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# GOVERNING SCARCITY. WATER MARKETS, EQUITY AND EFFICIENCY IN PRE-1950s EASTERN SPAIN

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# GOVERNING SCARCITY. WATER MARKETS, EQUITY AND EFFICIENCY IN PRE-1950s EASTERN SPAIN

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**ABSTRACT:** It is usually taken for granted that the existence of water markets allows economic efficiency gains to be achieved at the expense of equity losses. This paper addresses the issue by analysing the functioning of the irrigation communities in pre-1950s eastern Spain. While in some of them the water inhered in the land and could not be sold, in others there were tradable water rights. In the paper it is shown that, in the former, not only was equity greater but in fact the resource was also used more efficiently.

**Keywords:** water markets, Spain, irrigation communities, efficiency, equity.

**JEL:** Q01, Q25, N53, N54

**RESUMEN:** Es habitual dar por supuesto que la existencia de mercados del agua permite ganancias de eficiencia económica a costa de pérdidas de equidad. En este artículo se aborda la cuestión mediante el análisis del funcionamiento de las comunidades de regantes de la España del Este antes de la década de 1950. Mientras que en algunas de ellas el agua estaba ligada a la tierra y no podía ser vendida, en otras tanto el agua como los derechos sobre ella podían ser comprados y vendidos. En el artículo se muestra que en las primeras no sólo era mayor la equidad, sino que el recurso era utilizado de manera más eficiente.

**Palabras clave:** mercados del agua, España, comunidades de regantes, eficiencia, equidad.

# GOVERNING SCARCITY. WATER MARKETS, EQUITY AND EFFICIENCY IN PRE-1950s EASTERN SPAIN

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## I. INTRODUCTION

Over the last three decades the ideas that researchers and policy-makers previously held on water management in irrigated agriculture have been shaken by two major trends. On the one hand, the conviction that there is potentially room for a great deal of improvement if management is carried out by local communities has become the "new paradigm" (Kikuchi et al. 2001) and in many developing countries there has been a massive shift of the responsibility for the operation and maintenance of irrigation systems away from state agencies towards water-users' associations (FAO 2004, 311-317). On the other hand, there seems to be widespread agreement in favour of the need to adopt better water pricing policies, since underpricing of irrigation water is believed to be one of the main causes of water wastage. But no such agreement has been reached about which water pricing method ought to be used.[1]

Many stress the advantages of water markets. Their main argument is that the allocation of water through competitive market pricing would make prices reflect its marginal value both for the buyer and for the seller, so that it would be continuously reallocated to higher-value uses.[2] The irregularity and uncertainty that usually characterise surface water supplies, however, are complications that could prevent this from happening.[3]

The market will lead a resource towards its highest-value uses if a series of conditions are fulfilled, which include the absence of externalities, well-defined property rights, many sellers and buyers, perfect information and perfect mobility. Because the water market does have externalities and often has few sellers, water is prone to market failure (Livingston 1995 and 1998). If in addition supplies are very irregular and unpredictable, the irrigator will have to make many of his farming decisions with little information about how much water will be available in the near future. Perfect mobility might not exist simply as a result of the losses that are always

[1] Cumming and Nercissiantz 1992; Tsur and Dinar 1997; Perry et al. 1997; Johansson 2000; Johansson et al. 2002; Rogers et al. 2002; Molle and Berkoff 2007; De Fraiture and Perry 2007.

[2] Rosegrant and Binswanger 1994; Spulber and Sabbaghi 1994; Thobani 1997; Saleth and Dinar 2004; Bennet 2005.

[3] Rosegrant and Binswanger 1994; Beare et al. 1998; Livingston 1998; Bjornlund 2004; Hadjigeorgalis 2004.

produced when water is transferred from one place to another, which may mean that it cannot be readily switched from one use to another. The more perfect the conveyance system is, the lesser the losses will be, whereas the greater the distance is, the higher the losses will be. If little water is available during a drought and the farms of those who would be willing to pay the highest price for it are a relatively long way away from each other, the water might not reach all of them just because it is physically impossible to take it there. Under such circumstances, is the market the best system for allocating the scarce resource?

Are those problems solved better when the water is managed by irrigation communities? Are water markets compatible with the presence of irrigation communities? Using basically a priori reasoning, Mumme and Ingram (1985) and Young (1986) claimed that they are not, while Dudley (1992) and Rosegrant and Binswanger (1994) defended the opposite stance. But there have been few chances to test this in practice for one simple reason: to date, management by irrigators' associations and the presence of water markets – as in Chile and Mexico – have seldom coincided (Molle 2009).

Pre-1950s eastern Spain is a very appropriate framework for the analysis of these questions for six reasons. First, the scarce and irregular rainfall and high summer temperatures of the region made it crucial to have a controlled supply of irrigation water. Second, the flow rate of the rivers was generally low and always very irregular (a problem that partially disappeared after the 1950s, when the construction of large dams started to become widespread). Third, the management of surface water was always performed by irrigation communities. Fourth, while in some communities there was appurtenance of water rights to land, the farmer could only use the water belonging to each piece of land to irrigate that particular piece of land and irrigating was very cheap, in other communities there was a water market and tradable water rights. Fifth, contemporary observers almost unanimously defended the apparently counterintuitive idea that water was used more efficiently when it was tied to the land. Lastly, in the 1960s the two types of community were the subject of a comparative study by Maass and Anderson (1978), who came to the opposite conclusion. From then on, Maass and Anderson's findings have frequently been cited to illustrate the advantages that can be gained from using the market as a tool to allocate water.[4] Perhaps more important, Maass and Anderson's book was also used by Elinor Ostrom (1990, 69-82) to obtain information about the irrigation communities in eastern Spain, and therefore to obtain empirical evidence on which to base her famous "principles" concerning the conditions for the success of common-pool resources in general (Ostrom 1990, 90-102) and of water resources in particular (Ostrom 1992, 67-76).

