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Review

The Archaeology of Field Systems in Al-Andalus

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Abstract: The Berber and Arab conquest of the Iberian Peninsula in 711 C.E. led to a profound transformation of the agricultural landscape. The layout of the irrigated areas, both rural and urban, is recognisable because it is the result of social and technological choices. But irrigated agriculture was not the only option in Al-Andalus. Rainfed agriculture is supposed to have been the main form of agriculture in large areas of the centre and west of the peninsula, although the field systems have been scarcely identified. In regions where irrigation was the preferred option, rainfed crops were complementary. In regions where dry farming was the only possible agriculture, there were settlement networks linked to livestock breeding and to droveways and pasture areas. The original selections made by the Berber and Arab farmers can still be recognized despite the expansion that has mainly taken place since modern times. However, the more recent and destructive capitalist agriculture is erasing the last vestiges of the Andalusi agricultural landscape.

Keywords: Al-Andalus; irrigation; dry farming

1. Introduction

The Berber and Arab conquest of the Iberian Peninsula in 711 C.E. led to a profound transformation of the agricultural landscape. This was largely linked to the creation of irrigation systems and was particularly important in the eastern Iberian Peninsula, the Balearic Islands, and eastern Andalusia. The ecological conditions were favourable for the development of both small rural irrigated areas and *huertas*—large, irrigated areas usually associated with urban centres.

Much of the research conducted on irrigated areas in Andalusia is owed to the work of several pioneering authors; Thomas Glick's research on the *huerta* of Valencia brought to light the existence of management techniques not directed by the state but rather local communities [1]. Pierre Guichard and André Bazzana [2] identified a link between Andalusi rural hydraulics and the settlement of Berber and Arab tribes in *šarq* al-Andalus (eastern Iberian Peninsula). Their proposal was based on the studies of Pierre Guichard [3], who identified the migration of Arab and Berber groups to the Iberian Peninsula and described the tribal organization of the Andalusi society. Miquel Barceló's identification of rural peasant hydraulics challenged both the association of the new agriculture with the state and the supposed Roman origin of the *huertas* of the eastern Iberian Peninsula [4,5].

The initial attempts to study Andalusi hydraulics and irrigation were soon deeply influenced by Andrew M. Watson [6,7]. For Watson, the introduction of new plants of tropical origin into the Mediterranean agricultural cycle through irrigation made it possible to achieve greater crop diversification. This diversification and intensification brought greater and more substantial benefits to the area, which, in turn, led to population growth and urbanisation. Finally, the existence of a strong, centralised state would lead to the creation of a culturally homogeneous world—that of Dar-al-Islam—which would become the medium for the circulation of ideas, products, plants, and agricultural techniques. The role of elites as agents of diffusion would have therefore been essential. However, this view relies on the information provided by written documentation, which, in turn, is heavily biased by the perspective of the state. According to A. Watson, it was the combination

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of these processes that produced an agricultural revolution. This revolution cannot be understood as an abrupt change, but as a complex process that would gradually shape a "new agriculture" integrated into a "new network of exchanges" that would no longer resemble pre-Islamic agriculture.

Regarding new vegetables, our evidence is again based almost exclusively on the written record, such as the agricultural treaties, several references in historical or geographical Andalusi writings, and documents from the period immediately following the Christian conquest. In addition to the research carried out by A. Watson, it is worth noting the research done by other authors is also based mainly on Andalusi agronomic treatises [8–10]. See also the detailed compilation of species mentioned in agronomic works [11,12]. Regarding the information that can be obtained from the documentation generated after the feudal conquests, see [13,14]. This limitation makes it difficult to trace the actual spread of different plants, the local circumstances, and their chronology. Although Watson has been criticised, and some of the eighteen plants he studied may have been known and cultivated before the Islamic expansion (at least in the Middle East) [15,16], archaeology has not yet explored this question in sufficient depth [17]. Bioarchaeological techniques have been occasionally applied to Andalusi sites [18]. Successful results in this field depend on good preservation conditions. Therefore, the botanical macro-remains usually obtained by flotation or the sieving of sediments are not necessarily representative of the entire set of crops cultivated, but rather only of those that have been well-preserved by carbonization, mineralization, or exceptionally in waterlogged conditions. Under these conditions, the remains that are best preserved are those of cereals, legumes, and some stone fruits [19]. Although these findings are not representative of the plant diffusion from the 8th century onwards, some trends are being identified. At least two new species, pearl millet and rice, have been identified. Rice was among the crops mentioned by Watson [7], but pearl millet is a completely new find, especially well-spread and with textual references in the east of the Peninsula. Among fruits, apricots, quince, medlar, and citrus appear for the first time in Islamic sites [19].

