Presentation of case study
Water markets in Guadalquivir

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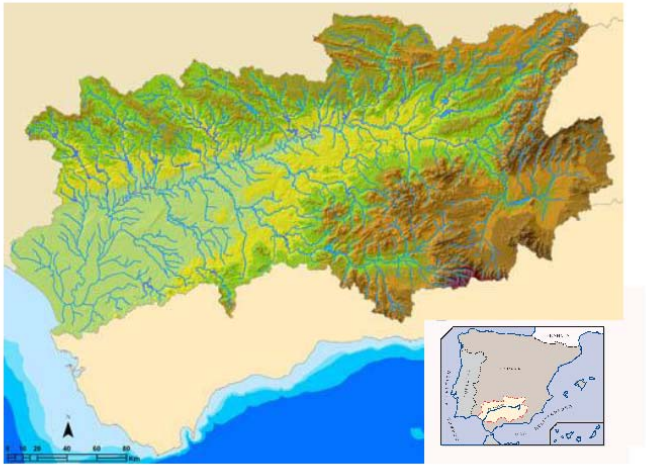
Presentation of the case study area

Location, geography, climate

The Guadalquivir River Basin is the longest in Southern Spain with a length of around 650 km covering an area of 57,527 km^2 with a population of over 4 million people. The basin has a Mediterranean climate with a heterogeneous precipitation distribution. Annual average temperature is 16.8°C and average precipitation 630mm. The most important land uses are forests (49.1%), agriculture (47.2%), urban areas (1.9%) and wetlands (1.8%).

Natural annual flow levels are 6,900 GL for surface water and 2,576 GL for groundwater (Confederación Hidrográfica del Guadalquivir, 2008). About half of these water flows are used mainly in agriculture (80% of volume). Per capita water consumption in the GRB in 2005 was 1,600 m^3. Water consumption is expected to increase by 5 percent in the coming years (Martín-Ortega et al., 2008). Figure 1 illustrates GRB location and physical map

Figure 1. Guadalquivir River basin



Source: Adapted from Confederación Hidrográfica del Guadalquivir, www.chguadalquivir.es

Water resources

The total lenght of rivers is 10.723 km and main populations are Sevilla, Córdoba, Jaén, Granada. The main rivers are are Guadalquivir, Guadiana Menor, Genil, Guadiamar, Jándula, Bembezar. There are 65 damns and the regulation is around 8500 GL. There are an inter.basin transfer (Negratin-Almanzora) that export water from the Guadalquivir to the intensive horticulture in Almeria.

Table 1: Water volume abstracted (2005); Source: CHG (2010)

Origin	Irrigation	Urban	Total
Regulated rivers	2.165,50	358,90	2.524,40
Non regulated rivers	347,00	0,00	347,00
Groundwater	830,00	136,80	966,80
Recycled	30,00	0,00	30,00
Total	3.372,50	495,70	3.868,20

The variability in water resource availability, the increasing demand from different water users and the recurrent droughts lead to episodes of cyclical scarcity. Local and seasonal drought causes aquifer salinisation and environmental stress. Water quality is also a significant problem throughout the river basin. The main sources of pollution include urban and industrial wastewater discharge, erosion, nutrients and pesticide runoff from agricultural land. Concentration levels of Nitrogen, Phosphorus, heavy metals and organic pollutants in surface and groundwater are expected to increase by about 30 percent in the near future (Berbel et al, 2008).

Water uses

Main drivers and water consumption by sectors are summarized in table 2, where it can be seen the growing pressure on resources by a competitive irrigated agriculture (citrus, olive, vegetables,..) and the increasing efficiency in water use per hectare, but the global consumption has grown 1,5% per year reaching the maximum in the year 2008 before implementation of PoM starts. The cities and industry imply a consumption of 12% of resources (against 88% agriculture) and the consumption has grown 0,75% per year and it is also expected to be moderated.

