Irrigation and drainage in al-Andalus:
Madīna Ṭurṭuša and rural settlements in the lower course of the Ebro River (Tortosa, Spain)

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Abstract: The evidence provided by the written record generated after the conquest of Tortosa in 1148 and the results of archaeological survey have allowed the identification of the boundaries of several farmland areas and their associated settlements in both banks of the Ebro River, in the hinterland of Madīna Ṭurṭuša. Detailed mapping has been carried out in order to describe how these cultivated areas were organized. Modern hydraulic technology and infrastructures, such as the big canals built in banks and the regulation of the river flow by means of large dams have deeply transformed the agricultural landscape. Nevertheless, it is still possible to recognize the ancient boundaries and plot morphology of some of the cultivated areas, as well as the remains of drainage and irrigation channels that came not from the river but from the mountains. In the Andalusi period, field systems, always located in the vicinity of rural settlements and near the madīna of Tortosa, formed compact and discontinuous cultivation areas on the riverbanks.
1. Introduction

The city of Madīna Turtûsha (Tortosa) was located in the administrative district of the Superior Border of al-Andalus\(^1\) \(\textit{(aṭ-Taḡr al-A′lā)}\), which approximately comprised the Ebro Valley (Fig. 1). Northern frontier cities started gaining prominence in the Islamic chronicles from the second half of the 9\(^{th}\) century, when the earliest references to constructive activity, mostly of fortifications, are documented. By the 10\(^{th}\) century the urban expansion of the cities in the region was consolidated, having walls, a fortified palace (\textit{sudda}), a mosque and suburbs \(\textit{arrabâḍ}\) (Garcia Biosca et al., 1998).

The Andalusi city surrendered to the army of the Count of Barcelona Ramon Berenguer IV, which also included a Genoese force and other allies, in December 1148, after a six-month siege. The conquest was followed by a process of colonisation that generated hundreds of documents before the end of the 12\(^{th}\) century. A large number of these documents refer to the alienation of plots of land and contain relevant information concerning the agricultural landscape found by the conquerors (including the precise location of plots of land and other features of the rural landscape, such as settlements, roads, irrigation channels, watermills and wells) (Virgili 2001).\(^2\) The rich information contained in these documents reveals that agricultural land tended to occupy the flat areas located by the river or alongside the roads that ran parallel to it. These agricultural areas, which were already active by the mid-12\(^{th}\) century, have been identified through a combination of land survey, the mapping of agricultural plots, and the interpretation of the written record; the methodology of ‘hydraulic archaeology’ – initially set forth by Miquel Barceló in the early 1980s (Barceló et al., 1995; Kirchner, Navarro, 1993) – has thereby been implemented.

To date, a set of over 200 hydraulic systems has been analysed using this methodology, mostly in the Balearic Islands and the Eastern Iberian Peninsula.\(^3\) This empirical corpus has been instrumental in increasing our knowledge of peasant settlement patterns, strategies and social structure. For instance, it has been demonstrated that the size of rural settlements, the settlement pattern at the regional level, and the distribution of the different peasant communities within the territory were to a large extent determined by the scale and position of hydraulic systems. The large number of case-studies at our disposal has permitted the application of statistical analysis, making it possible to calculate the average area dedicated to irrigation agriculture, which was 1.2 ha, and to establish a size hierarchy (small size: under 1 ha; medium size: between 1 an 2 ha; large size: above 2 ha - but usually less than 15ha) (Sitjes, 2006). Dry land agricultural practices, which were the result of complementary peasant strategies, are much harder to track, but can still be recognised in the landscape (Retamero, 2010).