The relationship established by Watson between population growth, the development of cities, commercial exchanges, and the state agency, on the one hand, and the diffusion of plants and hydraulic techniques of oriental origin, on the other hand, has been widely accepted, at least in the historiography of Al-Andalus. Various authors link the creation of urban irrigated areas (*huertas*) and the diffusion of techniques and plants with the consolidation of the Caliphate of Córdoba in the 10th century and the growth of the cities [20,21]. So, a long transitional period was characterised by the so-called "Islamisation" process [22–24] that had to be completed before the typical features of an Islamic society could be recognised and, according to these authors, state, religion, and urban development were the main drivers of the transformation of the agrarian landscape. Recently, Pedro Jiménez-Castillo and Inmaculada Camarero [25] have suggested that the emergence of geoponic books in the 11th century is closely related to the proliferation of private landowners in the growing cities of Al-Andalus. These landowners would have developed commercial agriculture.

On the other hand, other authors, following the approach of Miquel Barceló, have carried out extensive research on cultivation areas linked to networks of peasant settlements [26–33] and, more recently, on urban irrigated areas [34–38], which have demonstrated the capacity of immigrant peasant groups to create and manage a new agricultural landscape (Figures 1 and 2). Fèlix Retamero [39] warned that the codification of techniques in agronomic treatises presents a biased view of technical and plant-based dissemination conducted by state and urban environments. He instead proposes that the success of the transfer of plants and techniques, especially irrigation, required a network of peasant settlements, where the conditions for the transmission of the agricultural technical package were developed.