Table 2. Water use per sector (cities, industries, agriculture)

Consumptive Water Use	1.992	2.002	2.008	2015 (PoM)
Irrigation (GL)	2.826	3.209	3.373	3.136
Urban & Industry (GL)	442	486	496	455
Consumption (GL)	3.268	3.695	3.869	3.591
Drivers				
Irrigated area (ha)	410.000	652.867	845.000	885.000
Population	4.074.840	4.158.000	4.200.000	4.242.000
Indicators				
m^3/ha	6.893	4.915	3.991	3.543
L/ha-day	297	320	323	294

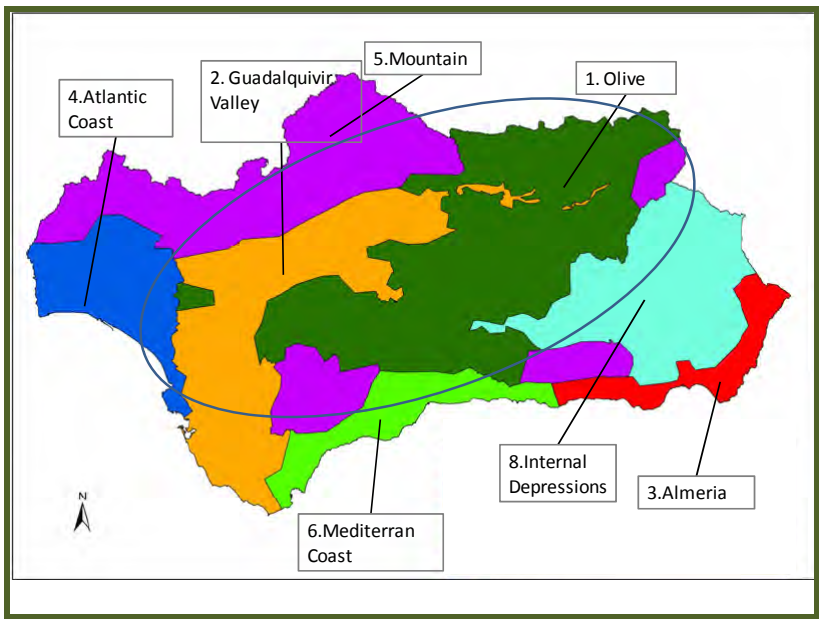
Source: Own elaboration from PoM (CHG, 2010)

The main pressure on water resources comes from irrigation, Next section describes agriculture in the basin.

Agriculture

Agriculture in general in Andalucia where Guadalquivir has 95% of the basin is described in figure 2:

Figure 2: Agricultural systems in Guadalquivir



Source: Consejería de Agricultura (2010) "Agenda del Regadío Andaluz"

In Andalusia the highest value crops is produced in Almeria (greenhouse), Mediterranean Coast (subtropical fruits, and Mediterranean crops) Atlantic coast (citrus and strawberry), Olive irrigated and rain fed in the upper Guadalquivir valley, mixed cropping and extensive irrigation (rice, maize, citrus, cotton, etc.) in the Guadalquivir valley an small Atlantic rivers of Guadalete and Barbate and the lowest value comes from Internal depressions and Mountainous areas that specialized in livestock, forestry and extensive rainfed crops.

The irrigated areas adapt to the agricultural systems described above, and the crops irrigated in the Guadalquivir are detailed in table 3:

Table 3. Guadalquivir river irrigation water use and relative irrigation supply

Crop	[1] Surface (ha)	[2] Average dose (m^3/ha)	[3] ETP-max	[4] RIS-ratio
Olive	380930	2281	3678	0.62
Cotton	77020	6048	8632	0.70
Cereals (winter)	58427	1500	4049	0.37
Vegetables	49886	6104	5918	1.03
Maize	46404	6621	8882	0.75
Fruit trees	24795	5386	3879	1.39
Citrus	22578	5501	4888	1.13
Sugar beet	20185	3730	6732	0.55
Sunflower	18032	1500	4853	0.31
Leguminosae	14806	1500	2215	0.68
Potatoes	12403	5142	5185	0.99
Others	8549	3490	4900	0.71

Alfalfa	6870	5907	10860	0.54
Potatoes mid-season	6129	6342	8574	0.74
Almond	6039	4945	3617	1.37
Forage	5470	1500	3600	0.42
Tobacco	4185	6875	7286	0.94
Strawberry	2357	6000	6000	1.00
Total / Average no rice	765065	3490	4919	0.70
Rice	36092	14000	13196	1.06
Total / Average with rice	801157	3964	5292	0.72