The detailed study of urban \textit{huertas}\(^4\) is a more recent phenomenon; the methodology of hydraulic archaeology has, to date, only been applied in Ibiza, Menorca, Tortosa and Valencia. The \textit{huerta} of Madīna Yabîsa (Ibiza) was created after the partial drainage of a coastal wetland; the irrigation of the reclaimed areas was carried out through the operation of wells and

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1 The term Andalusi is the demonym of Al-Andalus.
2 Most of these documents are already available in published form (see DCT and CCT in Bibliography). Specific references are only given in relevant places.
3 This research avenue was initiated by Miquel Barceló, from the Universitat Autònoma de Barcelona. For a synthesis, see Barceló et al., 1995; Glick, Kirchner, 2000; Kirchner, 2008; Sitges, 2006.
4 \textit{Horta} and \textit{huerta}, in Catalan and Spanish respectively, are terms specifically used to refer to irrigated areas, often located in the vicinity of large urban centres.
animal-drawn waterwheels (Barceló et al., 1997). The huerta of Madîna Manûrq (Ciutadella, Menorca), was built at the bottom of a gully, and irrigation there was also achieved by means of waterwheels (Retamero, Moll, 2010). In Valencia, for its part, the same methodology is being implemented in order to fully reconstruct the Andalusi huerta. In this case, discontinuous agricultural blocks were irrigated by irrigation channels which took water from the nearby watercourses (Esquilache, 2007, 2011). According to the information currently available, the size of these huertas was very irregular: the one in Madîna Yabiṣa, for example, was 72 ha, and the one in Madîna Manûrq was 20 ha; in Madîna Turtûsa, the irrigated huerta was 18 hectares and there was also a drained area of 67.5 hectares, which was mostly sown with cereal (Virgili, 2010; Kirchner et al., 2014). A significant aspect of this process is the emergence of dense networks of small hamlets around the cities and the associated huertas, for instance in Tortosa.

Other Andalusi huertas have recently been studied but, without the application of the methodology of hydraulic archaeology, the results have been incomplete and the different construction phases and the frequent transformations of the system over time have been impossible to determine.5

2. Settlements and road networks

Textual analysis in combination with fieldwork has permitted the reconstruction of the settlement pattern and the road network. Most settlements were located on the banks of the river Ebro to the north of the city of Tortosa: Bitem, Andust, Tivenys, Som, Aldovesta and Benifallet to the left, and Vila-roja, Palomera, Bercat, Labar (or Llaver), Aldover, Xerta, Arram and Xalamera to the right. To the south of the city there were fewer settlements, which were also smaller in size. They were often referred to as towers (turris): Llavaneras, Azmet (or Rocacorba) and Vinaixarop to the left, and Raval, Giramascor, Fazalfori, Vinallop, Mianes and La Carroba, to the right (between Tortosa and Amposta). The settlements of Camarles, La Granadella, Antic, la Aldea, Burjasènia and La Candela were set up along the coastline. Two public roads ran parallel to the river. Points at which the river could be crossed by barge have been identified in Tortosa, Benifallet and, probably, Amposta. The road situated to the left was known, from Tortosa southwards, as road of Camarles or L’Aldea. The road running alongside the right bank, which also headed towards the south, was known as road of Valencia; this road forked into two in Vinallop. One branch followed the river to Amposta, while the other climbed up the plateau in the direction of Ulldecona. The old via Augusta, from Tarragona, also forked into two at the area of Perelló: one branch arrived in Tortosa through the ‘coll de l’Alba’, while the other one skirted the coastline, linking the coastal settlements to the mouth of the Ebro (Virgili 2001).

3. The settlements to the north of Madîna Turtûsa

The agricultural area located to the north of the city of Tortosa was characterised by the large variety of plant species under cultivation. In the description of the plots of land special attention is paid to the different crops: vines, olive trees, vegetable gardens and miscellaneous trees (mostly fig trees). In a few cases, no crop is associated with the property, which is only referred to in general terms as ‘plot of land’ or ‘field’. It can be safely assumed that they have been sown with cereal. On the left bank of the river, between Tortosa and Benifallet, the land was most commonly used as vegetable gardens (around 50% of all the plots recorded). On the left bank, around Xerta, the situation was similar. Even in those areas where vegetable gardens

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were not predominant their presence was still significant, with 22% in Bitem and 10% in Aldover. The written record also makes frequent mention of ‘algeziras’, an Arabic word used to designate river islands and riverside lands. Vines occupied a significant proportion of the land around Bitem, to the left of the river Ebro, but nowhere was this more so than around Bercat, Labar (or Llaver) and Aldover, where vines were cultivated in 50% of the plots of land mentioned in the written record. In these areas, vineyards tended to gather in compact blocks adjoining several discrete plots. Although vegetable gardens seem to have been significant in the area, and despite the proximity of the river, the textual information does not mention water catchment, or channelling and distribution systems. Only some scant references to irrigation channel in Xerta, a few disperse wells, and animal-drawn waterwheels have been recorded (Virgili 2001, 2010).

