within the Catalonian Water Reuse Program. The aim of this program is to increase water availability and improve the ecological status of the Llobregat River. To achieve this

first objective, reclaimed water will be used to substitute freshwater uses. Water quantity and quality goals are interrelated and will reached by developing and implementing new strategies, including the reduction of water conductivity and restoration of aquifers.

Two different strategies, one for Sant Feliu and the other for El Prat de Llobregat, were assessed in order to verify the economic efficiency of the intersectoral water transfer.

Strategy I (El Prat de Llobregat WWTP) is composed by the following items:

- Desalinating the tertiary effluents from the WWTP El Prat by Electrodialysis Reversal (EDR) at the municipality of Sant Boi.
- Pumping the desalinated effluents to irrigation Canal Dreta.
- Distributing the desalinated effluents to farmlands.
- Releasing freshwater by farmers extracted from the Llobregat River.
- Using the released freshwater for domestic water supply.
- Saving cost of conveying remote sources (Ter River) for domestic water use.
- Saving costs of groundwater extraction for domestic water use.

Strategy II (Sant Feliu de Llobregat) is based on:

- Construction of a new tertiary treatment at the Sant Feliu WWTP (increase in treated water volume, nutrient reduction, sludge digestion).
- Installation of a pipeline network to convey reclaimed water for municipal, recreational, and agricultural use.
- Extension of use of reclaimed water in agricultural irrigation (Infanta Canal at the left bank of Llobregat river).
- Release freshwater by farmers extracted from Infanta Canal.

In case of the El Prat de Llobregat WWTP the freshwater volume released by farmers is 13.1 hm^3/yr multiplied with the domestic water price of 1.11 EUR/m^3 produces a lower estimate of the economic benefit for the city of 14.4 million EUR/yr; the total economic benefit of 14.6 million EUR/yr due to freshwater release is calculated by adding the value added of 231 000 EUR/yr equal to farmers´ income increase. The net benefit resulting from intersectoral water transfer of 9.3 million EUR/yr is calculated by subtracting the total cost of water transfer of 5.2 million EUR/yr (Table 9.8).

Regarding Sant Feliu de Llobregat WWTP (strategy II), the freshwater volume released by farmers of 7.4 hm^3/yr multiplied with the domestic water price of 1.11 EUR/m^3 produces an lower estimate of the economic benefit for the city of 8.1 million EUR/yr; the total economic benefit of 8.4 million EUR/yr due to freshwater release is calculated by adding the value added of 253 000 EUR/yr equal to farmers´ income increase. The net benefit resulting from intersectoral water transfer of 6.8 million

EUR/yr is calculated by subtracting the total cost of water transfer of 1.6 million EUR/yr (Table 9.8).

Table 9.8- Costs and benefits of intersectoral water transfer at Llobregat Delta

	Strategy I El Prat (EUR/yr)	**Strategy II Sant Feliu (EUR/yr)**
Cost of additional treatment (1)	3 685 000	589 000
Cost of conveying water and released freshwater (2)	1 550 000	1 018 000
Total cost of water transfer (3 = 1+2)	5 245 000	1 607 000
Farmers´ income increase (4)	231 000	253 000
City benefit (5)	14 430 000	8 126 000
Total benefit of water transfer (6 = 4+5)	14 631 000	8 379 000
Total net benefit of water transfer (7 = 6-3)	**9 386 000**	**6 772 000**

Source: FAO (2010)

Table 9.8 shows that despite the fact that water reclamation (treatment and conveyance) costs are not offset by the values added in agriculture (farmer cost savings and increased sales revenues), the use of reclaimed water in agriculture is economically efficient due to the high levels of benefits resulting from the intersectoral water transfer. The cost per cubic meter of released freshwater is lower than the water cost for users. In other words, the water exchange between farmers and the city provides additional water at considerably lower cost.

Cost-effectiveness analysis was not made. The main reason for EPI adoption was given by the fact that both farmers and users have increased their benefits. We should also take into account that the Spanish legislation concerning water reuse (Section 3.4) stipulates both quality criteria and the possible uses of reclaimed water.