Source: Berbel et al (2011)

The table shows the estimation of water consumption per hectare, resulting in a low average value (3,964 m^3 per ha) that is below the evapotranspiration needs. Water use for crop production is taken from the 'average irrigation water applied', which is obtained from the Water Agency (Confederación Hidrográfica del Guadalquivir, 2010) and summarized in Table 1. Generally, the farmer's adaptation to water supply limitations in water scarce regions is to cultivate crops with supplementary or deficit irrigation, (i.e. annual water application is smaller than annual irrigation water requirements for maximum yield). The ratio 'water application/water requirement' is known as Relative Irrigation Supply (RIS). Table 1 illustrates the level of scarcity of water resources in the basin as the average dose is 3,490 m^3/ha, versus Potential Evapotranspiration (PETmax) needs of 4,919 m^3 per ha, resulting in an average RIS of 0.70, (i.e. the irrigation doses in Guadalquivir is 70% of PETmax on the average). Some crops may adapt to Deficit irrigation (DI) such as sunflower (RIS=0.31) or wheat (RIS= 0.37) and other crops maybe 'over-irrigated', indicating that there is still room for water saving as the case of citrus illustrates (RIS=1.14) implying that water maybe used more efficiently in some crops for this basin.

Consejeria de Agricultura (2010) gives a value for the average RIS in the basin in 2008/2009 of RIS in 0.60 and a value of total production (sales plus direct subsidies) of 2.95 Euros per m3 in the Almeria greenhouse area, 1.39 Euros per m3 for citrus and fruit, 1.22 Euros per m3 for irrigated olive and 0.54 Euros per m3 in extensive irrigation for mixed crops in Guadalquivir. A detailed analysis of the value of the irrigated crops is detailed in table 4

Table 4: Water productivity ratios and residual value of water (2005)

Crop	Economic result per ha		Water	Apparent productivity		
	Total sales	Gross Margin	Average doses	Sales/water	Gross Margin/water	Residual Value
	(€/ha)	(€/ha)	(m^3)	(€/m^3)	(€/m^3)	(€/m^3)
Citrus	6584	3609	5501	1.197	0.656	0.344
Olive tree	2546	1521	2281	1.116	0.667	0.548
Sugar beet	3799	1664	3730	1.018	0.446	0.057
Cotton	4429	1973	6048	0.732	0.326	0.257
Wheat	1319	666	1500	0.879	0.444	0.083

Maize	2332	1019	6621	0.352	0.154	0.070
Rice	3044	1192	14000	0.217	0.085	0.043
Sunflower	913	534	1500	0.609	0.356	0.040

Source: Berbel et al (2011)

The average gross value added is 0.50 euro per cubic meter and the average residual value in the basin is 0.31 €/m^3. The residual value method divide the added value of the irrigated sector among the different production factors (land, labour,...) and estimates the value assigned to water as a 'residual' once all factors are assigned the share of production. The estimation of value of the different crops shows the high value of the water in the basin and the differences between crops. Usually the water in the farm is devoted to the main crop (citrus, cotton, ...) and the low value crops such as wheat and sunflower is done as a strategy to cover the water supply uncertainty leaving these 'buffer' crops as rain fed in case of reduced water supply concentrating all resources in the higher value crops of the farm.

As we mention previously, Guadalquivir basin is highly regulated and water resources used for irrigation is summarized in table 5 with reference to the source.

Table 5. Irrigated area and consumption according water origin in Guadalquivir (2008)

Water source	Ha	Consumption (GL)	m^3/ha
Regulated surface	372.412	2.148	5.666
Non regulated surface	152.398	574	4.118
Groundwater	308.455	726	2.575
Recycled	11.402	36	3.157
Sum	**845.000**	**3.568**	**4.222**

Source: (CHG, 2010)

It is worth mentioning that groundwater is 20% of resources but it has grown in the last decade devoted mainly to irrigate olives in the Upper valley.