The compilation of the data obtained from land survey, the morphological analysis of land-plot distribution, and the subsequent elaboration of plot distribution plans, as well as the examination of the written record, has permitted the precise description and demarcation of agricultural areas. Agricultural lands formed compact blocks that were situated in the proximity of settlements, most of which are still inhabited today. In Vila Roja, Labar, Bercat and Aldover, the plots were also distributed alongside the north-to-south roads which run parallel to the river, as shown by the written record; these plots are often recounted as being confined between these roads and the river. This also implies that, in the past, the riverbed was much wider and more diffuse than it is today.

These agricultural areas were of small size and were dispersed throughout the landscape: they did not form a continuous agricultural landscape. Along with the settlements, they were located near the river but in slightly elevated areas in order to be less vulnerable to floods. In general, they are on the flood thresholds for 50-year flood events. It was also common for these agricultural areas to be situated in close proximity of to the mouth of a torrent, where the accumulation of sediments may have created small islands which rise higher than the riverbanks. The most common system for water catchment was the digging of wells and the use of animal-drawn waterwheels.

In Xalamera, L’Arram, Xerta and Palomera, on the right bank, survey data and the analysis of the written record have contributed to the identification of clusters of plots located at the bottom of the gullies that descend from the mountains; these plots were irrigated with spring-water channelled down towards the valley for irrigation and also for the operation of watermills. At any rate, the watermills that had been found in these valleys, as well as in Xerta and Palomera, appear to have been built after de 1148 conquest. This changed the primary use of the channels from irrigation to powering the mills. The construction of watermills in Palomera (today Molins del Comte –Count’s Watermills) is undeniably dated to after the conquest, as demonstrated by a set of records that refer to their construction and to their owners, the Count and the Bishop. The written record is not as explicit in the case of Xerta, but the structure and outline of the hydraulic system are identical to the one in Palomera.

4. Madîna Turtûsa and the settlements to the south

Madîna Turtûsa was directly connected with two agricultural areas. First, the huerta of Pimpí (orta de Pimpino in documents) was located to the north of the madîna, alongside the road that ran parallel to the river. Pimpí is very well documented, since many deals involving the transfer of land plots were formally recorded, including details of the different crops (up to 24 documents between 1148 and 1212). In most cases, fields are situated along the route that

6 DCT: docs: 141, 301 and 517
went northwards from Tortosa, and sometimes also along the riverbank. Therefore, the cultivated area had an elongated shape along the axle formed by the road, and that the riverbank was not as intensively channelled as it is nowadays. According to the written record, half of the plots were used as vegetable gardens, but there is no mention to any channel. Irrigation was not, it appears, based on the tapping and distribution of fluvial water. In contrast, wells are documented. It is assumed that the mention of ‘wells’ in the sources also refer to the associated water-lifting devices and water cisterns, although they are seldom mentioned explicitly. In one case, we have the description of a well and its sanîya⁷ and cistern, located in a vegetable garden in Pimpi: orto cum...cenaia et çafareig.⁸ In this rare example, the whole system is described in detail, including the well, the sanîya and the pool, as well as the associated orchard. Field surveys and mapping have revealed morphological differences in Pimpi’s distribution of irrigated plot. Two strips of land can be distinguished, running parallel to the river. The one that is closest to the current riverbank is apparently more recent. The one (18 ha) that runs alongside the road from Tortosa, to the north, which is also the modern road, was colonised at an earlier date, and must be identified with the plots mentioned in the 12th-century texts.

