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Reaching the Limits of Water Resources Mobilisation: Irrigation Development in the Segura River Basin, Spain

Carles Sanchis Ibor
Centro Valenciano de Estudios del Riego, Universidad Politécnica de Valencia, Valencia, Spain;
csanchis@hma.upv.es

Marta García Mollá
Centro Valenciano de Estudios del Riego, Universidad Politécnica de Valencia, Valencia, Spain;
mgarmo@esp.upv.es

Llorenç Avellà Reus
Centro Valenciano de Estudios del Riego, Universidad Politécnica de Valencia, Valencia, Spain; lavella@esp.upv.es

José Carles Genovés
Centro Valenciano de Estudios del Riego, Universidad Politécnica de Valencia, Valencia, Spain; jcarles@esp.upv.es

ABSTRACT: The aim of this paper is to analyse the policy of water resources development implemented in the semiarid watershed of the Segura river during the last century, consisting of irrigation development promotion by means of the provision of new resources. The way in which this policy was implemented generated important conflicts among users, severely damaged riverine ecosystems and, paradoxically, created new water demands, perpetuating an outdated model of management.

KEYWORDS: Water management, irrigation, hydraulic policies, river basin development, Segura river basin, Spain

INTRODUCTION

> Let's tame the rivers with the brakes of dams and the chains of canals[1]
>
> Joaquín Costa (1911)

This sentence was written a century ago by Joaquín Costa, the father of Spanish *Regeneracionismo* movement – a century in which more than 800 dams and myriad canals were built to stimulate the economic development of the country, and which separated an agrarian and starving society – "half of the Spanish go to bed hungry", again citing Costa (1911) – from a post-industrial economy. This socio-economic and demographic change, together with its territorial and environmental impact, is unprecedented in Spanish history.

A great number of thinkers, engineers and politicians around the world have held the view that irrigation can spearhead economic development, and very similar hydraulic policies have been developed in many nations (Molle et al., 2009). Water was widely considered throughout the 19th and 20th centuries as an engine of economic growth. This concept took precedence over other values of

[1] Domestiquemos los ríos con el freno de los diques y la cadena de los canales.

water, and seems to have taken place mainly, or more intensively, in countries going through the Rostownian 'take-off' phase of development, the middle stage of demographic transition, and at the peak of Kuznets's environmental curve.

This is, in fact, the materialisation of a philosophy of the domestication of nature that has spread extensively in the last two centuries from paradigms originally elaborated by Buffon or Richardson (Glacken, 1967). In the case of Spain, it is also the result of the adoption of principles attributed to *Regeneracionismo*, a movement of intellectual renovation that emerged after the loss of the last colonies and placed water policies at the central axis of the economic regeneration of the nation (Ortí, 1984, 1996; Gómez Mendoza, 1992; Swyngedouw, 1999).

In Spain, the state engaged in a 'hydraulic mission' by developing a large amount of regulation and many water transfer projects. Between 1902 and 1998, the storage capacity of the reservoir system grew from 100 to 55,000 million cubic metres (Mm^3) and the irrigated area expanded from 900,000 to 3,400,000 ha (MMA, 2000). Subsequently, the state would often also manage those systems in order to provide water to users, mostly farmers, with a view to stimulating the development of economic activities.

At the end of the 20th century though, this model started to show weaknesses. For several reasons – environmental impacts, social demands, economic and territorial changes, etc. – water planning evolved through a long and conflicting transition to a model of demand management. The focus was set on the reduction of water demand and the search for efficiency and water saving. Moreover, the Water Framework Directive imposed a great challenge on the Spanish administration, requiring the achievement of very ambitious environmental objectives and promoting a new perspective on water resources management, where water is conceptualised as an eco-social asset (Carles and García Mollá, 2003).

Spanish legislation has taken steps to adapt to these new models. However, although public policies are being imbued gradually with these principles of efficiency and environmental conservation, there is still a great deal of inertia stemming from the previous paradigm, and the search for efficiency and water saving has not completely displaced actions aimed at increasing the supply of water resources. It is easy to observe the gap between discourses and materialisations, and between changes in the legal framework and water planning actions. Several authors have emphasised existing gaps, overlapping policies, and contradictory actions (Estevan and Naredo, 2004; Estevan, 2008; Arrojo, 2008).

In short, water management in Spain is facing a radical change of paradigm that cannot be completed in a few years. This kind of transition requires a longer period encompassing social, economic, cultural, and ecological transformations with very different paces and a complex matrix of interactions (Rotmans, 2005). Moreover, these changes unfold in a very complicated context due to the decentralisation of political powers among different regions and the presence of conflicting territorial and vote-catching interests (López-Gunn, 2009).

Some policies and actions, which could appear incoherent or outdated with regard to the emerging paradigm, can be understood following a historical analysis. In order to illustrate the complexity of these processes of change involving water management models in some southern European countries, this paper aims to analyse the policy of irrigation development implemented in the semiarid watershed of the Segura river over the last few decades. The way in which this policy materialised generated important conflicts among users, severely damaged riverine ecosystems and, paradoxically, created new water demands, perpetuating an outdated model of management.

The article is organised into four sections. First, there is a short review of the recent evolution of water planning in Spain. Second, we offer a reflection on the evolution of water resources development in the Segura river basin. The third section focuses on one subbasin, the Low Segura district, where conflicts around the development of new irrigated areas are carefully described, and finally conclusions and recommendations are presented.

THE NATIONAL CONTEXT: TOWARDS A MODEL OF DEMAND MANAGEMENT

In the early part of the 20th century, water policies were considered the central axis of the economic regeneration of Spain, and the development of new irrigated areas became the major strategy to achieve this goal. The first milestone in the development of this water policy was the General Plan for Irrigation Canals and Reservoirs of 1902, also known as the Gasset Plan, which had limited success and was only implemented across 150,000 hectares (ha), most of which were in the Ebro basin (Ortega, 1995). The Second Republic passed the National Water Works Plan of 1933, designed by Manuel Lorenzo Pardo and primarily aimed to prioritise agricultural development in south-eastern Spain, *the region most suitable for irrigation* (MOP, 1933).

However, the 1933 Plan never became law, but most of the projects were included after the Civil War in the Water Works Plan of 1940 (Gil Olcina, 2001). This document was the basis for waterworks development during the rest of the century. The *Confederaciones Hidrográficas* played a major role in the execution of this plan. Created in the first thirty years of the 20th century – perhaps the best achievement of this period – they were conceived as agencies for developing hydraulic infrastructures and managing each river basin integrally (Frutos Mejías, 1995; Melgarejo, 1995; Molle, 2006). The Confederaciones were also entrusted with water planning and became a powerful bureaucracy with a presidential structure and close links with civil engineering (Varela and Hernández-Mora, 2010). Water rights were also the responsibility of Confederaciones, although between 1959 and 1986 the Comisarías de Aguas (Watermaster Offices) processed water use concessions and authorisations, carrying out administrative work rather than effectively monitoring and ensuring public control.

The new infrastructures guaranteed the supply of traditional huertas and vegas and boosted the construction of new canals over former dry lands.[2] Irrigation was mainly extended by the state during the dictatorship and under the colonisation laws of 1939 and 1949, which led to the creation of the Instituto Nacional de Colonización (INC), later known as IRYDA.[3] The INC-IRYDA developed irrigation infrastructures in areas benefited by the construction of large dams, promoted groundwater use and wetlands drainage, and founded 289 new villages (Bosque, 1984).