[4] For example, Hearne and Easter 1995, 5; Howe 1997, 80; Lee and Jouravlev 1998, 21-22; Livingston 1998, 21 and 23; Burns and Meinzen-Dick 2001, 5; Easter and Archibald 2002, 23; Easter and Lin 2005, 13.

In this paper Maass and Anderson's theses will be discussed and, in doing so, the case of pre-1950s eastern Spain will be used to take a new look at an old topic, i.e. the relationship between efficiency (understood as the capacity to create wealth within a given resource base) and equity (which depends on how that wealth is distributed in society). As defended by Maass and Anderson, it will be shown that equity was greater in the irrigation communities that did not have tradable water rights. But something newer and more interesting will also be shown. The theoretical literature usually assumes that there is a trade-off between efficiency and equity (Msangi and Howitt 2007 offers a recent example of this), something which has been confirmed by a large number of case-studies (Molle 2009; Shah et al. 2009). But some researchers have argued that this does not necessarily have to be the case. According to Samptah (1992, 970), under certain conditions the promotion of efficiency can be compatible with improved equity, while policies introduced to promote equity have sometimes resulted in a simultaneous decrease in efficiency and equity. Others have claimed that the presence of water markets can lead to a reduction in rural poverty.[5] Here it will be concluded that, in pre-1950s eastern Spain, both equity and efficiency were greater in the irrigation communities without a water market.

Maass and Anderson considered that the irrigation communities of eastern Spain used three different systems to distribute the common water around the territory that had the right to be irrigated with it (which in Spanish is called the *huerta*). In this paper it will be assumed that there were only two such systems: the one used where there was no water market and that used where a water market did exist.[6] In order to study the functioning of the latter, Maass and Anderson chose the case of the *huerta* of Alicante, where, according to them, the fact that the farmers with the highest-value uses for the water were able "to outbid others during all periods" allowed the water to be used more efficiently than in places where it could not be sold (1978, 139). However, these conclusions do not appear to be consistent with the quantitative information offered by the authors themselves.

In 1964 the crop which provided the highest "full production net return/ha" in Alicante was the tomato, which allowed farmers to obtain 60,000 pesetas per year per hectare. So why were tomatoes only planted on 4.5 per cent of the *huerta*? (Maass and Anderson 1978, 144-145). If wheat and almonds only yielded 15,000 and 28,800 pesetas per hectare, respectively, why did they take up 20.5 and 24.6 per cent of the

[5] Fujita and Hossin 1995; Saleth 1998; Meinzen-Dick 1998; Rogers et al. 2002; Pant 2005; Narayanamoorthy 2007.

[6] Maass and Anderson distinguished between the *turno* (turn) procedure and the *tanda* procedure. With the former farms received water in a set rotation order and, when it was their turn to irrigate, the farmers could keep their headgates open for as long as they wanted, provided that the water was not wasted. The latter was also based on a set rotation order, but farmers could only withdraw water for a predetermined length of time, which was proportional to the area of their farms. In reality, the system used by nearly all the irrigation communities where the water inhered in the land was a mixture of the *turno* procedure and the *tanda* procedure (Garrido 2011).

irrigated area? In eastern Spain as a whole, the crop with the highest net return was the orange (80,000 pesetas per hectare, p. 99), which was the monoculture of most of the *huertas* without a water market (Garrido 2010a). Although its soil and climate were very well suited to growing oranges, yet on the *huerta* of Alicante there were no orange groves. Why not?

The search for an answer to these questions will serve as a thread connecting the four sections that make up the rest of the paper. The next section looks at the communities without a water market. Then the communities with a water market are examined. After that, the efficiency with which the water was used in each case is compared. Lastly, some conclusions are provided.

## II. COMMUNITIES WITHOUT A WATER MARKET

Throughout the nineteenth century the *huertas* in eastern Spain were visited by a number of engineers and geographers from France and the United Kingdom. Although some of them were very critical about the way the communities with a water market worked (Aymard 1864, 221-259; Brunhes 1902, 98-108), all of them praised the functioning of the communities in which the water inhered in the land. But what they said about the efficiency with which the resource was used in the latter appears to be contradictory. On the one hand, they said that very intensive farming was carried out in them and that a great deal of effort was made to ensure that no irrigators wasted water. "Nowhere in Valencia," wrote for example C. S. Moncrieff (1868, 149), "did I see a flooded road. The watercourses were all neat ... The fields were everywhere clean and carefully terraced to receive the water..." They also pointed out, however, that the average discharge flow of their main canals would have allowed some communities to irrigate a much greater area than they actually did, which seems to suggest that, on a collective level, water was in fact wasted (Aymard 1864, 103; Roberts 1867, 27-28; Moncrieff 1868, 150 and 168).

To test whether it is true that such wastage did not exist on an individual level, I consulted the archives of the communities in Vila-real, Borriana and Castelló (all of which used the river Mijares), the archives of the Júcar Canal (which conveyed water from the river Júcar to 21 towns), and also several cadastres (*padrones*) of Alboraia (a town that was part of the *huerta* of Valencia and got its water from the river Turia) and of Gandia (whose *huerta* obtained its water from the river Serpis).

Between 1870 and 1927 the community of Vila-real imposed 6,928 fines (an average of 121.5 per year) for offences against its Ordinances. If we bear in mind that in 1900 the community was made up of 4,123 landowners and that the 2,224 hectares of its *huerta* were divided up into 10,412 parcels, 121.5 fines per year is a very small number.

Three reasons related to the prevention of wasting water (i.e. irrigating out of turn,[7] failing to clean the secondary canals,[8] and not keeping watch over a field that was being irrigated) together accounted for 26 fines per year. But only five fines were issued per year for a non-preventive action that was also related with wastage of water, i.e. flooding fields against their owners' will.