The irrigation technologies in 2008 are mainly drip irrigation (64%), sprinkler (14%) and surface 27%.

Water allocation: issues and options

Current water allocation mechanisms

Guadalquivir water allocation is based upon the 1985 Water Law (WL) that essentially established that water resources are considered public domain (with small exemptions to groundwater rights previous to 1985) and defines the Basin Water Agencies (Confederaciones Hidrograficas) as the institution where planning and control of water rights and water use is carried out, and defines the mechanism for a public participation in the decision making of both long term planning and operative management.

General access to water rights is through the property of land in case of agriculture and by an administrative allotment in case of non agricultural sectors. The water right title have some conditions

for the user, mainly to respect quantity, destination, source, and it have a level of guarantee linked to the title as the WL only allow the administrative allotment of a water right subject to a certain level of minimum guarantee for the user. This guarantee is higher for urban and industry users and lower for farming.
The alternative way to access to water rights is the water market. The 1999 WL reform amended the Law and regulates the exchange of water rights allowing right-holders to trade and Basin Authorities to setup public water banks (PWB).
A limitation set up for the WL is the ranking of priorities that limit water trade from the lowest priority (mining) to highest (domestic); this ranking implies that most of the trade has taken place within agricultural sectors and between agriculture an urban. This is a barrier to the entrance of new users such as industry and specially energy (thermo-solar) but the Guadalquivir case has solved this problem by unifying all non-domestic priorities in a single 'economic uses category' that is also the solution adopted by the Autonomous region of Andalucia in the Andalusia Water Law (Junta de Andalucía-Consejeria de Medioambiente, 2010).
The Andalusian WL also determines a modification of the national WL as the PWB may reallocate water to new users that did not need to be previously water rights tenants, as it is required in the National Law that limits trade to water rights tenants.
Justification for administrative regulation of water rights allotment is the existence of externalities and the aquifers depletion. The Guadalquivir can be considered a 'closed basin' from the economic pointy of view, with a high regulation and most of the aquifers in the limit of exploitation. The PoM (CHG, 2010) does not allow new allotments[1]. The last big damn just finished (Breña) includes explicitly in the planning that no new irrigation area maybe developed.
Therefore the WL determines barrier to entrance of new water users in order to protect existing ones, no deterioration of the existing levels of guarantee of water supply to users.
Surface and groundwater are treated similarly since 1985WL in the sense that any new user demanding access to water is subject to local conditions of water availability either in non regulated rivers or in aquifers. For regulated surface water there are no noteworthy new administrative allotments as the basin is considered to be closed for new entrants.
There is not a market for administrative allotments and water pricing mechanism is limited to a partial cost recovery of financial and management cost of the infrastructure and Water Agency running cost.

Finally, water market that implies intra basin transfers is subject to approval by Ministry and this is done yearly based on hydrological conditions. Next section details the market in the Guadalquivir.

Water markets in Guadalquivir

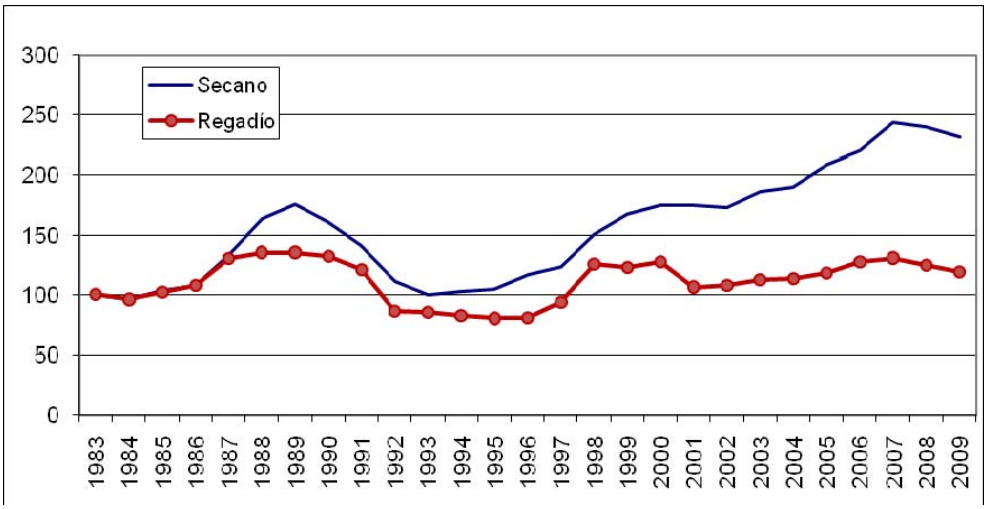
[1] There is a very small quantity to be distributed that comes from the previous Hydrological Plan (1998) and some aquifers with available capacity.