Following the boom in the Spanish economy in the 1960s, competition for the utilisation of water escalated as a result of the increase in irrigated lands, urban development, industrialisation and the mounting demand of tourism. At the same time, there was growing concern about the environmental consequences of this development process, particularly about the pollution of rivers and over-exploitation of groundwater bodies.

Consequently, in the last few decades of the 20th century, the traditional supply-based model became obsolete due to the variety of changes undergone by Spanish society. The increasing amounts of water used for agricultural purposes and enormous urban developments were mainly responsible for water shortages, and disputes between regions began to arise. In addition, irrigation ceased to be as strategically important as it was in the past and agriculture lost importance in the gross domestic product. Furthermore, the supply of food ceased to be a problem and irrigation was no longer considered the only option for rural development (Carles, 1997). In this context, the government financing of public works to supply water for private irrigation activities became questionable; consequently, the Water Act of 1879, which had been in force for more than a century, was unable to tackle these problems.

For this reason, and due to administrative changes induced by the advent of democracy, a new legal framework for water was passed in 1985. The Water Act of 1985, currently in force, was a turning point in Spanish water policy and was characterised by two main aspects. First, since 1985, all public water has been subject to a concessional regime. The collection and utilisation of new quantities of water require prior administrative authorisation by the Confederaciones Hidrográficas, which may be revised

[2] The Spanish words *huerta* and *vega* refer indistinctly to traditional gravity irrigation systems created in the Medieval Age, most of them during the Islamic period, developed along the river sides and around historical cities and villages.
[3] Acronym for Instituto de Reforma y Desarrollo Agrario (Institute for Agrarian Development and Reform).

and modified when the circumstances that justified the concession change. Therefore, the confederations are in charge of monitoring the public water domain and controlling compliance with concessions, as well as imposing sanctions accordingly (Avellà and García Mollá, 2008).

Second, the Water Act involved the obligation to elaborate a National Water Plan (NWP). The NWP Bill, presented in 1993 by a Socialist Party government, intended to connect all river basins on the Iberian peninsula with a transfer capacity of 4000 Mm^3, in order to reduce substantially the imbalance of water resources across the country (Gil Olcina, 2002). The enormous investment involved and the amount of water to be transferred caused huge controversy and the plan was never sent to Parliament (Albiac et al., 2007).

The People's Party came to power in 1996. Highly critical of the NWP Bill, they expressed the need to review Spain's water policy. As a result, the White Paper on Water (MMA, 2000) was elaborated, recognising the crisis of the traditional supply model and the need to reform water policies (Naredo, 2008). The White Paper on Water was intended to improve the information available on water and acted as a basis for public discussion, addressing new models for managing the resource. Indeed, changes were proposed in the legislation in order to correct aspects such as environmental management in relation to water, the control of water authorisation and concession systems, and the adaptation of the administration to the new challenges. The White Paper also recognised the need to use economic instruments to improve the allocation of the resource and indicated, apart from exploiting new sources of water, steps to be taken to manage demand.

Some of the proposals of the White Paper on Water came to fruition a year later in the reform of the Water Law, whose objectives included making the concession system more flexible by introducing the possibility of transferring water rights, so as to allow the optimum economic utilisation of water.

In 2000, a new NWP was presented, along the same lines as the previous plan, but involving less infrastructural works. The most controversial aspect was the proposal to transfer water from the Ebro river to south-eastern regions that were suffering from a structural shortage of water. Apart from this large water project, Appendix II of the NWP contemplated the construction of more than 100 new reservoirs. As had occurred previously, this plan generated a great deal of criticism from social, political and environmental organisations which believed it was still based on the traditional water management supply model.

When the Socialist Party returned to power in 2004, one of the focuses of the electoral campaign had been the abolition of the Ebro River Transfer, finally replaced by the AGUA Program.[4] This plan was also based on a generous mobilisation of water resources, whose main objective was to increase water supply by means of desalination, replacing the 1000 Mm^3 water transfer with 621 Mm^3 provided by new desalination plants. Nevertheless, other measures implemented by this plan were a clear example of demand-management policies: the reform of water confederations; promoting citizen participation in decision making; creating public water banks to reallocate historical water rights; establishing water charges in accordance with the real costs involved in obtaining and treating the resource; and improving management and water-quality controls. Some of these changes were conditioned by the application of the Water Framework Directive, which had gone one step further by advocating a new model in which water was considered primarily an eco-social asset – instead of a production factor – giving priority to water quality ahead of its uses in production.

In short, even though the policies aimed at the expansion or consolidation of irrigation areas have been losing their leading role during the last three decades, they are still important. Waterworks are now legally conditioned to the preservation of riverine and wetland environments and to the full recovery of the costs of water services, whereas inter-basin water transfers have been replaced by small intra-basin transfers or by the use of new resources, such as desalinated water and wastewater recycling.

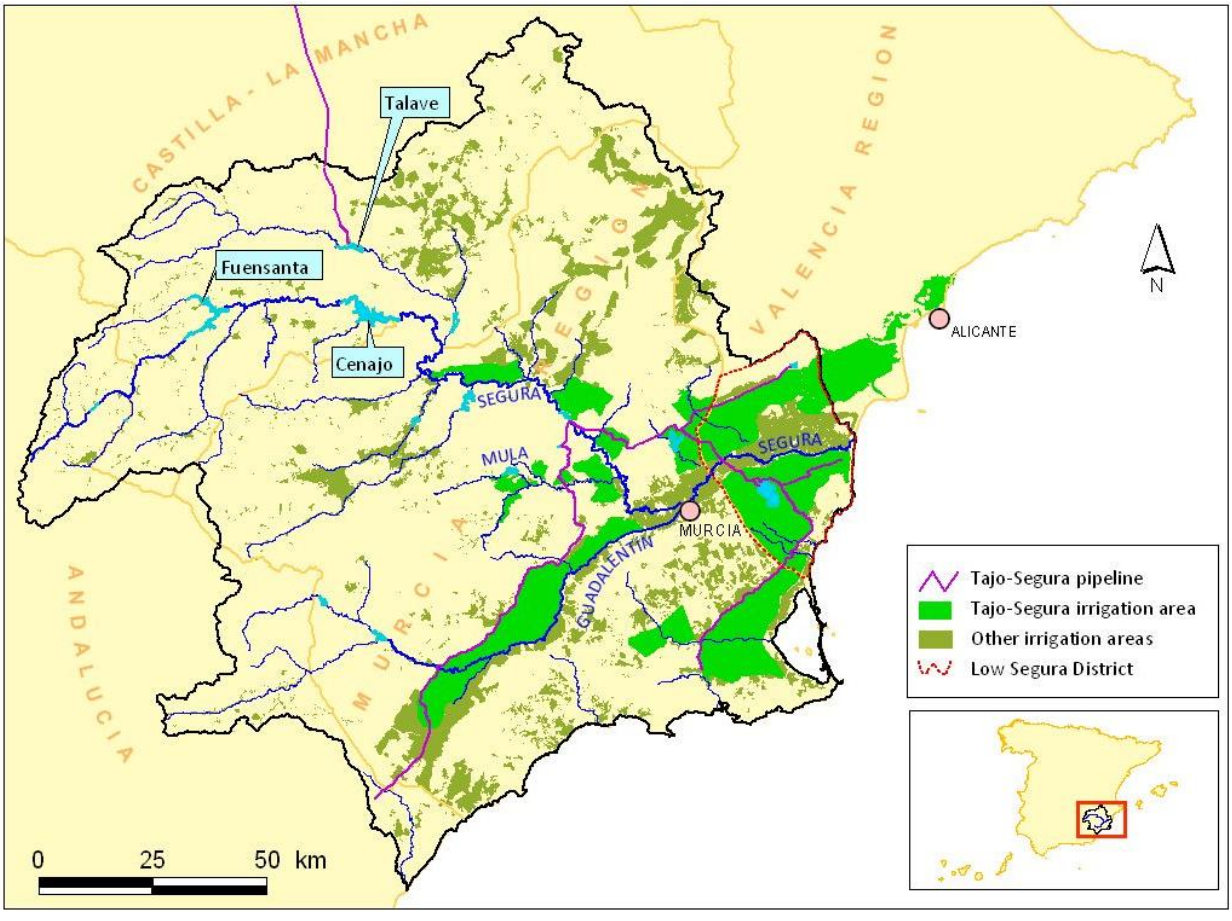
[4] AGUA, meaning water, is an acronym for Actuaciones para la Gestion y Utilización del Agua (Actions for Water Management and Use).