After the EPI introduction, there was no policy instruments aimed to increase the supply of water. The implementation of the EPI has not lead to a cost saving for water users because farmers and users have to pay the cost of conveying the water and the released freshwater which are 2 568 000 €/yr (Table 9.8). However, the EPI has delivered additional benefits such as an increase in farmers income and an improvement in the water availability for the municipalities. The implementation of the EPI has involved savings in groundwater pumping costs and fertilizer costs.

There were no losers after the implementation of the EPI, and all the parties, mainly farmers and municipalities, are winners since both have obtained a positive net profit.

The voluntary intersectoral water transfer has an important risk-reducing role in the area. Farmers are guarantee the availability of water even in summer when demand is greatest; likewise, farmers are assured that water quality meets quality criteria

determined by legislation. Moreover, the municipalities obtain an additional source of water that can be very useful especially in times of drought.

The cost of the additional treatment for regenerating the treated water is paid by the citizens and the cost of conveying water is paid by farmers, therefore, the EPI has been designed to recover all the costs. The revenue is collected by Metropolitan Area of Barcelona (AMB) which is the institution that manages all the water cycle in the LRB. The revenues are earmarked to pay for the regeneration and distribution of the water.

3.3 Distributional Effects and Social Equity

The main stakeholders of the project were farmers, the water company of the metropolitan area of Barcelona, the water administration (at regional and local level), and the environmental administration. Because the intersectoral water transfer was made between farmers and the city, the cooperation and negotiation process between farmers and the water supply company was essential. As part of the regenerated water is used for environmental purposes the environmental administration was also involved in the project. Based on interviews with farmers organizations and with local administration the following information has provided.

The first step to ensure that the project will develop successfully was to count on the support of the farmers because they would have to stop using the surface and groundwater and start using reclaimed water. For this reason, it was considered key to involve them early in the process by showing them the benefits of the project. The main benefits for farmers are presented below. No health problems been detected as Spanish legislation on the use of reclaimed water (Royal Decree 1620/2007) specifies chemical and microbiological parameters for regenerated water. In any case, during the months prior to the use of reclaimed water, farmers were briefed on some guidelines to keep in mind to avoid any type of health problems. Although education is not essential for the effectiveness of the EPI, it was vital to inform farmers about the benefits to be gained by the use of reclaimed water, and above all explain that the use of this water would not imply quality problems in their products or salinity in the soil. The use of reclaimed water for agricultural purposes has not altered employment levels.

Regarding environmental issues, the main concern of farmers was possible soil salinization due to regenerated water containing high concentration of salts. However, farmers have not noticed any worsening of the soil quality. Because there are major and endemic drought problems in the Llobregat Delta water, and so farmers feel that the use of reclaimed water enables them to ensure their crops even in drought years. This is one of the main causes that prompted farmers to use reclaimed water. Cooperation between farmers and administration has reduced the need of bureaucracy to a minimum. Farmers have actively participated in the decision-making process and they feel that the administration takes into account their interests before adopt final decisions in water management. Farmers feel that

their relationship with the administration has improved. The social connections between farmers themselves have not changed.

The water administration and water supply company are the other stakeholders to take into account because they have to ensure the supply of drinking water. Although the water supply company has to pay the cost of additional water treatment through uses (4 274 000 EUR/yr) and may be unable to benefit fully from extra sales revenue, it has nevertheless increased its income by around 18 000 000 EUR/yr because the existing infrastructure is sufficient to extract and distribute the additional water to the city and so pumping costs are saved. No change in the health of the water administration and water supply company workers has been detected. Because of water scarcity problems, the water administration has launched major education campaigns aimed at reducing the water consumption by domestic users. The administration considers that most important benefit of the intersectoral water transfer is the increase in the availability of water, even in a drought, and this was the main reason for developing the project. The impact of the EPI in the leisure time was neutral since the additional paperwork was insignificant. Employment has been positively influenced by the EPI since additional workers have been hired by the water supply company mainly to meter the supplied water. Employment in the WWTPs also increased since additional workers are needed to supervise and maintain the tertiary treatment for regenerating the treated water.