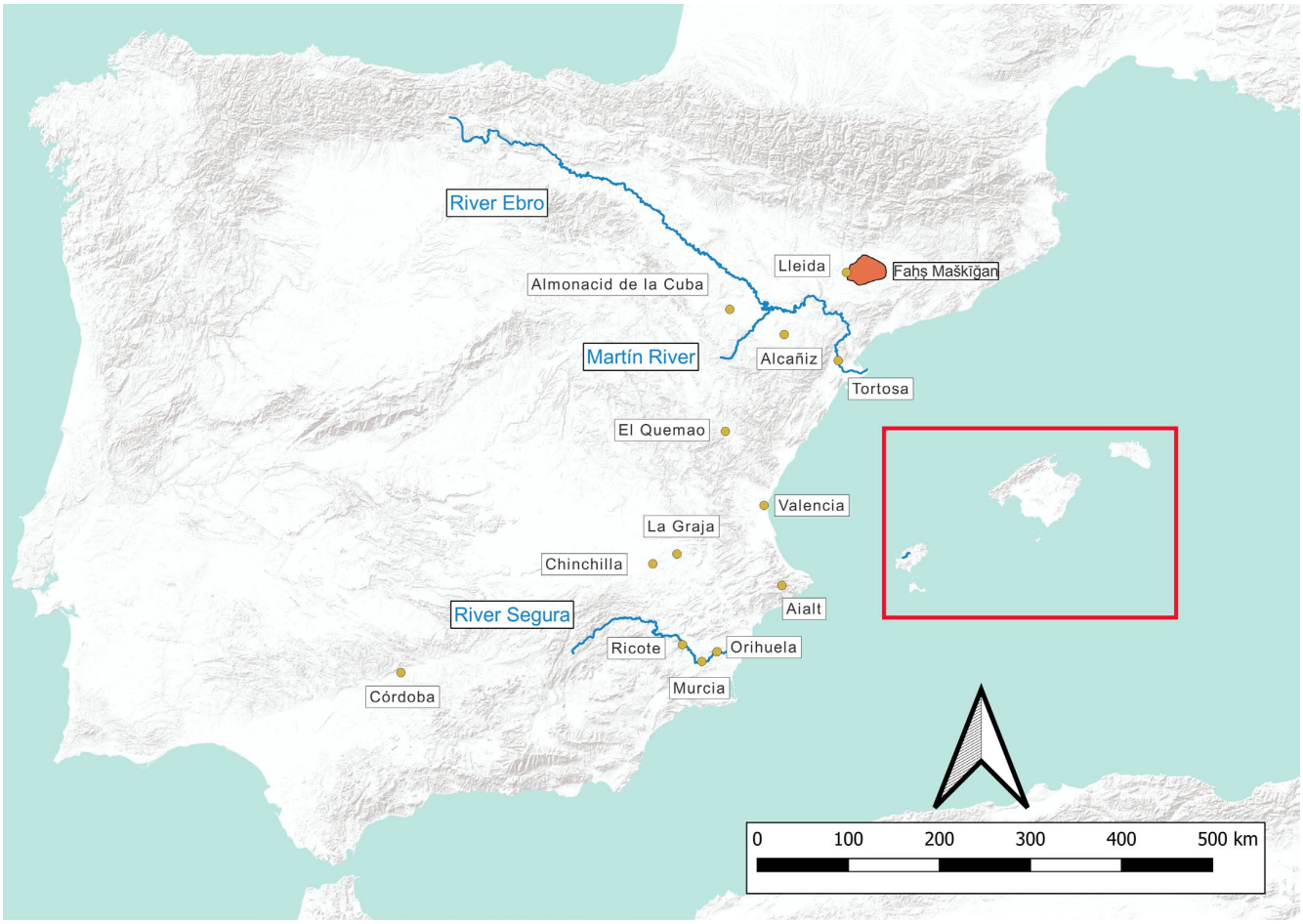

Figure 1. Location of cited sites in the Iberian Peninsula. Red square: see Figure 2.