THE SEGURA RIVER WATERSHED: BASIC FEATURES AND RECENT EVOLUTION

The basin of the Segura River is located in the southeast of the Iberian peninsula and has an area of 18,870 km^2, distributed among four autonomous regions: Murcia (60%), Castilla-La Mancha (25%), Andalucía (9%) and Comunitat Valenciana (5%) (see figure 1). This basin lies in a semiarid environment with scarce rainfall (400 mm yearly average, with two-thirds recorded in autumn) and soil conditions (marls and salty clays). Evapotranspiration ranges from 600 mm in the highlands to 700 mm in the low valleys and coastal plains, whereas the total run-off reaches 15% of the basin rainfall. These adverse environmental conditions are offset by the favourable thermal regime, particularly optimal for early crops, due to the mild winter temperatures and the high number of sunny days.

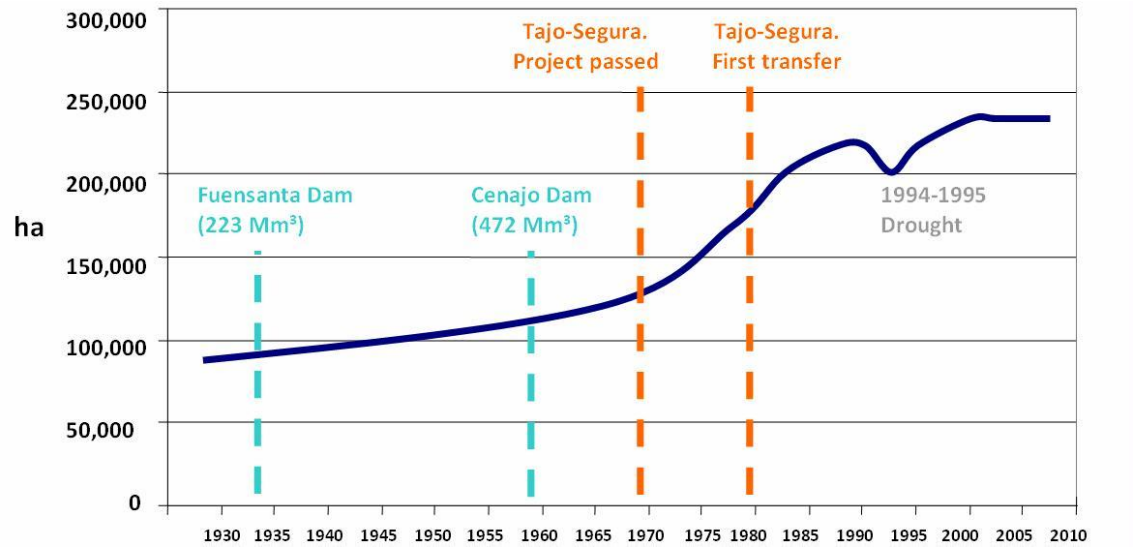
Even so, the main characteristic of this basin is the structural deficit between available water resources and agricultural and urban demands. The Segura river basin gathers 714 Mm^3 annually, if we consider the period 1940-2005, but only 575 Mm^3 for the period 1980-2005, whereas groundwater provides 700 Mm^3 yearly. Moreover, the Segura basin receives water from the Tajo river through an inter-basin transfer that provides a maximum of 510 Mm^3 and a historical average (1981-2008) of 348 Mm^3. On the other hand, estimated gross demand reaches 1,881 Mm^3 with 1,662 for agricultural uses, 189 for urban and industrial uses and the last 30 for environmental uses (CHS, 2009). Consequently, deficit of water resources rises to 606 Mm^3 each year, when considering local resources, and 258 Mm^3, when considering the Tajo-Segura transfer. Moreover, recurrent and frequent drought periods (1980-1982, 1993-1995, and 2005-2008) have generated important crises and greatly complicated water management. This is, in general terms, a clear example of basin closure (Molle et al., 2010).

Figure 1. Map of the Segura river basin.



The evolution of the irrigated lands is particularly revealing. At the beginning of the 20th century, traditional irrigated areas encompassed 65,000 ha distributed on the Segura river flood plain (Vega Alta, Media and Baja) and in the Guadalentín and Mula valleys. In 1933, one year after the inauguration of the Fuensanta reservoir (223 Mm^3 storage capacity), the total irrigated land area had reached 89,656 ha. In 1954, this figure reached 104,420 and then 117,230 in 1967, when the Tajo-Segura project was approved by the national government. This transfer plan played a key role in irrigation expansion. In 1983, when the water from the Tajo river started to reach the Segura lands, the irrigated area increased to 196,874 ha. Between 1989 and 2009, the area of irrigated lands fluctuated at around 230,000 ha, with some variations in the planted area between dry and wet periods (figure 2).

Figure 2. Evolution of irrigated lands in the Segura basin.



Source: Anuarios de Estadística Agraria and Confederación Hidrográfica del Segura, Ministerio de Agricultura Pesca y Alimentación.

In short, whereas during almost 50 years (from 1920 to 1967) irrigated lands increased by 50,000 ha, due to the construction of eight dams contributing 800 Mm^3 of storage capacity, and the generalisation of pumping techniques that permitted the massive exploitation of groundwater, in only 16 years (from 1967 to 1983) this value increased by 80,000 ha. The Tajo-Segura Transfer Project panicked people into extending irrigation as much as possible so as to have trees in full production when water arrived and be the first to claim and receive the new resource.

When the preliminary studies of the project were launched, the deficit, considering only surface water, was estimated at 380 Mm^3. Some authors (Sahuquillo, 1984) calculated the total amount of groundwater abstracted to be between 505 and 600 Mm^3, half of which was taken from renewable annual resources. If we add regulated river resources to renewable groundwater, the balance among resources and demands was almost in equilibrium. Nonetheless, the official discourse was based on the idea that this situation jeopardised the future development of irrigation in the region. In this sense, the preliminary report on the transfer project underlined the strategic importance of these waterworks, expected to "solve the present and unavoidable economic development stagnation and to avoid that the present irrigation decline could become more severe" (CEH, 1967).[5] However, the statistical data of the period do not show any irrigation decline at all (see figure 2).

[5] In the original: "para poner remedio a su actualmente inevitable estancamiento en el desarrollo y para evitar que la regresión de los regadíos ya iniciada, llegue a adquirir gravísima importancia".