Water market properly is limited to water leasing in a yearly basis, but it is relevant to study the indirect value of water implicit in the market for land as there is an operation in the basin where land has been bought only for the use and transfer of the water rights, and this will be treated in the next subsection.

Indirect market for water (market for land)

For agricultural users the allocation mechanism is the acquisition of land with water rights, this determine an indirect market for water rights that can be observed in the market for land. Evolution of prices of rain fed and irrigated land in Andalucía has been unlike, figure 3 illustrates the evolution. It can be observed the decrease of land values for both irrigated and rain fed after 2006 when last reform enter into effect, this reduction has been greater for irrigated land compared to rain-fed, nevertheless the analysis of land prices is outside the scope of this paper.

Figure 3: Evolution of land prices for irrigated and rain fed land, Andalucía:



Source: Mesa & Berbel, 2007

The differential between both types of land by location is shown in table 6. Theoretically, next step is to estimate capitalized value of water is to divide the value of the difference in Price between both types of land by the water allotment, such as expression [1].

$$V = \frac{\Delta}{D} \qquad [1]$$

Where (Δ) is the difference between both types of land estimated previously; D is the allocation estimated for the different locations and V is the estimated capital value of water. This is a simple analysis that yields a gross estimate of the value of the resource in the Guadalquivir.

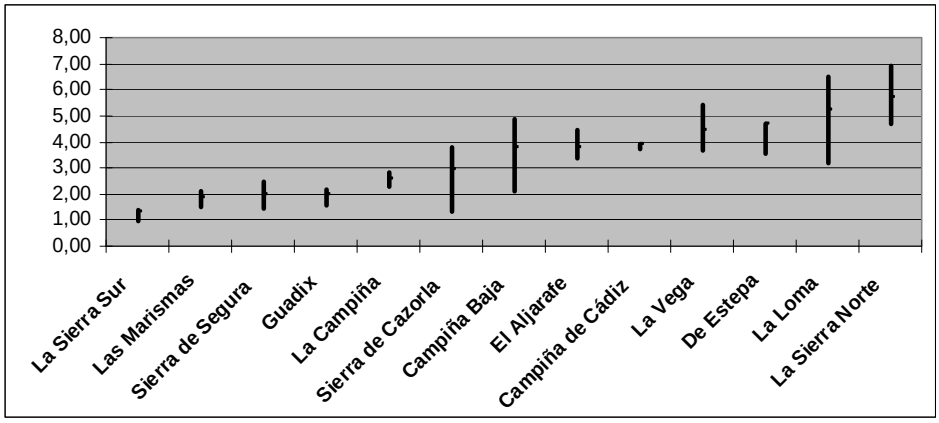
Table 6: Differential value of irrigated and rain fed land by province and crop (2004)

PROVINCE	Field crops			Olive (oil)			Olive (Table)		
	Difference (€)			Difference (€)			Difference (€)		
	Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
CÁDIZ	15,817	16,203	16,331						
CÓRDOBA	7,658	12,488	16,038						
GRANADA	30,786	35,333	41,554	1,854	3,235	4,987			
JAÉN	6,711	9,843	11,998	10,933	14,298	18,566			
MÁLAGA	18,184	22,045	25,550						
SEVILLA	9,852	11,393	13,163	9,937	10,055	11,793	7,099	7,427	9,333

Source: Berbel & Mesa, 2007

By applying equation [1] a certain value of the capitalized value of water can be obtained, this is done at 'comarca' level (group of ten municipalities approximately) and this is shown in figure 4 for the 'field crops' technical orientation.