Second, a large alluvial plain (which is currently around 500 ha in size) unfolds to the south of the city, in an area outlined by a large meander. In the written record, this area is generally referred to as Les Arenes and it features in approximately 70 property deeds (Virgili 2001). The agricultural plots flanked the road of Camarles (or of La Aldea) and were especially dense between the road and the river. There are mentions of nine channels⁹, which were always located around the perimeter of the plots. The channels were set up hierarchically – a distinction between the major, the medium and the meadow-channels was made – and followed a grid plan – they were either located along the plots’ eastern or western boundaries, and therefore ran in a north-south direction, or along the northern and southern boundaries, thus forming a straight angle with the north-south channels. Finally, in this sector, the properties are simply described as ‘plots of land’ or ‘fields’, and were presumably sown with cereal. In the late 12th and early 13th centuries, there was a movement towards the expansion of the vine into the area, as is revealed by around a dozen contracts by which the tenant assumed the responsibility for planting vines (ad plantandum vinea) (Virgili 2001). Therefore, the Les Arenes plain was affected by the introduction of new economic criteria after the feudal conquest. The conquerors encouraged the cultivation of vines and cereals, which were already usual crops during Andalusi times, and probably enlarged the cultivated surface. These crops are mentioned in the written record dated to immediately after the conquest, and they have also been archaeologically recorded in recent urban excavations (Kirchner et al 2014; Alonso et al. 2014).

The survey and the examination of the written record has shown that the acequias mentioned in the documents were part of a drainage system aimed at regulating and evacuating excess

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⁷ The bibliography on hydraulic techniques conventionally uses the Arabic term saqiya to designate this water-lifting device of oriental origin, which is characterised by a gear connected to a chain of vases that sink into the well and come back to the surface full of water; the gear is propelled by an animal tied to a horizontal shaft. The Catalan term sinia derives from sanîya, while the term saqiya has instead evolved into séquia (Catalan) and acequia (Spanish), meaning channel. For a classic reference see Thorkild Schiøler, Roman and Islamic water-lifting wheels, (Copenhagen: Odense University Press), 1973.

⁸ ACA: còdex 115, doc. 202; CTT: doc. 62. The Catalan term çafareig, from the Arabic sahrij, designates a cistern for the collection of irrigation water in association with a nearby vegetable garden. In this case, the pool was filled with water lifted from the well with a sanîya.

⁹ The channels are alluded to, both in the written record and today, with the Catalan séquia, which comes from the Arabic term saqiya (the Spanish acequia). We use the term channel to designate both irrigation and drainage channels.
water caused by the rise of the river and by sudden run-offs, among other factors. Without these infrastructures, these soils would have been unsuitable for agriculture, and access to the pastureland would have been much more difficult. The frequent mentions of acequias in the earliest Christian documents seem to indicate that the network was, at least partially, already in place at the time of the conquest. In order to obtain initial dates and additional information about the drainage system, the geoarchaeological analysis of a sediment column has been carried out. The results of these analysis has linked drier past environmental conditions, between AD 686 and 873/720 and 944, with the earliest drainage of Les Arenes, which is likely dated to the 8th century (Puy et al. 2014). The survey work carried out in Les Arenes shows that the drainage channels were constructed in successive stages, following a north-to-south and east-to-west general direction. At the time of the conquest, as shown by the written record, only the area closest to the madîna and the areas of land located furthest away from the river had been broken-up for agricultural purposes. The riverbed must have been much wider, and the banks and islands must have been more instable than today. The displacement of the bank in the meander of Les Arenes can be followed by fossilized riverside boundaries that are also the limit of the successive stages of the land-reclamation process.

South of Les Arenes there was an extensive area of wetland intersected with lagoons and islands, and inhabited by the plant species commonly found in these marshy environments. This area, which in the written record is referred to as a ‘meadow’ (pratum of Tortosa), was within the river inundation area and received sediments from the nearby hills; this resulted in morphological instability, especially with regard to the areas adjacent to the river. There were other place names like Aquilen (which later derived into Naguillem and which corresponds with the modern hamlet of Campredó), Quinto (prato de Quinto) and Pedrera. The record attests that the river Ebro operated as the Western boundary of several plots as well as of several drainage channels. In Quint, the north-to-south cequia de prato (channel of the meadow) probably was one of the main axles of the drainage system. Nevertheless, the references to uncultivated areas indicate that the pratum was not fully drained.

In addition to this, several mills existed in this area. In 1172, the Moncada family acquired a field and the mill of Pedrera, near Quint, also including the channel that supplied it with water (caput rego). The complex was adjacent to the river Ebro (to the West) and to a channel and an area of marshland (palud) (to the North). Although the mill of Soldevila in Campredó does not exist anymore, some people still remember it, and recollect that two springs converged in it. The mill mentioned in the 12th-century documents was probably in the same place.