3.4 Institutions

The regulatory framework of the EPI is composed of different levels which not only relate to institutions with policy-making capacities (EU, state, region and municipalities), but also by the confluence of the regulations governing sanitation and wastewater treatment – and that the regulations on water reuse.

At a European level, Directive 91/271/EEC binds member states to ensure an adequate wastewater treatment in urban agglomerations with more than 2 000 people equivalent. Meanwhile, Directive 2000/60/EC requires the implementation of the necessary measures to achieve a good ecological status of water bodies. Thus, in the most sensitive water bodies, for the achievement of this objective it may be necessary prevent urban discharges through the reuse of treated water.

In Spain, the environment ministry in cooperation with the health ministry promoted in 2007 the Royal Decree 1620/2007 of 7 December, establishing the legal framework for the reuse of regenerated water in Spain. The norm defines the chemical and microbiological parameters that the regenerated water must fulfil to be used for different purposes.

Because LRB is an intraregional basin the responsibility for its management is entirely belongs to the regional administration that is represented by the ACA.

On the other hand, we must not forget that in Catalonia the responsibility in the field of urban water supply belongs to local entities. In the area of the Llobregat delta, this

responsibility is held by the Metropolitan Area of Barcelona (AMB). According to the competences of the AMB, it is the principal responsibility for the intersectoral water transfer developed in the Llobregat delta since it has to ensure the supply of drinking water and operates the WWTPs involved in the project.

Along with the rules, the social acceptance of water reuse is another aspect of great importance for successful EPI implementation. In this sense, given the continuing problems of drought, the local population and the farmers showed a considerable willingness to use reclaimed water, as long as it fulfilled the legal quality criteria.

The existence of extensive legislation in the field of wastewater reuse has affected both the design and implementation of EPI. The fact that Royal Decree 1620/2007 does not allow the use of water regenerated for urban supply, determined the design of the EPI. The Catalonian Water Reuse Program defines general criteria for the repercussion of the water reuse costs, and therefore affects the implementation of EPI.

The EPI has not changed the existing institutions but by using the experience gained in the LRB, the Administration is thinking of implementing the same or similar EPI in other areas which also have drought problems.

Based on its objectives, we can say that voluntary intersectoral water transfer has not failed. However, the stakeholders involved in the process consider that institutions are much too complex, not in respect to the quality required and to process monitoring, but in gaining the necessary permissions for water reuse. Streamlining these procedures might be a very positive step for promoting the implementation of EPI in other areas with similar characteristics.

Even economically efficient water reclamation and water exchange projects can fail due to restrictions that are deeply rooted in societal structures and attitudes. It is necessary to highlight the legal, institutional, economic and social obstacles hampering the implementation of such projects, and to assess the effectiveness of ways to overcome or remove these barriers.

3.5 Policy Implementability

Voluntary intersectoral water transfer is a flexible instrument because it allows negotiation between the parties involved and can be adapted to local circumstances – including ex post adaptations. The quantity of water transferred is adjusted depending on the water requirements of both farmers and city. This flexibility has facilitated the implementation of the EPI. The ACA has defined a generic protocol for the public participation of all interested parties. At an early stage, a database was developed with participants that might be affected as a consequence of the implementation of the EPI. In a second stage, the ACA drew up a specific dissemination of material for the various stakeholders involved. Simultaneously, briefings were conducted with the farmers and the affected municipalities, as well as several environmental organizations. In a third phase, briefings for the general public

were launched with the aim of involving society and improving the acceptance of the use of reclaimed water. This last stage was mainly concerned with future actions for water reuse in other areas.

The experience of the Llobregat delta has shown that the most successful strategy was to undertake a communication policy that addresses all stakeholders from the very first stages. The best way to deal with communication is to implement a participative strategy. Hence, before adopting any measure, the perception of all stakeholders was known. In this way, it was possible adapt the strategy to follow and consequently, litigation processes were minimized. There were not dominant stakeholders which have influenced in the implementation of the EPI.