Figure 4: Capital value of irrigation water for field crops orientation by 'comarca' (2004)



	Minimum	Mode	Maximum
Weighted average Basin	2,65	3,51	4,14

Source: Berbel & Mesa, 2007

The relevance of this analysis is that the acquisition of land with water rights is the method for the accession to water rights by new users such as thermo-solar plants. This analysis can be done in the most recent case of new users of waters such as thermo solar plants who are buying land on order to access the water for the plant: a 50 MW plant needs around 10 GL for operation. Unfortunately there is not information available because most of the plants are in the project phase and market is not transparent, and also there is a problem with this market as the level of guarantee for agriculture and industry are not equal and the administration should make the analysis of water rights conditions in case of change in water destination.

Inter-basin Water trade

There is an open water market in the basin around the inter-basin transfer Negratin-Almanzora., water is taken from Guadalquivir and destination is Almeria zone, specifically the Irrigation Community of Almanzora. The Negratin-Almanzora Decree have a rules of operation under the R.D.-Law 9/1998 (28 august) so that a normal hydrological year 50 GL

are transferred to Almanzora and users pay the administrative price (6 cent/m3 for the water and 6 cent/m3 for the financial and management cost of the infrastructure.
When the hydrological year is considered to be under draught protocol no water transfer is allowed through the administrative allotment and markets start operating. The year 2005 under draught regulations Aguas de Almanzora (destination) buy a land devoted to rice with the following characteristics.

Table 7: Values of land and water for inter-basin transfer Guadalquivir -Almeria

Concept	Value	Units
Land price	42,000,000	€
Surface	1,500	Ha
Water per ha ([2])	6,500	m3 /ha
Water per year	9,750,000	m3
RATIO (euro/m^3)	4.31	€/m3

Fuente: Mesa & Berbel (2007)

According table 7 and table 6, average capital water value in Guadalquivir is 3.46 Euros per m^3 and in the case of the transfer of water rights by the acquisition of land in the rice growing area estimated value is 4,31 €/m3, which is in the range of maximum value for field crops orientation shown in figure 4. Additionally to the long term acquisition obtained by buying land, Aguas de Almanzora has also bought water in an annual basis using the Negratin-Almanzora transfer infrastructure the years 2005-2008 with a total volume of 50GL and an average price of 0.18€/m^3. This volume is around 2% of the consumed resources for the years of reference. Table 8 illustrates the operations in Spain, with detail of the Guadalquivir operations where the Buyer has been 'Aguas de Almanzora'.

Table 8: Water trade in Gualdaquivir 2006-2008

Seller (2008)	**Buyer**	**Volume (m^3)**
Aguas del Almanzora SA	Aguas del Almanzora SA	8.479.673
	Total Spain 2006	75.048.408
2007		
Various	Aguas del Almanzora SA	35.315.378
	Total Spain 2007	102.393.891

Fuente: DGA, MIMAM, 2008

We may conclude that inter basin water transfer has been operating properly although the water trade is limited to draught years when the rules of operation for the water transfer do not allow the free transfer.

[2] CHG authorizes only the transfer of around 50% of location water rights (originally) 12000 m^3/ha, because estimates that rest should remain in situ for control of salinity, year 2007 the authorized transfer has been 4500 m^3/ha

Trade in draught year are similar to the described for California, Australia and Chile where volumes traded are around 2-5% in dry years. Price for moist operations in Guadalquivir has been around 0.18 Euros per m^3.

Scenario for future water resources and demand in Guadalquivir

Resources in the Guadalquivir basin have been managed with a remarkable success, without tensions and with an open participation of all agents: Water agency, farmers, cities and industry. There have been tensions but this has been managed by participatory process and flexibility by all agents and long term planning. The main failure in this process has been the lack of control of groundwater abstraction linked to the irrigated olive in the Upper Guadalquivir, that has not been properly controlled by the Water Agency and that implies the existence of an open conflict as the users have not an properly recognized right[3].