The evolution of the project shows a progressive and considerable reduction in the magnitude of the water transfer. In 1967, when the Minister of Public Works announced the initiative in Murcia, the aim of the project was to transfer 1000 Mm^3 yearly. The government passed the project 18 months later and the water pipe was designed with this capacity in mind. The transfer was planned to improve irrigation for 147,000 ha with insufficient supply and to extend irrigation to 122,000 ha of dry land. The amounts invested in the main water pipe (Tajo basin) and the distribution system (Segura basin) was €140.3 million and 150.7 million, respectively.[6]

In 1971, the transfer project was supported by the Law of Common Use of Tajo-Segura System. This document defined that, in a first stage, the transfer could only distribute 600 Mm^3 annually, as the remaining 400 Mm^3 were allocated to the future construction of several sets of infrastructure in the Tajo basin. In 1980, when laying the water pipe was completed, the government defined the management of the infrastructure through the Law of the Economic Regime for the Exploitation of the Tajo-Segura Conduct, establishing that the Tajo watershed administration (Confederación Hidrográfica del Tajo) would only authorise the transfer of water considered as 'surplus'. After the approval of the project, a fierce debate ignited between users and political powers of the Tajo and Segura watersheds over the amount of water to be transferred (Melgarejo, 1997).

The 1971 Law of Common Use distributed the 600 Mm^3 in this way: 385 Mm^3 were given to agriculture, 83 to urban uses and 132 were considered as losses. Nine years later, the 1980 Law of the Economic Regime modified these volumes, allocating 400 Mm^3 to agriculture, 110 for urban uses and reduced losses to 90. However, the average volume historically transferred has been only 348 Mm^3, just a little more than a third of the infrastructural capacity. Consequently, expansion of the irrigation areas was developed with considerably less water resources than planned, contributing to a structural deficit.

Thus, there was an important imbalance between the expectations created in the region and the amount of water finally transferred, which was a result of inefficient management of the public initiative. On the one hand, there was a clear lack of control over irrigation expansion, as described in the next section and, on the other, two facts explain the reduction of the volumes transferred in the 1980s and 1990s. First, political pressures against the transfer increased with the advent of democracy, in 1978, when representatives of the donor region of Castilla-La Mancha were able to express their opposition in Parliament and use it as a vote-catching instrument. This pressure conditioned the decisions taken by successive governments to allocate the volumes transferred on a yearly basis. Second, the inappropriate management of the Tajo headwater reservoirs led to a reduction of expected water volumes annually transferred. The headwater macro-dams of Entrepeñas and Buendia were literally emptied between 1979 and 1983, when 2000 Mm^3 of water were released in a short period – a volume three times higher than the real Tajo basin demands – with the intention to eliminate all the 'surplus water' planned for transfer. In fact, the average headwater resources stored in the 1910-1980 period is twice higher than the average of the 1980-2000 period (MMA, 2000). In the 'water war' between supporters and detractors of the transfer, the leadership of the Confederación Hidrográfica del Tajo aligned itself with the political opposition to the Transfer Project.

The direct consequence of this imbalance was the intensification of groundwater use to compensate for the water deficit, but the intensive use of this resource was also linked to irrigation expansion in those areas of the basin not considered in the Tajo-Segura project. As a result of both factors, the number of wells pumping water in the basin increased from 7829, just before the arrival of the Tajo waters, to 20,350 in 1995 – most of them neither controlled nor registered by the Confederación (Calvo, 2006). The lack of control of groundwater exploitation in the basin seriously affected 40 of the 63 groundwater bodies of the Segura river basin, with a yearly overdraft of 300 Mm^3. Overdraft affects mainly the Guadalentín valley, the southern coastal area and the endorheic northern highlands. The lax control of groundwater use is linked to the strong pressure withstood by the Confederación Hidrográfica, which had to face the failure of the previsions for the Tajo-Segura project. In other words,

[6] At 2010 constant prices of 633.8 and 416.8 M€.

the administration generated expectations for the farmers (irrigated lands, water volumes) but failed to carry out the project properly, so the farmers claimed and searched for alternative resources.

In this context, the agriculture sector made an important effort to reduce consumption through the introduction of water saving technologies, mainly drip irrigation, which reached 53% of the total irrigated area in 1999 (INE, 1999). The drip systems have been mainly implemented in new irrigated areas, those supplied with groundwater, or Tajo-Segura transfer resources. Conversely, most of the traditional irrigation areas have preserved gravity infrastructures, because the Segura's historical irrigation system is a complex structure of irrigation and drainage, where return flows play a major role in the distribution of water resources. In fact, several irrigation communities are only provided with return flows and water from drainage canals.

In areas adopting drip irrigation systems, no changes have been introduced in water rights. The aim of these water saving technologies is to improve the guarantee of supply or to reduce groundwater abstractions and pumping costs. Very recently, important investments are being sunk into the reservoirs of the irrigation communities, so as to reduce evaporation loss and improve water saving through the installation of shade-cloth covers.

The generalisation of drip systems has been developed with the financial support of the administration. The Ministry of the Environment and Rural and Marine Affairs and the state-owned company ACUAMED have made some investment, primarily put into practice by the public company SEIASA del Sur y del Este under a programme set up to "improve and consolidate irrigation systems". The financial framework of the investments states that farmers must contribute 30% of the investment, operative European Union programmes 24%, and Spanish public funds the remaining 46% (either entirely through SEAIASA or 50% in cooperation with regional governments). Farmers must return the Spanish public sector contribution in 25 annual instalments (between the 26th and 50th year after project completion) as a depreciation payment, without interest or capital upgrades. Regional governments also award subsidies to communities that wish to carry out their own irrigation rationalisation and enhancement projects, and to projects undertaken at farm level. Some initiatives, declared of 'general interest', are planned, executed, and financed entirely by these regional governments.

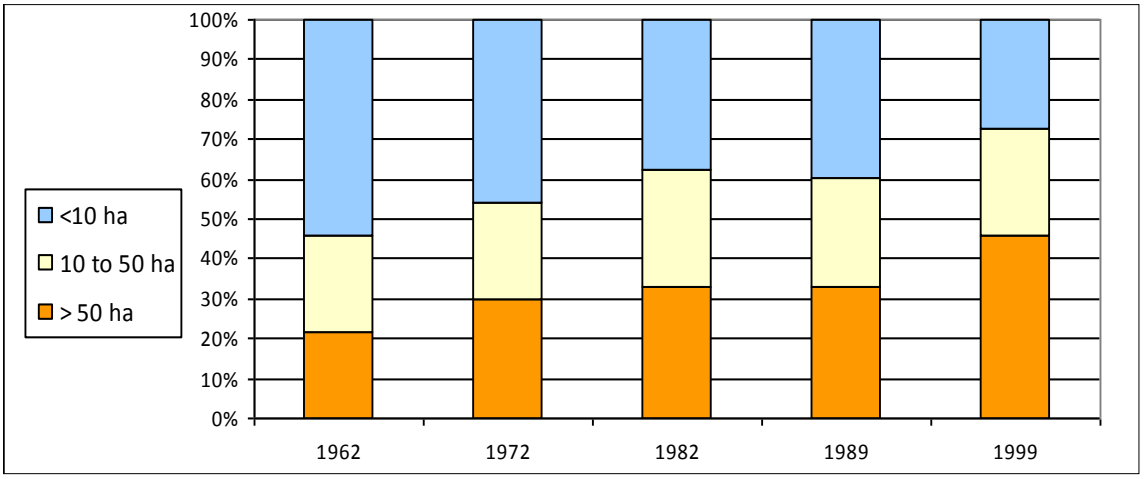
Despite the huge investment in modernisation, most landowners' hopes were placed in the Ebro-Segura transfer. The abolition of the project in 2004 was perceived as catastrophic by regional and local authorities. The present National AGUA Plan intends to reverse this water imbalance through the construction of several desalination plants (350 Mm^3) and further modernising of 97,628 ha by means of drip systems. Nevertheless, the regional governments of Valencia and Murcia have not abandoned the political claim for new water to be transferred from the Ebro basin and keep financing favourable reports, public demonstrations, and advertisement campaigns.