If somebody irrigated their parcel too much, part of the water usually ended up flooding the lanes or (more likely) the neighbouring parcels. In contrast to what happened with the rest of the infractions (which were usually reported by people employed by the communities), those who flooded their neighbours' fields were nearly always reported by the affected neighbours themselves. This behaviour was due to the fact that most of the crops grown on the *huertas* could not withstand excessive amounts of moisture, but also because unplanned irrigation upset the whole schedule of work to be done on the farm.

Small farmers predominated on all the *huertas* and the typical farm consisted of a large number of scattered parcels. The main reason for the dispersion of the parcels, however, was not a wish to minimise the risk of the whole farm being affected by some meteorological disaster (which is the reason that is usually put forward to explain this kind of situation). Instead it was the result of a desire to optimise the use of the family workforce (Garrido and Calatayud 2010). If several scattered parcels were cultivated, it was relatively easy to ensure that irrigation was staggered. Since all farm work had to be stopped for several days after a plot had been watered, the labour demand was therefore more regular. This made it less necessary for farmers to work for other farmers on a daily wage basis at certain times, while also reducing the need to engage wage workers on other occasions.[9] They were therefore highly motivated to report neighbours who flooded their fields, and the fact that so few cases were actually reported suggests that little water was wasted.[10]

The same conclusion is also reached from another very significant indicator. If the practice of wasting water had been widespread, it is to be expected that those who did so most frequently would be the irrigators whose farms were located at the top-end of the canals (Bardhan 1984, 215; Ostrom 1995). If this were the case, there would be differences in the type of crops grown in the head-end and in the tail-end areas (because the former would tend to be more water-intensive), there would be differences in crop

[7] If a farmer missed the chance to irrigate and later interrupted the flow of water to do so, all the water contained in the canal between this farmer's parcel and the last parcel that had been irrigated downstream would run towards the canal tail and, since nobody in particular was waiting for it, it could be lost.

[8] What usually happened in eastern Spain is that the main canals were cleaned by workers paid by the community, but the irrigators cleaned the stretches of secondary canals that ran alongside their farms.

[9] The scattering of parcels also meant that during droughts it was easier to reach an agreement between irrigators on how to share out the water (Wade 1988, 185; Garrido 2011), but that was just a by-product.

[10] The way fines were issued in Borriana (Garrido and Balaguer 2010) and Castellón (Glick 1970, 85-93) followed similar patterns to those of Vila-real.

intensities (at the tail-end a larger portion of the land would be left fallow every year) or both things would happen at the same time. However, none of this happened on the Júcar Canal, and in fact quite the opposite occurred: in 1845, almost half the area it irrigated was devoted to growing rice (and therefore had to be kept flooded for part of the year), but the towns where the cultivation of rice was most widespread were the ones located at the tail-end of the canal (Calatayud and Garrido 2010). On the *huertas* of Vila-real, Borriana, Castellón, Gandia and Alboraia no differences are observed between what was grown at each end of the canals.[11] During a drought that occurred in 1849, some tail-enders of the main canal in Vila-real protested about the criteria that had been adopted by the community for distributing the water, since, in their opinion, they went against the interests of farmers who were growing vegetables.[12] The really significant thing about those complaints, however, is that they show that irrigators took it for granted that the tail-end fields could be planted with crops that consumed large amounts of water. The fact that the same crops could be cultivated all over the area served by an irrigation community was to become even more apparent as of the late nineteenth century, when it started to be more and more common to use both the head-end and the tail-end water to irrigate the orange trees that were becoming the monoculture of the *huertas*.

But was water wasted on a collective level? In the late 1920s the eight irrigation communities of the *huerta* of Valencia needed, as a whole, 196 $hm^3$ of water a year (Bellver 1933, 27), which was much less than the 460 $hm^3$ that, as an annual average over the period 1914-1950, the river Turia could have provided them with. Although this apparent wastage was partly a result of the inability to store water during the months in which consumption was lower (which were the ones in which the flow rate of the river was higher), Figure 1 shows how the consumption of the resource was below the average amount available even in the hot dry summer months. In Figure 2, however, it can be seen that the average amounts available are not really representative values, because in 15 Augusts over the period 1912-1950 the Turia carried less water than was considered necessary for this month in the late 1920s. When that happened, supplies were rationed, part of the harvest was lost and there was an increase in the number of conflicts among irrigators.[13]

[11] In some communities, it was easier or harder for farms to irrigate depending on the canal they received their water from. For instance, because it had a poor supply of water, a small part of the *huerta* of Castellón contained only olive trees, which can resist long periods of drought, whereas in a privileged area of the *huerta* of Borriana they grew far more vegetables than in the neighbouring areas. Yet this did not happen because some farmers took more water than their due, but because the Ordinances stated that some areas of the *huertas* (usually the ones whose right to irrigate went back furthest in time) had the right to irrigate more often than others.

[12] Archive of the Community of Vila-real, *Antecedentes-I*, no. 42.

[13] Yet only the most severe droughts had disastrous repercussions on the *huerta* of Valencia, for only 9,519 of its 16,058 hectares had full rights to irrigate from the Turia. Although the other 6,539 only had the right to irrigate when there were surpluses, they very often had access to supplementary water from shallow wells and small springs.