The EPI was immediately accepted because society in general and farmers in particular were very aware of the serious problems of drought. Although the EPI was not designed collectively, given that it relies on cooperation between farmers and the administration, from the beginning of the process the opinion of the farmers was taken into account since the success of EPI was based on the acceptance of the reclaimed water by farmers.

To implement the EPI, cooperation between the water administration at regional level (ACA) and at a local level (AMB) was necessary since both were involved in the design and implementation process. However, responsibility for the EPI in the 'operation' phase exclusively belongs to the AMB since this administration has competence both in the field of wastewater treatment and water supply. Hence, AMB is responsible for the monitoring of the quality of the regenerated water and to raises the funds for treating and distributing the reclaimed water. The introduction of the EPI has meant no change in the regulatory burden. Because the level of competences in the field of water is well defined in the LRB, it was not necessary to adapt the institutional and financial structures in response of the EPI implementation. In this context, the existence of a clear division of responsibilities for water management had facilitated the implementation of the EPI.

The fact that Directive 91/271/EEC, of 12 May 1991 concerning urban wastewater treatment applies to agglomerations with more than 2 000 people equivalent for treating urban wastewater has favored the implementation of EPI, because as wastewater is already treated, only tertiary treatment is necessary for the regeneration of the water. Taking into account that in some periods, 92% of the flow comes from WWTPs (Muñoz et al., 2009) the ACA has considered that to achieve good ecological status for this water body it is necessary to prevent the discharge of effluent from WWTPs that this decision promoted their reuse. The fact that water reuse constitutes one of the measures to be implemented within the scope of the Water Framework Directive has been an advantage when it comes to the success of the EPI.

Table 9.9-Interaction between the EPI and other relevant policies

EPI Policy Objective: Improve river flow and maintain and restore wetlands		
Other sectorial policies	**Objectives of sectoral policies**	**Synergies and Barriers**
Urban wastewater treatment	The wastewater generated from populations higher than 2 000 people equivalent must be treated by December 2005	+++ Only tertiary treated is necessary for the regeneration of the water.
Water Framework Directive	Achieve the good ecological status of water bodies by December 2015	++ To achieve the objectives of the Water Framework Directive is necessary to prevent the discharge of effluents from WWTPs.

3.6 Transaction Costs

For intersectoral water transfers, the literature does not specifically define the concept of transaction costs. The cost of intersectoral water transfer can be interpreted as a component of the scarcity cost, because this cost is incurred when improving the availability of water for municipal purposes. Thus, water prices should also incorporate the scarcity cost in order to enhance the cost recovery in municipal water supply. In this context, a tax of 0.283 EUR/m^3 for environmental purposes is incorporated in the water price of 1.1 EUR/m^3. This tax levied by the ACA is a charge on water users to guarantee the long-term water supply of towns and improve the quality of both surface and groundwater. As a result, environmental and water scarcity costs are, to some extent, considered.

The main participants involved in the project are farmers and water administration which at regional level is the ACA and at local level is the AMB. The EPI was designed jointly by ACA and AMB since both administrations have competences in water management. The negotiation was between farmers and the administration being the ACA the main supervisor in the implementation process. The monitoring of the EPI corresponds to AMB. The ACA and the AMB share the role of administration but their functions are clearly defined.

The mechanism used to choose the EPI was unclear. However, after the publication of the Catalonian Water Reuse Program in 2009 the implementation of the EPI was carried out.

The selection of this EPI was difficult in the sense of deciding the amount of water that should be regenerated and the percentage that would be allocated to each use. In

doing so, several models were developed to predict the evolution of the concentration of chlorides in the Llobregat aquifer without regenerated water injection and with the injection of different volumes of regenerated water. Nevertheless the uncertainty about the amount of water needed to restore the aquifer was high.

The framework for the EPI is the Catalonian Water Reuse Program since it integrates the objectives, principles and criteria to promote water reuse in Catalonia. The program also includes the economic analysis of several defined projects, however, transactions costs are not considered.