In general terms, several authors have put a positive slant on the economic impact of water transfer during the last thirty years. Perhaps the aspect of the project that attracted a wider consensus in the role played by the Tajo-Segura transfer is the Taibilla Supply System, a network devoted to distributing drinking water among urban and industrial users in the Murcia and Alicante provinces, today supplying a population of 2.5 million (Bru, 1993; Morales et al., 2005). Other authors have emphasised the importance of the transfer for agriculture in the Segura basin in terms of employment, water productivity, demographic growth, consumption indicators, and familiar and regional income (Hernández and Morales, 2008). These authors have also underlined that the Tajo-Segura transfer has stimulated the creation of very dynamic and innovative local companies and agricultural associations.

Moreover, Avellà (2003) has shown that big landowners and companies have played a leading role in this transformation process, dominated by the participation of non-agrarian capital, to the detriment of

family farms and small landowners, for reasons of economies of scale.[7] The recent evolution of land size in the Murcia region is therefore quite significant (figure 3). At the same time, consequently, wage labour in agriculture has increased enormously in the last decades in the region, growing from 32.2% in 1982 to 59% in 1999, when it almost doubled the Spanish average (31.5%).

Figure 3. Evolution of land size in the Murcia region.



Source: Censos Agrarios de España, Instituto Nacional de Estadística (INE).

However, at the same time, the over-exploitation of water resources led to a severe crisis for surface water ecosystems. Martínez-Fernández and Esteve (2002, 2004) described the impact of this expansion of irrigation in some coastal areas, far from the river flood plain, underlining the environmental and socio-economic unsustainability of this process. However, the river flood plain (the *vegas*), mainly in the Low Segura district, is probably the area where the impact of this environmental crisis is more noticeable. The effects of the scarcity of river flow were compounded by the limited and late investment in sewage treatment in the Murcia region, as well as the lack of control from the Watermaster Office (Comisaría de Aguas).

The river regime has now been drastically modified. The natural flow has completely vanished in the Low Segura area, the river bed only receives small quantities of agricultural return flows, polluted sewage and treated wastewater, and some stretches of the river remain completely dry during most of the year (see figures 4 and 5). In fact, the river flows abundantly only four times a year (twice or less in dry years), over 25-day periods. These periods are known as *desembalses*, when the dams release water requested by agriculture in the historical irrigation areas of la Vega. During the first days of these *desembalses*, the water flow sweeps away all the pollution accumulated on the river bed. For this reason, some communities of irrigators have recently introduced rotational turns in their delivery, in order to avoid the same group of farmers always receiving the most polluted water.

Pollution has reached alarming levels in the last two decades. Concentrations of mercury, nickel, tin, ammoniac, and phenols, as well as other parameters such as the biological oxygen demand (BOD), exceed legal levels, whereas oxygen injectors have had to be installed in the river in some urban areas (Orihuela and Rojales) to reduce the stench. Pollutants present in the watercourse are disseminated through irrigation canals scattered across the entire floodplain, increasing soil and water salinity beyond acceptable levels. Water conductivity in the river in the Low Segura district oscillates between

[7] For reasons of economies of scale, small properties have been sold or abandoned, whereas the largest were allowed to grow. Moreover, money coming from other sectors, in some cases '*dinero negro*' (undeclared capital), was invested in the new development of large agricultural estates to be laundered.

1.5 and 4 dS/m and is very frequently higher than 3 dS/m in most of the drainage canals of the historical irrigation area on the flood plain. This, in turn, is affecting crop distribution in the district, and plants with less salt-tolerance have been displaced from the lowest areas.

Figure 4. Segura river pollution in Orihuela.

Figure 5. The Segura river bed, dry under the Tajo-Segura pipes.

Wetlands placed at the end of the irrigation system are also prone to the impact of salt and pollutants. Reservoirs of the El Fondo d'Elx marshes, recognised as Ramsar sites, are supplied with water from the river mouth through the community Riegos de Levante en la Margen Izquierda canals. Consequently, the water masses present important levels of eutrophication, with winter concentrations of chlorophyll of 100 µg/l and peaks of 1200 µg/l during the summer, when parts of the ponds are frequently dry and covered by a salt crust. Moreover, two outbreaks of botulism among birds have been reported in the last decade.

IRRIGATION DEVELOPMENT IN THE LOW SEGURA DISTRICT

The Low Segura district encompasses the last stretch of the river basin at the south end of the Valencia region. In the past, there was a straight division between the flood plain, *la Vega*, where the lands were historically irrigated with surface water, and the hills that flank the valley to north and south, *el Campo,* where the farms had no sources of water for irrigation. During the 20th century a huge expansion of irrigation has taken place over these former dry lands.

River regulation and management deregulation (1900-1969)

At the beginning of the 20th century, the development of several regulation structures in the Segura basin – the reservoirs of Alfonso XIII (1917), Talave (1918), Corcovado (1929) and Fuensanta (1933) – substantially improved water flow and generated important business expectations. The traditional irrigation areas of the Vega Baja improved the guarantee of supply, whereas some companies started the elevation of water from the historical drainage canals or from the river mouth towards the adjoining parts of *El Campo*.

To the north, the Nuevos Riegos el Progreso company was founded in 1906, the Real Compañía de Riegos de Levante en la Margen Izquierda del Segura in 1917, and the Sociedad de Riegos el Porvenir in 1918.[8] To the south, in 1918, two landowners – V. Chapaprieta and L. Barcala – obtained a concession to pump water to the right bank of the river, which was the origin of the Comunidad de Riegos de Levante en la Margen Derecha del Río Segura. In all these cases, the area finally transformed went beyond the original plans and water rights allocation procedures.

The case of the Real Compañía de Riegos de Levante en la Margen Izquierda del Segura, on the left bank of the river, is the best regional example of the uncontrolled development of irrigation (figure 6). Initially, the company had a division devoted to hydropower exploitation on the Segura river and another for supplying irrigation waters (Gil Olcina, 1968; Bru, 1993; Canales, 1988). Since its foundation, the operation was distinguished by two facts. First, there were important financial imbalances, generated by the loss-making behaviour of its irrigation division, and secondly the company boosted the extreme expansion of the irrigated area, much beyond the 9900 ha legal limits stipulated by the public allocation of licences.

Such expansion was the result of a strategic decision made by the company. Most of the land considered by the public allocation licences was supplied by historical irrigation communities, which only required a small amount of additional water to meet the demands of the most valuable crops. Thus, the company's best clients were those placed in areas without any supply at all. For this reason, Riegos de Levante extended its irrigation networks beyond the legal boundaries, in order to gain the highest number of clients and reach the customers with higher water needs.