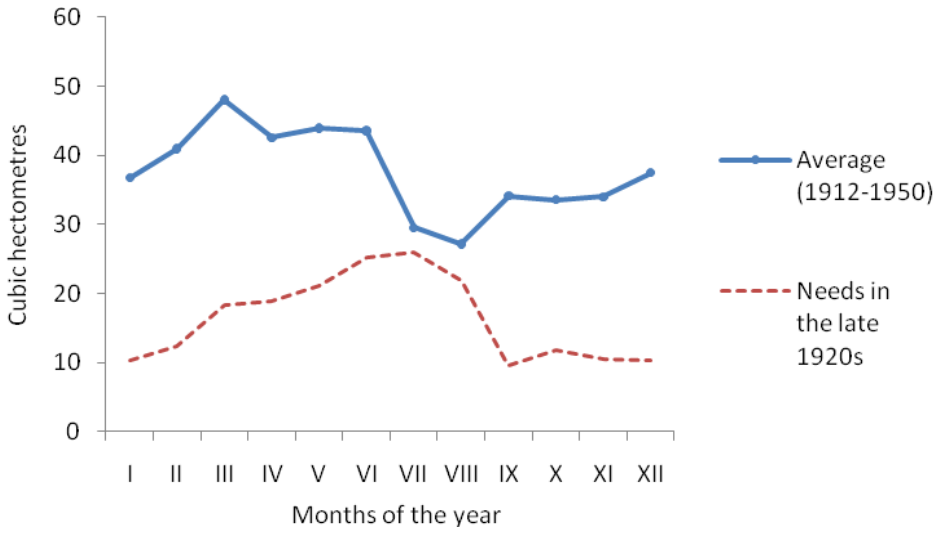


Figure 1. Water available and water needed on the *huerta* of Valencia
*Sources*: http://hercules.cedex.es/anuarioaforos/afo/estaf-datos.asp?indroea=8022 (used to know the flow rate of the Turia) and Bellver (1933, 26-28).

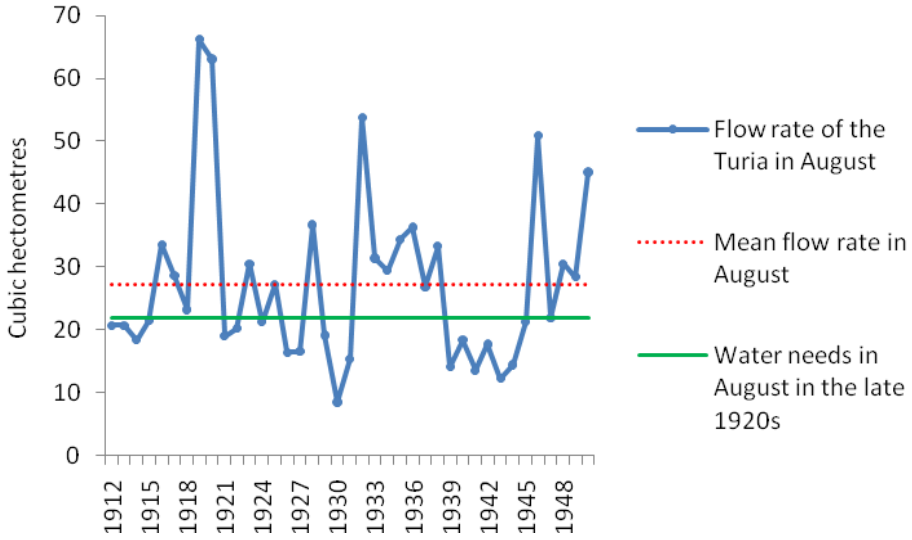


Figure 2: Water available and water needed in August on the *huerta* of Valencia
*Sources:* See Figure 1.

That situation was repeated in all the *huertas* without a water market. To illustrate this, Figure 3 and Figure 4 (which will be discussed below) show what happened on the *huerta* of Vila-real. This particular *huerta* was chosen for three reasons. First, because we have very complete information about what was cultivated on it over the years. Second, because (unlike what happened on the *huerta* of Valencia) in

Vila-real there were no areas that irrigated using surplus water.[14] Third, because it was one of the first *huertas* in eastern Spain where the orange became a monoculture.

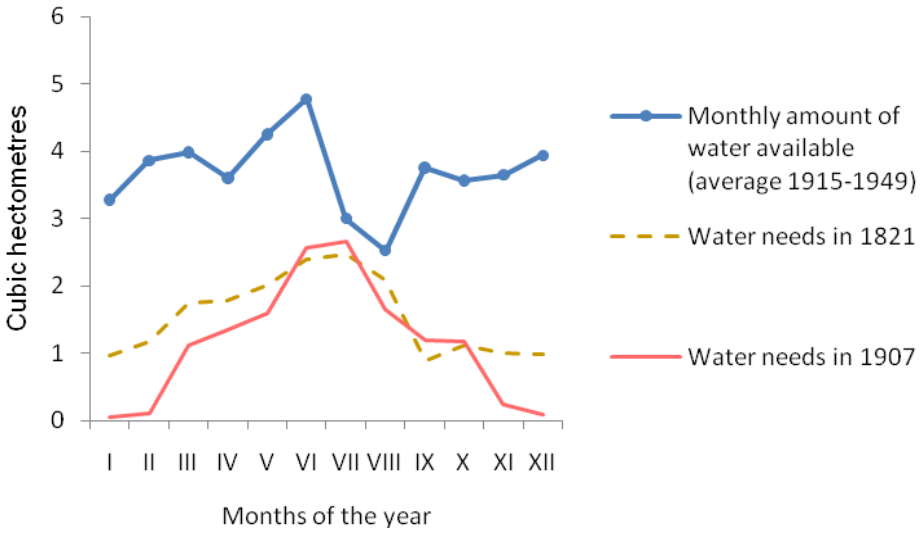


Figure 3: Water available and water needed on the *huerta* of Vila-real
*Sources:* Garrido (2004, 163) provides information about what was cultivated on the *huerta* of Vila-real, and Ministerio de Fomento (1918, I, 413-415) offers data about the amount of water needed by each crop. Information about the flow rate of the river Mijares from 1915 onwards can be consulted at http://hercules.cedex.es/anuarioaforos/afo/estaf-datos.asp?indroea=8005. The Vila-real weir diverted 23.33 per cent of the river's discharge, and I have considered that 30 per cent of that water was lost by evaporation and seepage.