At the same time as the EPI was implemented, the water administration started a campaign to make users aware about the importance of reducing water consumption. It can be said that the ex-ante transaction costs are the costs associated with the negotiation between the parties. Although these costs have not been quantified, it is considered that are not important. As for the ex-post costs, they are associated with the monitoring of the quality of the reclaimed water. Every month the quality of the reclaimed water is assessed in order to check if it fulfils the requirements of the Royal Decree 1620/2007. It is estimated that the annual cost of these analyses is approximately EUR 2 000.

3.7 Uncertainty

The specific objectives of the EPI were not clearly defined when it was designed in the sense that it was difficult to predict the specific environmental outcomes and the increase in economic activity. The major source of uncertainty was associated with the volume of water to be regenerated and the percentage that should be allocated to each use. To narrow such uncertainty, firstly it was studied the volume of water that could be regenerated according to the capacity of the WWTPs and water needs for the regeneration of the aquifer. The future urban water demand in the metropolitan area of Barcelona was then studied and how the intersectoral water transfer could contribute to solving the problems of water scarcity.

After the implementation of the EPI it was confirmed that farmers have slightly increased their income, seawater intrusion in the Llobregat aquifer has been reduced, and the amount of water for urban supply has increased. If the intersectoral water transfer had not been developed successfully, the above-mentioned objectives would have been unfulfilled taking into account the problems of water shortage in the area. If farmers had not used the regenerated water, the salinization problems of the aquifer would have increased and it would have been necessary to bring water from remote sources, at considerable cost, to supply the metropolitan area of Barcelona.

When the EPI was being designed, the environmental and economic outcomes were vaguely defined and had no quantitative target. Hence, it is impossible to quantify the difference between the intended and actual outcomes. If the EPI has not

introduced its objectives would be achieved by the implementation of other alternatives much more expensive.

All the stakeholders considered that the introduction of the instrument was appropriate since it was demostrated to be the cheapest option to guarantee the availability of water for urban and agricultural uses. The introduction of the EPI was not controversial.

4 Conclusions

The severe drought in 2007-2008 in the Llobregat River Basin showed that it was necessary to take measures to improve water availability in the area. The solution had to be suitable from economic and environmental point of view considering the institutional context.

It was identified that voluntary intersectoral water transfer could be a plausible alternative because it would enable a non-conventional water source for irrigation purposes and so release freshwater for urban supply. The comparison of this instrument with other alternatives showed that this was the cheapest option.

4.1 Lessons learnt

The EPI has succeeded because because farmers started to use the reclaimed water and freshwater has been released, and the availability of water for the Barcelona metropolitan area has improved. The income of the farmers has increased and the availability of water for irrigation has been guaranteed even in summer. Water consumption for domestic use has decreased and the water quality of the Llobregat aquifer has increased widely. All of these outcomes have been achieved with the cheapest alternative.

Regarding the criteria of the assessment framework, the lessons learnt can be summarized as follow:

- Environmental outcomes: although there was no a direct objective for the EPI, the implementation of the voluntary intersectoral water transfer has enabled users to be made aware about water scarcity problems. Hence, as a consequence of their behaviour, significant water savings have been produced.
- Economic assessment: the EPI was designed in order to increase the benefits for both farmers and municipalities. The fact that the cost per cubic meter of freshwater released is lower than the water cost for citizens is a key aspect. Hence, the water exchange between farmers and the city provides additional water at considerably lower cost. This issue was one of the key aspects for the success of the instrument.

- Distributional effects and social equity: the cooperation and negotiation process between farmers and water administration was essential. Considering the opinion of farmers from the beginning of the process and not attempting to impose any policy was key for the success of the EPI. The EPI proved successful at providing opportunities to develop strong future cooperation and agreements between farmers and administration since it has been proven mutually beneficial.
- Institutions: the institutional framework for developing the instrument is extensive since it involves norms from EU, state, region and local levels. The clear definition of regenerated water uses and quality criteria has eased the design and implementation of the EPI.
- Policy implementability: voluntary intersectoral water transfer is a flexible instrument because it allows negotiation between the parties involved in the agreement and adaptation to local particularities including ex post adaptations. The instrument has been well accepted by society since most people have become aware of water scarcity problems.
- Transaction costs: In the design of the EPI, transaction costs were not considered. The ex-ante transaction costs are the costs associated with the negotiation between the parties. Although these costs have not been quantified, it is considered that are not important. Ex-post costs are associated with the monitoring of the quality of the reclaimed water and are insignificant.
- Uncertainty: uncertainty is mainly associated to the environmental outcomes derived from the implementation of the EPI. The environmental and economic objectives were vaguely defined and without any quantitative target.