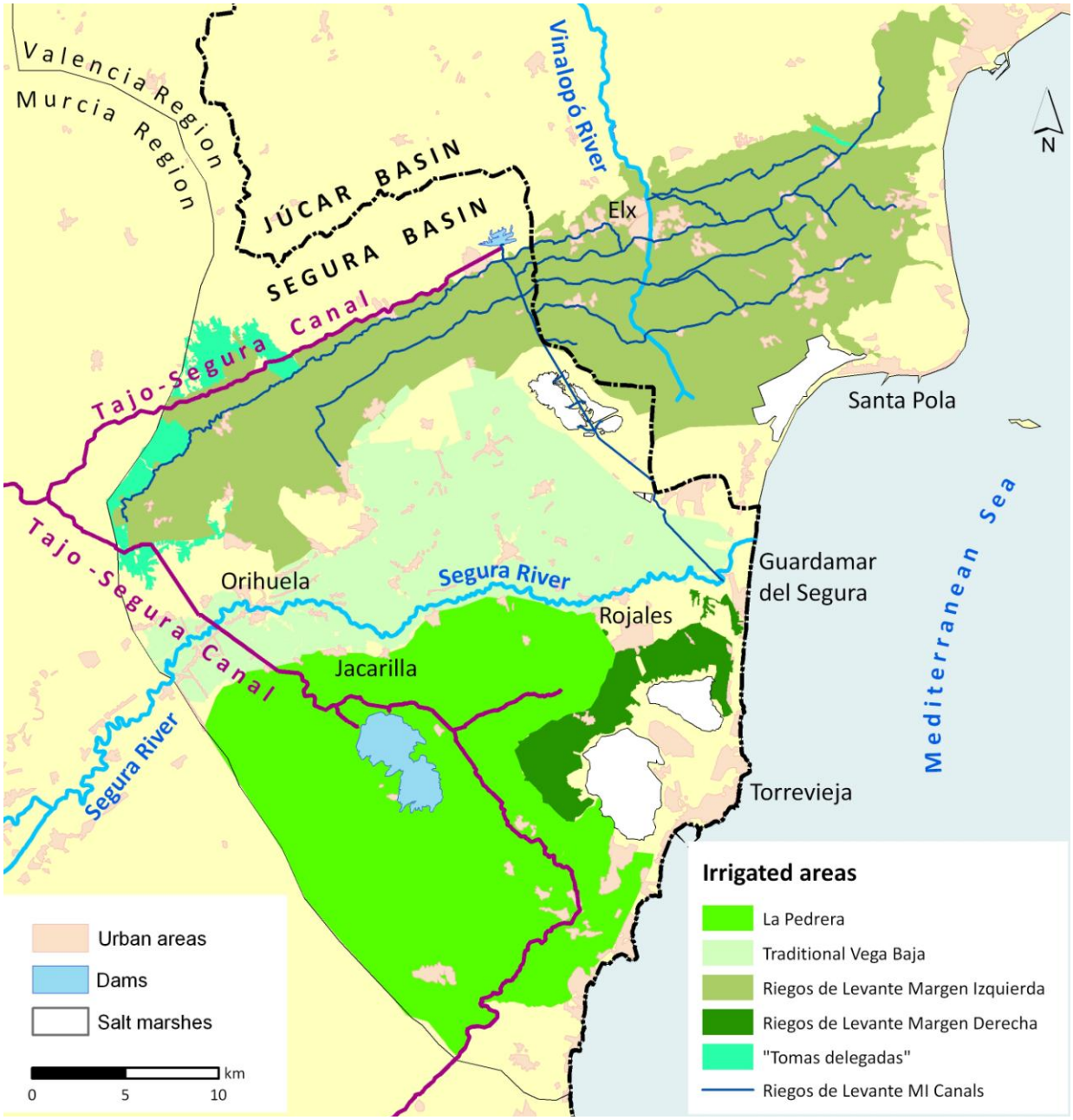
After the Spanish Civil War, in 1940, the new government came into play with a Ministerial Order, denouncing the 'bad usage' of granted outflows. The argument was that the aforementioned company

[8] They were originally private companies promoted by local or international investors (the Dreyfuss Bank was involved in Riegos de Levante Margen Izquierda project development). The companies sold shares proportional to water rights to farmers. Whereas Nuevos Riegos el Progreso is still a public limited company, the other companies went bankrupt and farmers created water users associations (*comunidades de regantes*) for the management of these water resources in the area.

had signed supply contracts with landowners and/or water user associations out of authorised districts, and exceeded the legal limit of 9900 ha established under administrative concessions; for instance, in Elx district alone, there was around 6500 ha more irrigated land than initially allowed (Maass and Anderson, 1978).

In accordance with the policy of supply expansion followed by the Franco regime, the ministry approved the solution proposed by farmers to consolidate lands in original concessions with other areas developed without legal authorisation and create new (larger) legal units. As a result, all extensions carried out to that point were validated, increasing by four times the original area to 39,300 ha. It was a substantial area, taking into account that the administrative concession was originally just for 'leftover' water from the river mouth. For this reason, the demands of landowners could never be satisfied and the real irrigated surface area never exceeded 25,000 ha.

Figure 6. Irrigated areas in the Low Segura district.



On the right bank of the river, a similar expansion process took place at the same time. Riegos de Levante en la Margen Derecha doubled the irrigation area from the 2000 ha considered in the 1918 legal concession of water rights, to the 4183 ha registered in 1947 (López and Melgarejo, 2007). In this right bank, the uncontrolled expansion of irrigation continued across the land sat beside the southern boundary of the historical irrigation area of the Vega Baja. There, irrigation development increased after the Spanish Civil War, notably through diversions to land belonging to military officers or supporters of Franco's dictatorship. This happened, for example, in the municipality of Jacarilla, through pumping initially used to irrigate lands of the Orihuela bishopric or those of the Francisco Franco family, and extended later to other small landowners.

The gradual but uncontrolled increase of the irrigated surface area by these means – consisting of 2000 ha – was legalised by the Decree of 25 April 1953. The text also established a priority order in the allocation of flows: first, the traditional irrigated lands – previous to 1933 – and second, all those irrigations entitled to consumptive use that – with or without administrative concession – should regulate their situation within the 6 months following publication of the Decree. In addition, in case of 'surplus', the increase of irrigation surface areas next to traditional irrigated lands was allowed.

A subsequent ministerial order of 27 December 1966 established that newly created irrigation – after 1953 and without consolidated rights – should be considered in the distribution of irrigation resources, providing that the sum of the diversions of both historical areas, and those authorised by the 1953 Decree, did not exceed in the Low Segura district the quantity of 28.5 Mm^3/yr. This resolution forced the Comisión de Aguas del Segura, in charge of allocating concessions, to assess the irrigated area and its water needs in order to determine the outflow available for new extensions. In the Low Segura, 3500 ha of land irrigated after the 1953 Decree were identified (Canales and Juárez, 1994). The irrigation of this land – in many cases abusive extensions of the administrative concessions made in the 1953 Decree – generated a great deal of conflict between the landowners of these exploitations and traditional water user communities from Vega Baja, affected by river withdrawals upstream of their land.

Allocating expectations: Irrigation development under the Tajo-Segura Transfer

In 1969, the government approved the construction of the Tajo-Segura Transfer Project, with the aim of moving 1000 Mm^3 from the Tajo's upper basin to the Segura basin for agricultural development of, and urban supply to, this area. The project was designed to use 125 Mm^3 for the Low Segura district, of which the larger part – 92.5 Mm^3 – should complement the volumes diverted by Riegos de Levante Margen Izquierda. It also considered the creation of the irrigated area of La Pedrera to the south, on the right bank of the river, integrating old pumped irrigation sectors with new extensions (see figure 6). The new irrigated area, established by Decree in 1973, received an allocation of 14.5 Mm^3, and the maximum irrigated area was stated as 7500 ha.

The foreseeable arrival of water for irrigation had an immediate effect on the land market (Costa, 1981), increasing land prices by 600%. Local chambers of agriculture channelled landowners' interests and, between 1977 and 1978, several meetings were arranged to create water user associations in those areas where there were no previous irrigation communities, with the aim of dealing with water applications and starting the land transformation works.