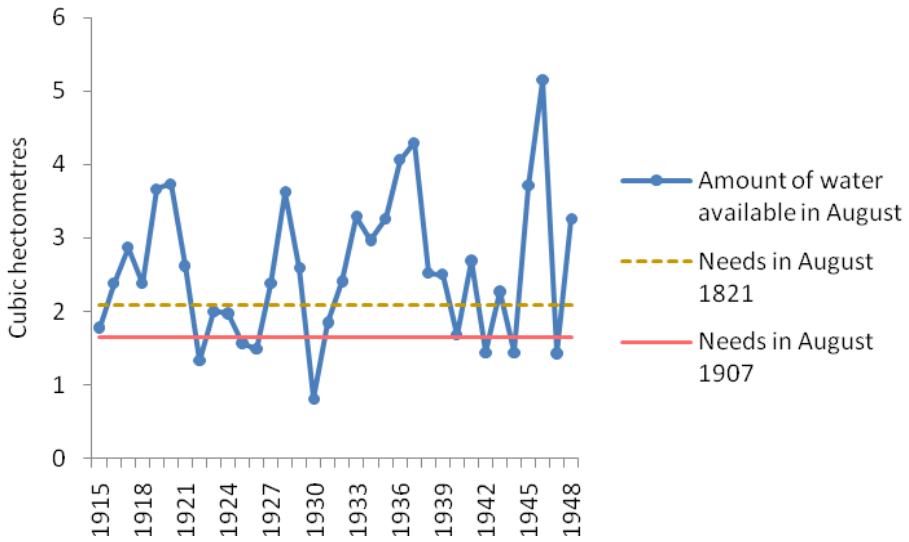


Figure 4: Water available and water needed in August on the *huerta* of Vila-real
*Sources:* See Figure 3.

[14] In order to prevent the conflicts that flared during droughts, what usually happened was that the only areas that were allowed to irrigate with surplus water were those situated along the edges of the *huertas* that also had access to other water (coming from wells, etc.), and in Vila-real this last possibility did not exist.

In a technical report from the early 20th century it was said that the part of the *huerta* of Valencia that irrigated using surpluses could take advantage of this right not only when the river Turia carried a large volume of water, but also "in normal years" (Ministerio de Fomento 1918, I, 375). If looked at the other way round, this statement meant that the territory with full irrigation rights comprised a smaller acreage than the part that could be irrigated with the average flow rate of the river. The same thing happened in practically all the communities where water was tied to the land because, in order to provide farmers with a reasonable degree of certainty that they would not lose their harvests during the frequent moderately dry years, the maximum limits of the *huertas* had been set taking into account the maximum acreage that could be irrigated in times of "ordinary low water".

If it is true that "uncertainty about the physical quantity of water available at particular times and locations impedes efficient resource use by lessening the expected value of engaging in water-related activities" (Livingstone 1998, 20), then the idea that constraining the size of the *huertas* was a means to enhance the creation of wealth no longer appears to be nonsense.

## III. COMMUNITIES WITH A WATER MARKET

> Good regulation can prevent ... the wastage of water; nothing can prevent the tragic consequences of an organisation that entrusts the fate of the land to capitalists whose interests run in the opposite direction to the development of the water sources. (Aymard 1864, 244)

Four types of arguments have been put forward to explain why ownership of the water was separated from that of the land in some irrigation communities. Maass and Anderson (1978) suggested that there was a cause-and-effect relation between the fact that water resources were especially scarce in some regions and the existence of this kind of separation.[15] But this explanation is not sufficient. Most of the 35 or so communities with those characteristics were in very dry areas in the provinces of Alicante and Murcia. Yet they were also to be found in the comparatively wetter provinces of Valencia and Tarragona and in the rainy province of Girona, whereas the water always inhered in the land in the semi-arid province of Almeria.[16]

[15] Many other authors have reached similar conclusions: due to the great expenses involved in establishing them, "water markets will only be active in regions with water scarcity" (Easter, Rosegrant and Dinar 1998, 280).

[16] The total number of communities with a water market mentioned by Lemeunier (1989, 10-11), Ferri (2002, 17) and López and Melgarejo (2007, 309) comes to 35.

The second argument has its origins in Glick (1970, 213-215), who observed that both systems had a lot in common with two "irrigation models" used in the Islamic world. This leaves room for the possibility that the model adopted in each place by the Muslims while they occupied Spain would have continued to be used following the Christian conquest in the thirteenth century. Yet water and land were separated by the Christians in all the communities for which we have records describing their situation immediately after the conquest (Gil 1993; Barciela et al. 2004).

Third, because Alicante, Elche, Lorca, Elda, Petrel and Totana had small reservoirs and tradable water rights, other authors (Brunhes 1902, 95-108 and 427-429; Foster 1936, 65-66; and to a certain extent also Ostrom 1990, 92, and 1992, 51) have linked the presence of dams with the existence of water markets. But in actual fact these already existed before the dams were built. In Almansa, the first municipality in the area where a dam was constructed (in 1584), the water always continued to inhere in the land, whereas the irrigators of Alicante built a dam (the so-called Tibi Dam) in 1594 with the aim of forcing the previously existing water market to vanish from their *huerta*. They did not succeed in their undertaking, but from then on half the water available was again tied to the land.