The meadow ran downriver as far as the coast. On the fringe of this plain, on more stable soil, several settlements may be noted: Camarles, the tower of Granadella, the hamlets (almunia11) of Antic, Aldea, the tower of Burjasénia and La Candela. Again in this sector, the properties are referred to as “plot of land” or “fields”; barely two vineyards and one vegetable garden are mentioned in the record. To date, the survey and the analysis of the property distribution have been unsuccessful, and the agricultural areas have not yet been identified; in any case, they should be close to the aforementioned settlements (towers). It may be significant that the

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11 From the Arabic al-munya (Catalan. Almúnia, Spanish: almunia). What this term really meant in al-Andalus is not very clear. Almunias were found around cities and were, apparently, quite small estates, administered by a single owner. Sometimes, however, the owners were related to prominent state officials (Lagardère 1999).
towers, as they stand today, are not dated to the Andalusi period, but to the second half of 12th century or slightly later.

The meadow of Tortosa was rich in pastureland and was traversed by a network of drove ways (still known in the area as iligallos). A very revealing document dated to 1258 invited the Saracens of La Aldea to graze their cattle, horses, asses, sheep and goats, free of charge, in the pastureland which was near the road between La Aldea and Tarragona (Font Rius, 1969-1983, doc. 303).

The area located before Tortosa, in the right side of the Ebro is referred to in the written record as ‘ultra Iberis’ (‘beyond the Ebro’). The hamlets or settlement areas of Raval, Giramascor (Algezira Mascor), Alcàntera, Beniguerau, Falzalfori and Quart stood on the other bank, directly opposite Tortosa. Most properties in this area were described as ‘plots of land’ or ‘fields’, but it seems that in this case cereals were already giving way to vines, as in Les Arenes. From this sector southwards, meadows became the predominant feature and extended over the entire riverside plain. The texts are, once more, full of generic references (‘lands’ and ‘fields’) and mentions of drainage channels and river islands (algeziras). One of these islands was known as Algezira Mascor, which later developed into Giramascor, a toponym that was eventually lost but which we have been able to pinpoint with certain precision to near the mouth of the gully of Sant Antoni. Other documents refer to the settlements of Vinallop, Mianes and, finally, the tower of Carroba, which was the last settlement before Amposta. Only one of these channels had his catchment area in a torrent. The dam was in the beginning of the Sant Antoni torrent and could irrigate a small area of plots located nearby the riverbank. This channel is mentioned in a document that describes its itinerary: cequia illa maiori inferius que descendit de Marenxa et venit per Algevira Mazcor ad Yberum (DCT: 398). Marenxa and a watermill are mentioned in later documents and can be located in the upper course of this torrent.12

5. Conclusion

In 1248, when the feudal troops of Ramon Berenguer IV conquered Madina Turtûsa, there was a network of rural settlements and their associated agricultural areas along the riverbanks of the Ebro River. The city-dwellers, for their part, had created a huerta and a drained area for the cultivation of cereal and vines on the left bank of the river. There were also large expanses of meadowland near the river, which were used as grazing areas. The field systems that have been identified in the landscape were not irrigated through channels diverted from the river but by means of wells and water lifting wheels, at least on the left side of the river, or, in some cases on the right side, by channels that drew water from the torrents that come down from the mountains. The result was a series of riverside discontinuous plot clusters located in the vicinity of rural settlements and the madîna of Tortosa itself. These compact clusters were formed by contiguous fields located near major roads and the riverbank, in which case they were slightly elevated areas, often as a result of the accumulation of sediments brought by the torrents. Finally, there is written and archaeological evidence of the construction of drainage channels that ran along the left riverbank south of Tortosa. They were instrumental in the development of cereal land and grazing areas. After de feudal conquest, the new owners of the land increased the cultivation of vines and probably made the first attempts to enlarge the cultivated area.

12 J. Negre (2015, 28-31) is mistaken in his interpretation of this and other documents, and argues for the construction of a long channel, which drew water from the river Ebro, promoted by de Caliphate of Cordoba.
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