The first transfer of water from the Tajo river reached the Vega in 1979. Of the original 600 Mm^3 initially allocated to the whole basin, a mere yearly average of 175.6 Mm^3 of water was distributed during the first five-year period of operation. The gap between the expectations and the volumes actually transferred provides a measure of the water deficit in the La Pedrera irrigation area and, to a great extent, of the subsequent agro-ecological problems in the whole Segura basin.

Coinciding with the launch of the Tajo-Segura Transfer Project, a joint technical commission, formed by staff from the IRYDA and the Ministry of Public Works, was created to coordinate the management and transformation works of the irrigated area of La Pedrera. The Commission met in 1979, and one

year later, in March 1980, presented a first report about water distribution from Tajo-Segura joint exploitation. The report explained the criteria to be followed to share the resources. At that time, the applications for water concessions from farmers interested in irrigation (and also from some urban promoters) had already exceeded the forecasts. Although the 1973 Decree limited the irrigated area to 7500 ha, the transformed land reached 9136 ha. Given the lack of water resources, the new irrigated areas obtained water from tankers or pumped it from the drainage canals of the traditional irrigation area of the flood plain.

The estimated need for water for the whole irrigated area was 51 Mm^3, an amount that far exceeded the volume initially allocated. The conclusions of the aforementioned report revealed how aware the hydraulic administration was of sponsoring the creation of water-short areas, while it seemed impossible to control the expectations for such hydraulic work. The Commission concluded that

> the needs for water to attend all applications far exceed water availability… The irrigation of the selected areas presents a high profitability, due to the great quality of soils, climate, etc… Great interests are involved and those negatively affected will do everything possible to oppose any adopted resolution (CTM, 1980).

In view of the evident imbalance between available resources and irrigated areas, at the beginning of summer, 1980, the Commission approved "selecting an area to allocate a reasonable annual water duty of 3750 m^3/ha (…) in view of the impossibility of irrigating the whole area" (CTM, 1980). Even so, the irrigation of selected lands with an annual water duty of 3750 m^3/ha demanded the allocation of an annual 31 Mm^3 volume that largely exceeded the 14.5 Mm^3 allocated by the Transfer Project. With a view to meeting this shortage, the Commission agreed to request the General Direction of Hydraulic Works (Ministry of Public Works) a concession of 12 Mm^3 of stream waters, whose origin was defined with a lack of rigour.[9] The administration did not approve the application.

Finally, in 1981, the water user associations reached an agreement to share the limited volume of water available across all transformed land – a total of 13,671 ha. The following year, the administration, incapable of limiting the expanding irrigation area, accepted to share resources between water users, stipulating that "these waters (…) do not set a precedent nor create any kind of right".[10]

However, examination of the documentation reveals how some administrative actors never agreed with such a verdict. In fact, the Division of Hydraulic Resources, belonging to the Comisaría de Aguas del Segura, published a critical report – later not endorsed by higher authorities – in which they expressed their bewilderment in view of the created process of irrigated area:

> Although this engineer does not know all the antecedents of the irrigated area, he cannot figure out how this dichotomy between irrigated area and hydraulic resources, which does not seem to exist in any other area of the Transfer, has come about.[11]

The report was very critical of the solution adopted because of the imbalance between resources and irrigated area, and concluded, almost in a prophetic way: "If resources are going to be applied on the

[9] Of the 12 Mm^3 requested, the larger part came from Riegos de Levante Margen Derecha. This community had a concession of 9.5 Mm^3 of Segura 'surplus' water in the river mouth, but in 1974 obtained a verdict which considered this volume as a historical flow. It was just a change in the legal consideration of the allocated volume of 9.5 Mm^3, but the Commission misinterpreted it as a new liberation of 9.5 Mm^3 of the remaining waters. In the river, really, there were just 9.5 Mm^3 that were going to be used by Riegos de Levante Margen Derecha, although under a new legal category. The Commission calculated the same volume of water twice, trying to allocate 9.5 Mm^3 anew to La Pedrera.

[10] In the original: estas aguas [...] no suponen ningún precedente ni crearía ningún tipo de derecho.

[11] In the original: Aunque el ingeniero que suscribe no conoce todos los antecedentes de la zona regable, le es difícil comprender como ha podido producirse esta dicotomía zona regable recursos hidráulicos, que no parece haberse dado en ninguna otra zona del Trasvase.

whole irrigated area, shortly afterwards the conclusion will be that there is a wealth promoted with Administration consent, which will need to be sustained with additional water resources".[12]

With regard to the lands located north of the district, supplied by the Riegos de Levante Margen Izquierda canals, the arrival of a very generous supply (92.5 Mm^3) from the Tajo river alleviated the chronic lack of water, and also meant an opportunity to improve the economical situation of water user associations. Throughout the 1980s, in order to obtain extra income and make use of the remaining volumes from the transfer, Riegos de Levante Margen Izquierda elaborated a method known as syndication, which involved selling water to farms not included in the community. Without processing any application for authorising or modifying irrigated areas, the community allowed the incorporation of new members after payment of a contribution.

The method of *syndication* led to the emergence of the term *tomas delegadas*, new water user associations without any administrative concession at all and located, almost without exception, out of the irrigated area of Riegos de Levante (see figure 6). The term *tomas delegadas*, whose translation could be 'delegated intakes', seems to mean – euphemistically – open intakes for Riegos de Levante's particular use, although delegated to lands outside the legal perimeter of irrigation. This risky neologism, used regularly by the hydraulic administration, is absolutely inadequate, because water was never provided by Riegos de Levante, but instead directly distributed by the Confederacion Hidrográfica del Segura.

Syndication operations were justified as an exchange of lands – agricultural lands encroached on by urban areas compensated by new lands – but, in fact, no administrative procedure was followed to legalise the exchange. It was, in essence, the same procedure used in the 1920s to expand the irrigated area without legal permission. Thus, several landowners and new irrigation associations began to use the resources of the Tajo-Segura Transfer Project with the consent of the public administration, which built new intakes and tolerated the sale of water. In total, an area around 3300 ha was transformed with the support of the Confederación Hidrográfica, but without any legal water concession.

When expectations became bottlenecks

In the last two decades, in order to solve the water deficit generated by the uncontrolled expansion of irrigation, the administration and water user associations have searched for new resources, mainly from non-conventional sources. The Tajo Transfer, instead of balancing out supply and demand, severely diminished water availability as it stimulated new demand, just as some technicians had dared to forecast some years earlier.

Treated sewage effluent resources for irrigation have been the most successful initiative to compensate for this imbalance. The tourist development of the district's coastal zone has provided an important amount of water, which is particularly abundant during the summer, when crops need the highest amount of water. In the northern area, very recently, the administration has also allocated resources from three new treatment plants (Santa Pola, Alicante, and La Marina d'Elx) to Riegos de Levante Margen Izquierda. In the Pedrera area, the reuse of this resource started some years earlier.

In 1982, modest effluent from the sewage treatment plant in the city of Torrevieja was allocated to a small group of 23 farmers, who ten years later set up the community of irrigators of Torremiguel. Due to explosive tourist development – the city grew from 12,000 to 101,000 inhabitants from 1981 to 2008 – the effluent increased considerably. Consequently, the farmers could not absorb this amount of water, and started to sell it to their neighbours. At the end of the 1990s, the administration began the construction of pipes and pumping stations to distribute the water to other water user associations in La Pedrera, who paid a tax to the farmers of Torremiguel, owners of the water rights. Finally, in 2007, the government redistributed the water rights of the treatment plant, maintaining the privileged

[12] In the original: Si los recursos se aplican a la totalidad de la superficie, dentro de un tiempo se esgrimirá que existe una riqueza creada, propiciada por el consentimiento de la Administración, que habrá que mantener con otros recursos hidráulicos adicionales.

position of the Torremiguel farmers – 5.9 Mm^3/yr, a volume considerably higher than their needs – and allocating rights up to 1.7 Mm^3/yr to the irrigation communities of La Pedrera. Part of the new water allocated to the Torremiguel community – 3.3 Mm^3/yr – was used to supply a golf course situated far from the traditional irrigated area of the community.