And fourth, most irrigators on the *huertas* with a water market thought that it was the largest landowners who, illegally and against the will of the majority, caused the water to be separated from the land.[17] Thanks to the references made to it in the proceedings from a trial held in the early eighteenth century, we know that some of the people that enjoyed the greatest economic and political power in Puerto Lumbreras (province of Murcia) began to take possession of more water than their land was actually entitled to and to sell it through a spot market. Then a formal market appeared in which not only the water was tradable, but also the water rights (Gómez 2004). In Alicante or in Lorca something similar must have happened several centuries earlier (Altamira 1902; Musso 1847). After the formal water markets had been established, a group of large holders of water rights who owned relatively little land (or none at all) often came into being (Pérez-Picazo and Lemeunier 1990), because ownership of the water not only provided rents that were higher than those from the land (Alberola 1990), but also meant accepting lower risks in order to obtain them, as the demand for water was nearly always very high and the purchasers paid on the spot. As one specialist in irrigation matters from Lorca (who was also the owner of an important number of water rights) explained, wealthy owners "were better off selling the water of their land than using it to irrigate, and from there they went on to sell their land and to keep the water" (Musso 1847, 29).

[17] This is mentioned in the first article of the Ordinances of Lorca (Ordenanzas de Lorca 1932, 18). Maass and Anderson acknowledged that, following the establishment of the water market, "the history of the Huerta of Alicante ... has been in some significant degree the history of unsuccessful efforts to reattach land and water" (1978, 100).

From the point of view of the social interest, however, it is not clear that the change brought about good results, because the functioning of the water market was affected by three dysfunctions.

First, the sellers were interested in there being a rise in the demand. Increasing the size of the *huertas* was the easiest way to achieve this and as a result nearly all the *huertas* with a water market ended up being too large in relation to the amount of water available, in contrast to what occurred in the communities where the water was tied to the land.[18] Thus, the little more than 0.25 $m^3$/s supplied by the river Montnegre (which became 0.5 thanks to the Tibi Dam) were used in Alicante to irrigate 3,700 hectares, and in Elche 12,000 hectares were watered with about 1 $m^3$/s.[19] But it is important to keep in mind that what made the water/land ratio so low in these last communities was not the scarcity of water, but instead the use of the little water that was available to irrigate an area that was too large. Although it is possible that after the Christian conquest excessively large sizes were established for some *huertas*, and that this poor initial design acted as an incentive to set up water markets,[20] the truth is that, almost as a rule, the area with the right to be irrigated experienced great increases following the introduction of water markets. The *huerta* of Lorca offers a good illustration of this. With a mean volume of 1 $m^3$/s of water available, it initially comprised less than 5,000 hectares (Manrique 1912, 350). It had a water market from the fourteenth century onwards and by the early sixteenth century it had already risen to 9,000 hectares (Hernández et al. 2002, 208). In the mid-nineteenth century the number had again increased to 11,000 (Musso 1847, 3), which went on to become 12,000 following the construction of a small dam in the 1880s (Manrique 1912, 350).

It is sometimes taken for granted that "increased prices increase supply" (Rogers et al. 2002, 2), but the second dysfunction has to do with the fact that this did not happen in eastern Spain. Instead, the conclusion reached in an official report about Elche was that the owners of the water succeeded in keeping the amount on offer from increasing (Echevarría 1875, 247).[21] In Alicante, the Tibi Dam was built against the wishes of the owners of the water, who were accused of being responsible for an important rupture that put it out of service for the next forty years in 1697 (Alberola

[18] The cases of the Júcar canal and the river Mijares are good examples to illustrate the most common situation where water markets did not exist. The communities that used the Júcar canal (which carried a mean volume of about 20 $m^3$/s) irrigated a total of 19,000 hectares in the late nineteenth century. With a "normal" flow rate of 10 $m^3$/s, the river Mijares irrigated 10,000 hectares.

[19] Of course it was impossible to irrigate 12,000 hectares with 1 $m^3$/s. What I mean is that altogether the surface area of the farms that were connected to the network of canals added up to a total of 12,000 hectares.

[20] This is what happened again in Alicante following the construction of the Tibi Dam. As has already been said, from then on half the water available was attached to the land, but it was only enough to irrigate a tenth of each farm; as a result, the water attached to the land also ended up being used as a marketable commodity.

[21] Aymard (1864, 189) made some insightful reflections on the matter.

1990). It is also a well-documented fact that in Lorca the owners of the water objected not only to the building of dams but also to the sinking of wells (Hernández et al. 2002; Pérez-Picazo 2002).

The third dysfunction is related to the upkeep and improvement of the system. It has often been observed that irrigators are unlikely to cooperate with one another in situations characterised by a great abundance or great scarcity of water (Wade 1994; Bardhan 2001; Araral 2009). In general, the communities without a water market managed to ensure that the size of their *huertas* was such that there were strong incentives to cooperate. But this did not occur in the communities with a water market, where the purchasers of the water did not usually make any kind of payment towards improvement and upkeep. The funds used in those operations normally came from two sources: the owners of the resource gave the community a percentage of the amount they obtained on selling it, and the community itself was the owner of a part of the volume of water and obtained a complementary income from selling it (Aymard 1864, 177-178 and 187-188). The perversion of the system lay in the fact that: (a) because there was hardly any water to sell during heavy droughts, the community had no income with which to pay its employees; (b) when, from time to time, a flash flood damaged the derivation weirs and the first stretches of the main canal, the amount of water available was reduced and hence the income needed to carry out repairs also decreased; and (c) the initiatives put forward to increase the amount of water available on a permanent basis had to be funded by those who were not interested in this taking place, which therefore reinforced the second dysfunction.

## IV. COMPARING EFFICIENCY

> Nineteenth-century interpretations opposed “community” to “market”. Economic relations were non-commercial and non-progressive in the “community”, and the reverse with the “market”. The research of agricultural historians in the last fifty years has demolished this paradigm. (R. C. Allen 2001, 66)

In the late nineteenth century, in Murcia (as in all the *huertas* without a water market) land was not usually left fallow and two successive crops were harvested every year. When wheat was grown, corn was then planted and altogether a net amount of 651 pesetas per hectare per year was obtained. But wheat and corn were being grown on a relatively small portion of the *huerta*, “because the rest is used for cultivating vegetables, which are always more profitable” (Dirección General de Agricultura 1891, II, 416).