Users of Resources in the Guadalquivir basin has been managed with a remarkable success, without tensions and table 2 shows irrigated area has doubled in the period 2992-2008 (410,000 ha to 845,000) but average water use has reduced to 56% (from 6,893 to 3,991 m^3/ha), thus implying a increase in total consumption for irrigation of 19%, in the same period consumption for urban and industry has increased 12%.

The basin has reached the limit so that no additional sources of water are planned and the PoM under decision estimates a reduction by water saving in both irrigation and urban sectors around 8% for both sectors. The observation of last irrigation campaigns (2009/2010) shows that these projections of water saving by irrigation are achievable. Nevertheless, the existence of a consensus on the fact that the basin is closed and no new entrants can be authorized by expanding supply is already in the draft PoM. Up to this moment (PoM 2010) tensions has been solved by a certain resistance by the Water Agency that finally make a political participatory process 'Acuerdo por el Agua en la Cuenca del Guadalquivir' (CHG, 2005) where the agreement was to stop any new irrigated area. This agreement was a movement to stop political pressure from lobbies that demand additional water rights. There is a paradox as all municipalities assume the closeness of the basin in general terms, but simultaneously demand additional resources for their localities. This territorial demand is general in all the basin as irrigation is seen as a source of employment and income for the rural areas, and this position has a stronger support the Upper Guadalquivir irrigated olive regions where farmers are closely colligated to all political parties and municipal power to demand additional resources for the new entrants.

The territorial conflict between old water rights tenants (mostly in Lower valley) against new demands (mostly in Upper Valley) is a potential source of conflict that in our opinion should be solved by closing the basing and redistributing existing water rights rather than the false solution of creating artificial water rights coming from hypothetical water savings.

Therefore the only instrument to give flexibility to the plan is the existence of the market, and from our opinion this will be of the following types. Table 9 summarizes classes of markets that can be possible in Guadalquivir.

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[3] CHG estimates around 10% the irrigated water to be not properly acknowledged by all legal permissions, some of them fully illegal but many of them under a process to be recognized.

Table 9: Water Market in Guadalquivir

Class	Seller	Buyer	Market type	
			Leasing (yearly)	Land water rights
Intra basin	Low value crops	High value crops	Draught	Permanent
	Low value crops	Industry	Draught	Permanent
	Low value crops	Urban	Exceptional	No
Inter basin	Agriculture	Agriculture/urban	Frequent	Operative
PWB	Water savings/Other	High value crops	Exceptional	Various sources

Source: own elaboration

In this river basin there has been some operations of water leasing where buyer was city of Seville and sellers farmers from 'Comunidad del El Viar' but in the present level of infrastructure development and given the fact that urban use is priority, new trade between agriculture and urban (domestic use) should be exceptional. Same applies to PWB operations that probably will be supplied from various sources such as water rights out of use (mining, industry, irrigation) that will be recovered for public management.

Next section will explain main focus of the research.

Objectives of the research

The class of markets for water in Guadalquivir that may be studied in this project are:

- Inter-basin transfer, analysing the conditions of 2007-2008 trade quantifying profit and losers in the operations.
- Industry-agriculture trade, analysing current examples under development linked to the operations of thermo-solar plants
- Agriculture-agriculture (intra-basin), this market is not operating and it is important to understand barriers to the functioning.
- Public Water Bank, analysing the Guadalquivir PWB as projected by Autonomous administration, suggesting rules of operation for transparency in order to satisfy criteria of efficiency and equity.

The entire above commented task are policy relevant, and there is a regional demand for knowledge that can be exported to other areas of Europe. Local expert committee already integrate main agents of the market, also direct interviews with key persons (seller, buyer) is planned. All documents will be reviewed by agents in order to give transparency and integrate their comments and suggestions.

The research plan will put the energy in order of the exposed class of markets trying to start with the already existing (inter-basin), and the market under development (industry-agriculture) to end with the future class (agriculture-agriculture and PWB).

Acronyms

CHG: Confederación Hidrográfica del Guadalquivir; DI: Deficit irrigation; PET: Potential Evapotranspiration; PoM: Programme of Measures PWB: Public Water Bank; RIS: Relative Irrigation Supply; WL: Water Law (1985 and amended 1999)

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