Despite the important contribution made by the recycled sewage, recurrent water shortages stimulated the farmers to demand new resources from the central government, with the support of regional authorities. The 2001 National Water Plan was received by farmers as a final solution for this structural deficit. The document recognised a need of 11 Mm^3 in La Pedrera and 10.5 Mm^3 in *Riegos de Levante*. This volume had to be met with water from the Ebro-Segura Transfer Project, whereas small coastal desalinisation plants would solve the supply problems of urban and tourist developments. When the project was discussed in the public arena, water user associations adopted a strong commitment to the initiative, participating in several demonstrations and public acts of support.

In 2004, when the National Water Plan was reformulated, suppressing the Ebro transfer, the farmers were deeply disappointed. In the Low Segura district, the AGUA plan considered the construction of a large desalinisation plant in Torrevieja, with a capacity of 80 Mm^3 per year, 50% for urban uses and 50% for agricultural ones. Water user associations supported this alternative plan, but they did not abandon their claims for the Ebro Transfer. Their position was based mainly in the uncertainty regarding the final price of desalinated water.

In parallel to the search for new resources, the uncontrolled expansion of irrigation stimulated by the Tajo-Segura Transfer Project caused important distortions in the water rights regime. Two decades after the first Tajo transfer, none of the water user associations of both La Pedrera and the *tomas delegadas* had received any administrative water concession from the Tajo-Segura transfer canal. In 2002, the Condeferación Hidrográfica del Segura intended to legalise water sold to the tomas delegadas, and produced a document proposing the allocation of water rights to all users. In addition, the document recommended the legal concession of rights, stating that the Tajo water sold annually by the Confederación "was a concession of expectations worthy of protection and, for this reason, any of the users registered in the invoices list of the Confederación should be provided with Tajo water" (Bravo, 2001). The lengthy legal defence for this argument, and the opposition of other water user associations – including those of La Pedrera – paralysed the progress of this initiative.

In 2005, the administration once again undertook the process of allocating water rights, through negotiations with all users of the Tajo-Segura Transfer. According to the agreements established among users and the administration, the amount of water rights to be allocated reached 400 Mm^3. The volume was totally unrealistic; in fact, during the 27 years of history of this transfer, only in two seasons did the water sent to the Segura watershed from the Tajo river reach this amount. Today, the conundrum has not been solved and the future of the Tajo Transfer is even questioned by the politicians of the donor region of Castilla-La Mancha.

CONCLUSIONS

The development of irrigation in Spain in the 20th century shares similar characteristics with other countries, where the model of supply management has been intensively put into practice. While water was perceived as an abundant input, the state invested in the construction of dams and canals, boosting the expansion of irrigation, directly or indirectly, and promoting other uses for water. The singularity of the Low Segura district case stems from the active participation of the private sector, which assumed the development and management of irrigation expansion, frequently going beyond governmental limits.

During the first stage, between 1900 and 1970, irrigation communities and companies led agricultural expansion. The administration acted accordingly, subsequently legalising most of the actions carried out illegally to extend irrigation to new areas, for instance in the cases of Riegos de Levante Margen Izquierda and Margen Derecha, and in the Decrees of 1953 and 1966. Thus, water

rights were overallocated a posteriori, in order to please private agents and due to the necessity to establish priorities of use among different communities. There was a common interest among both the administration and individual users, with the aim of increasing incomes through agricultural development. Other agents, such as the private construction companies and the financial sector clearly benefited from this alliance too. There was, moreover, policy coherence between the model of supply management and implementation on the ground.

The category of 'surplus water' proved to be useful in this persistent strategy. It was the perfect tool to overallocate resources without provoking the reaction of users with historical rights and with priority of use. It provided the administration the opportunity to preserve an undefined or imprecise assessment of water resources availability in order to fuel expectations. This instrument has been repeatedly used along the 20th century.

The Tajo-Segura Transfer is the epitome of the model of supply management. The impact of the project, in social and environmental terms, was amplified by the huge expectations created by the Franco regime in the region. The political pressures of the emerging regional powers – the donor region of Castilla-La Mancha – during the advent of democracy and the inappropriate management of the Tajo headwater reservoirs in the 1980s explain the subsequent imbalance between the volumes defined in the project and the water transferred during the last three decades.

Nevertheless, the case of La Pedrera irrigation area also shows the importance of the lack of control over irrigation expansion in explaining the imbalance. It is interesting to underline the opposition of some technicians to this expansion, who tried – unsuccessfully – to instil sound management practices and were disavowed by their superiors. This reflects the emerging contradictions between the forthcoming model of demand management and existing inertias. It is also evidence of the complexity of these transitions in water culture.

Since the 1985 Water Law, the principle of demand management has dominated the discourses of governments and has begun to materialise in the legal water framework. However, the strategy of non-enforcement and neglect by some key bureaucratic bodies has widely contributed to perpetuating the former model. In the Segura watershed the instruments of control of irrigated areas have been clearly underutilised during the last two decades.

In this period of time, in spite of the huge environmental impact on wetlands and riverine ecosystems, the Confederación Hidrográfica del Segura has been unable to implement executive actions to enforce legislation. The inertia that has hindered the consolidation of the new model of demand has, to some extent, an administrative origin, due to the lack of staff qualified for new functions and budgetary limitations. However, the main cause of this problem is social and political pressure, caused by the unpopularity of executive actions of control. The result of several decades of confidence in the domination of nature, of cheap water provided by the state or easily extracted from the ground, of expectations eventually converted in water rights, cannot be reversed in a few years.

The *syndication* procedures are the best example of lax enforcement of such control. Developed during the late 1980s and throughout the 1990s, they were clearly contrary to the new model of management and intrinsically opposed to the spirit of the legislation. Despite the existing legal instruments of control of irrigated areas and regulated procedures for water rights allocation, the Confederación Hidrográfica del Segura relinquished part of its duties. It is also evidence of the persistence of the hydraulic-mission ideology, strongly rooted in the society of south-eastern Spain, due to the huge dynamism of the agriculture of export, in terms of income and job creation.

It is widely known that water in Spain has become a strategic vote-catching affair. This fact is also weakening the position of those managers and technicians trying to carry out sound management and due to lack of political support they are unable to adopt unpopular measures. For this reason, the subsidised transformation to drip irrigation has become the most effective and generalised instrument used for reducing consumption. These 'modernisation' plans are financed by several administrative bodies, whereas coercive actions are not taken by anyone. At the same time, and for the same reason, the search for new water resources – those from the Ebro river, waste water, or desalination plants –

has become the best political solution for both majority parties to please all users in the basin and to solve the water deficit. Consequently, the state seems to be endlessly supporting irrigation development, despite the shifting social and economical context.

The strong persistence of the hydraulic mission ideology among most sectors of Murcia and Valencia makes these regions the last Spanish bastion of the model of supply management. In this context, although the environmental model imposed by the European Water Framework Directive poses serious difficulties to the Spanish hydraulic administration, it is also an opportunity that should be used as a powerful tool to overcome these historical inertias. In the future, the Confederaciones' action of controlling water rights – also water quality, rivers and wetlands environments, and groundwater abstraction – must be executed more rigorously than it was in the past and is at present.

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