Thanks to the increase in national and international demand for these kinds of products, both the growing on vegetables and oranges on a widespread basis was by

then becoming a very attractive option in eastern Spain. The farmers on the *huerta* of Valencia became specialised in the former and "frequently change[d] crops, depending on the prices that farm produce reach[ed] on the market" (Ministerio de Fomento 1918, I, 367). It was more common for the *huertas* without a water market, however, to specialise in the cultivation of orange trees, partly because they needed less water than vegetables.

Figure 3 shows the water needed on the *huerta* of Vila-real in 1821 and in 1907. In 1821, 70 per cent of the land was used to grow cereals and pulses, while another 20 per cent contained trees and bushes (olive trees, carob trees and vines) that did not require much water. In 1907 orange groves covered 86 per cent of the area, while olive trees, carob trees and vines had completely disappeared. Although the farming was more intensive, thanks to the orange tree the overall water consumption remained similar to that of 1821. Furthermore, in Figure 4 it can be seen that, also thanks to the orange tree, in August (the month in which Spanish Mediterranean rivers undergo the greatest interannual variations in flow rate) water consumption was smaller in 1907 than in 1821, and in consequence there was less need to ration it. It was still necessary to resort to rationing on occasions, but although the orange harvest was affected by such shortages the trees survived.

At the same time, important social transformations were also taking place. In their analysis, Maass and Anderson (1978) set out from the assumption that the most efficient farms were the largest ones. According to their interpretation, water markets would have favoured those farms while penalising the small ones, and would therefore have allowed society to achieve efficiency gains in exchange for equity losses. However, the most efficient farms on the *huertas* were the ones that used essentially family labour (Garrabou 1985). It was for this reason that in the nineteenth century the large landowners usually had their estates worked by a large number of small tenants, who were often landless peasants (Garrido and Calatayud 2010). From the late nineteenth century onwards, it became usual for the tenants to acquire the ownership of the land they farmed (Calatayud 1989; Garrido 2010b), which they were able to do partly thanks to the complementary income that they, their wives and their children obtained from working for the orange export industry.

Where a water market existed, however, things were very different. There, growing cereals continued to be very important in the early twentieth century, the practice of leaving land fallow was still widely used and oranges and vegetables were hardly cultivated. In the social domain, in addition, water markets failed to satisfy the role that Thobani (1998, 47) attributes to them, i.e. "[They] help the poor by increasing employment opportunities resulting from more productive water use and increased investment in water-intensive activities".

As a consequence of the disparity between the large surface area with a right to be irrigated and the little water that was available, it was impossible for all the farms to

irrigate every year. The 12,000 hectares of the huerta of Elche, for example, were irrigated using a rotation system in which half the territory was left fallow and "dry" every year (Echevarría 1875, 247). In Lorca cereals, which covered over 80 per cent of the huerta, were cultivated following a four-year crop rotation system consisting in wheat-wheat-barley-fallow. In each of the years in which wheat was sown, the net yield per hectare was 373 pesetas (Dirección General de Agricultura 1891, II, 448-449). But altogether the rotation yielded 867 pesetas per hectare, and therefore only 217 pesetas were obtained per hectare per year (that is, 867/4), which is a very small amount compared to the 651 pesetas that, as mentioned earlier, were obtained in Murcia. Of course, all this was reflected in the selling price and in the rent paid for the land: in the early twentieth century, the average rent per hectare was 70 pesetas in Lorca, 100 pesetas in Alicante and 226 pesetas in Murcia (Ministerio de Fomento 1918, I, 446 and 475).

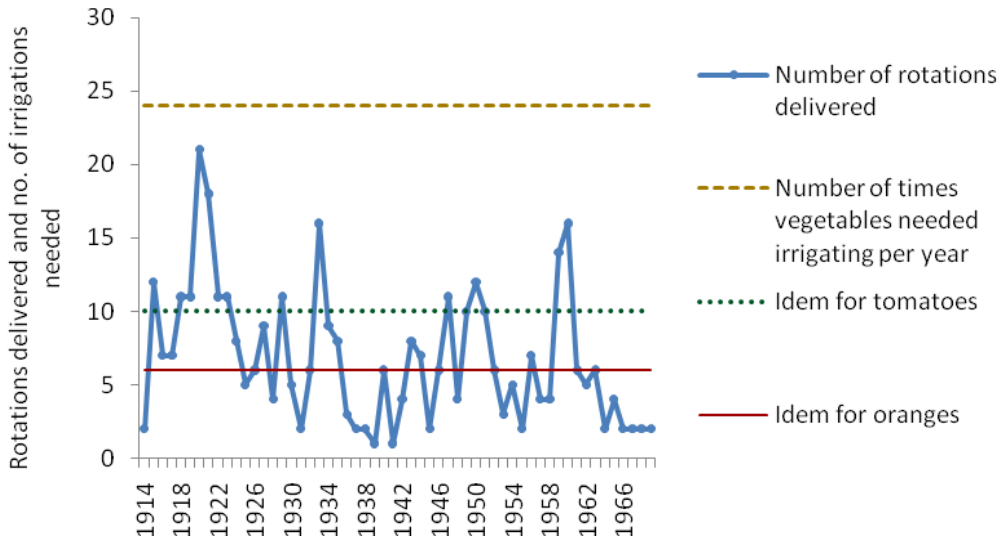


Figure 5: Number of water rotations delivered in Alicante and the minimum number of rotations needed by some crops (1914-1969)
*Source:* For the number of rotations, Maass and Anderson (1978, 108-109). For the water needs, Ministerio de Fomento (1918, I, 443-445).