Although it was not a specific objective of the administration, the introduction of the EPI has made an improvement in the public awareness about the serious problems arising from the scarcity of water resources. As a result of this awareness, many users have changed their behavior by adopting measures to save water. In fact, Barcelona is the European city with lowest consumption per capita water for domestic use.

There is no room to improve the design and implementation of the EPI since the design is largely conditioned by legislation (Royal Decree 1620/2007 and Catalonian Water Reuse Program) and the implementation and operation by the willingness of the farmers to accept the use of reclaimed water and the capacity of the WWTPs to produce water with sufficient quality.

4.2 Enabling / Disabling Factors

Taking into account the assessment criteria, three aspects have contributed significantly to the success of the instrument:

1. The institutional context. The fact that Spain and, in particular, Catalonia have specific legislation concerning the reuse of wastewater has been key to the design of the EPI. The fact that the Royal Degree 1620/2007 establishes the permitted uses and the quality of the water regenerated depending on their uses greatly facilitated the design of the EPI. At a regional level, the Catalonian Water Reuse Program lays down criteria to be used to finance projects for reuse. Therefore, the implementation of EPI should follow these basic criteria – albeit with a certain degree of flexibility.
2. Take into account the opinion of the stakeholders from the begining of the process. Since the instrument is voluntary intersectoral water transfer, the first step is to ensure that the project will develop successfully was to count on the support of the farmers because they would have to stop using surface and groundwater and start using reclaimed water. Nevertheless, the support of domestic users is also important since they have to be aware of the serious water scarcity problems. The experience of the Llobregat delta has shown that it is extremely important to undertake a communication policy that involves all the stakeholders from the very first steps. The best way to deal with communication is to implement a participative strategy.
3. The economic assessment of the instrument must be positive for all the parties involved. In the framework of the voluntary intersectoral water transfer, a broad range of strategies can be developed. Experience shows that the negotiation process is developed successfully if the defined strategy enables the generation of positive benefits for all parties involved. In the specific case of the Llobregat, although some farmers initially showed resistance to the use of reclaimed water, when it has shown that their income not fall but through the use of reclaimed water and may even increase, the negotiating process was developed much more easily.

The main disabling factor is the imposition of the administration criteria without the consent of farmers and other stakeholders. In this way, the negotiating process will not be accepted and therefore the EPI will fail in its implementation.

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7 Annexes

Subsequently is presented the matrix regarding distributional effects of the EPI implementation from the point of view of farmers and water supply company.

FARMERS:

Indicator	Direction of change				
	--	-	0	+	++
Material Living Standards					
Health					
Education					
Personal Activities					
Employment					
Environment					
Security					
Political Voice					
Social connections and relationships					

Key

Grades assigned directly by interviewees

WATER SUPPLY COMPANY:

Indicator	Direction of change				
	--	-	0	+	++
Material Living Standards					
Health					
Education					
Personal Activities					
Employment					
Environment					
Security					
Political Voice					
Social connections and relationships					

Key

Grades assigned directly by interviewees

In order to complete the assessment of the uncertainty, pedigree matrices for the environmental outcomes and economic objectives of the instrument are as follow:

Table A.1- Pedigree matrix for environmental outcomes

	Reduction water demand for urban use	**Increase the use of reclaimed water**	**Improve the water quality of Llobregat aquifer**
Objective to be assessed	Not defined	20 hm^3/yr	Not defined
Proxy	3	4	3
Empirical	2	3	3
Method	3	3	3

Table A.2- Pedigree matrix for economic objectives

	Increase farmers´ income	**Improve the availability of water at lowest cost**
Objective to be assessed	Not defined	Not defined
Proxy	2	2
Empirical	2	2
Method	2	2