Since it was crucial to minimise the losses of water that took place during transport, the different areas of a *huerta* could only be irrigated at certain pre-established times. In spite of the fact that the resource could be bought and sold, it was not possible to irrigate "on call", in the strict sense of the term, on any of the *huertas* with a water market. In the case of Alicante, once the water had gone past the headgate of the farm on which the cycle began, a new rotation did not start until it had passed the headgate of the farm that finished the cycle. In theory, all the farmers could buy water every 23 days (and more often in times of abundance), which meant that they could

irrigate their land at least 15 times a year. Figure 5 shows how, in fact, there were 15 years over the period 1914-1969 in which three or fewer water rotations were delivered. It can also be seen how the land could not have been used to cultivate vegetable rotations in any of the years under consideration, and if somebody had planted orange trees they would have lost the large investment needed to produce their groves, because orange trees would have died if they had only been irrigated once or twice for several years in a row. For this reason, the *huerta* of Alicante contained mainly "dryland" crops, such as cereals, almond trees or olive trees. In other words, they were crops that produced a larger harvest if they were irrigated, but could survive without being watered and always provided modest monetary returns in comparison to vegetables and oranges.

It must be noted that from the early twentieth century onwards the *huerta* of Alicante did not receive just the water from the Tibi Dam (which is the only water that has been considered in Figure 5), but could also use that which reached it (albeit in on a very irregular basis) thanks to a small transfer from the river Segura as well as some that came from wells. In an "average year" in the 1960s, the Tibi Dam provided 1.6 cubic hectometres and the *huerta* had a total of 5.35 cubic hectometres available, which Maass and Anderson (1978, 110) calculated as accounting for 23 per cent of the volume of water that would have been needed to be able to carry out intensive farming throughout the whole territory. This percentage was too small for anyone to risk planting orange trees.

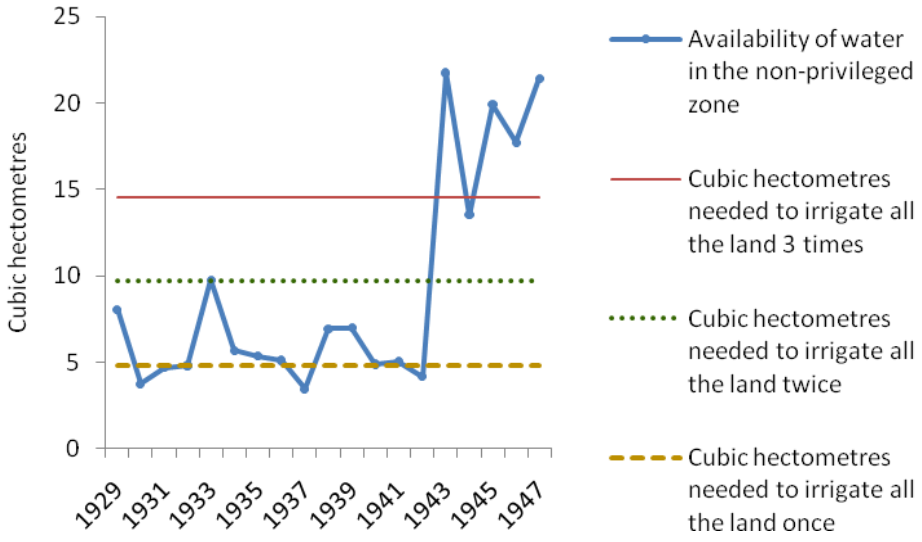


Figure 6: Water availability and maximum number of times it was possible to irrigate per year on 9,700 hectares of the *huerta* of Lorca (1929-1947)
*Source:* http://hercules.cedex.es/anuarioaforos/afo/estaf-datos.asp?indroea=7033, Dirección General de Agricultura (1891, II, 452-453), and Ministerio de Fomento (1918, II, 471-474).

In Lorca the water market was regulated by a very different set of rules to those used in Alicante. Following the institution of a water market in the Middle Ages, the water continued to inhere in the land on about 20 hectares, which were used for the intensive cultivation of vegetables and fruit trees. Although they had to pay to be able to do so, the farmers of another 2,300 privileged hectares could irrigate their land quite frequently. But for the remaining 9,700 hectares on the *huerta* there was hardly any water left to be bought. Figure 6 shows that if all the farms located in this last area had been irrigated every year, in most of the years over the period 1929-1947 they would have received water on just one single occasion. What really happened was that, every year, a large percentage of the farms did not irrigate at all and this meant that the others could water their land three or four times. In any case, on both these 9,700 hectares and the 2,300 relatively "privileged" ones it was always impossible to carry out intensive farming.[22]

## V. CONCLUSIONS

In pre-1950 eastern Spain there were two types of irrigation communities: those in which the water was tied to the land and others in which there was a water market. In addition to producing lower equity, separating the ownership of the water from that of the land was also a less efficient system. As the nineteenth-century historian Pedro Díaz-Cassou put it, because water markets tended to generate "the paralysation of agricultural progress" (1889, 121).

Maass and Anderson performed a simulation of what would have happened on the 3,700 hectares of the *huerta* of Alicante if there had not been a water market. The conclusion they reached was that the economic results would have been worse. This conclusion is likely correct. The right question, however, was not the one that Maass and Anderson attempted to answer, but rather that of why the *huerta* of Alicante had 3,700 hectares. That is, why it was so disproportionately large in relation to the amount of water available. Perhaps the great scarcity of water in absolute terms acted as a trigger for water markets to be established on some *huertas*. But in this paper it has been shown that, in the particular case of pre-1950s eastern Spain, not only were water markets unable to solve the problems arising from scarcity, but in fact they actually made them worse.

[22] In the mid-1930s, the 20 hectares on which the water was tied to the land were sold for 24,000 pesetas per hectare, the 2,300 "privileged" hectares went at an average selling price of 4,700 pesetas per hectare, while the remaining 9,700 hectares were worth 1,750 pesetas per hectare (Elul 1946, I, 29).

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