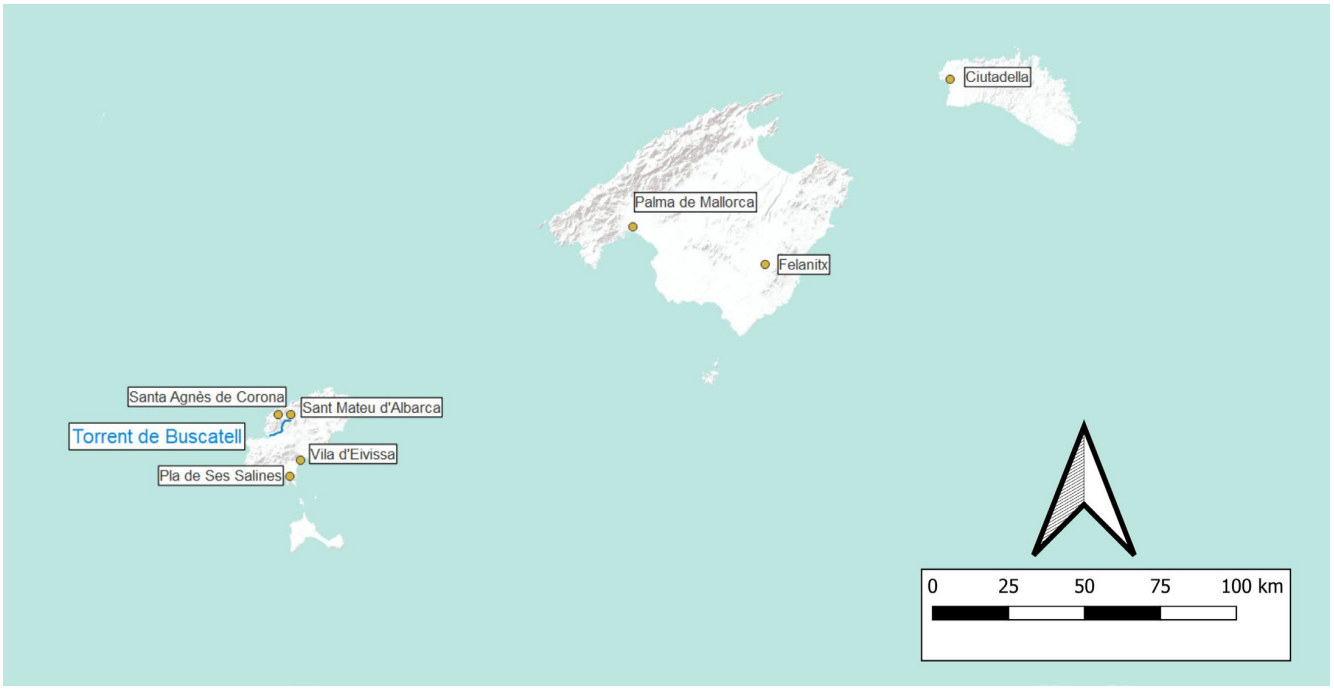

Figure 2. Location of cited sites in the Balearic Islands.

The aim of this paper is to present an overview of the main debates and outcomes of the longstanding research done on irrigated field systems, but also on the less-investigated rainfed agriculture of Al-Andalus.

2. Irrigation in Al-Andalus

Although it is indeed difficult to obtain absolute dates for the creation of these cultivated areas, the Arab and Berber migration that accompanied the Islamic conquest provides a plausible context. This does not preclude later creation and enlargement of irrigated areas. Most of the available chronologies rely on the association between the toponymy, the archaeological sites, and the irrigated areas, as well as references in written records that usually only establish a *terminus ante quem*. This procedure is not as precise as would be desirable, but it has been and still is the best and only way to establish chronologies of the field systems studied and, in any case, this type of study is essential to addressing the new dating techniques such as OSL that are increasingly being tested in fields and terraces [40,41].

The lack of chronological precision also affects the assumption of a later creation. The authors who defend the later creation of irrigated cultivation spaces usually base this on the same criteria, but they identify textual mentions with the initial moment of construction, and this cannot always be justified [20,21]. First, textual mentions typically only confirm the existence of a specific irrigated area at a certain time but not the date of its construction. Furthermore, mentions in Arabic texts are not only scarce but mostly refer only to urban spaces without detailed descriptions. Therefore, it is difficult to ascertain irrigated surfaces, or if there was more than one phase of construction.

Attempts at the absolute dating of plots within well-studied irrigated systems of Al-Andalus have been limited to two cases: one in Tortosa (Catalonia) and another in Ricote (Murcia). The first cultivated area has been dated between the 8th and 9th centuries in Tortosa [42], and between the 10th and 13th centuries in Ricote [43]. In a previous article, the dating of the irrigated area of Ricote was attributed to the 9th century [44]. Much more dating of field systems is needed to be representative.

Regarding the species cultivated in the irrigated areas, it is still extremely difficult to know the cultivation regime and the combinations of plants. There is scattered documentary evidence related to specific sites, mostly recorded in Christian documents written immediately after the conquest [13,14] or by a few Arab chroniclers or geographers [45]. Not only the specific species but also the combination of plants, cultivation regimes, and field systems are relevant to determine whether there were changes in the landscape and agriculture because of the Islamic conquest. In this sense, research into field systems is of great importance.

When we think of the hydraulic techniques that spread throughout the Iberian Peninsula, we usually think of water collection techniques such as *qanāt*(s) and water-lifting devices, or water mills with vertical penstocks [33–46]. Some authors have gone to great efforts to demonstrate the Roman origin and the diffusion of these hydraulic techniques [47–50] that, moreover, were already intensively used in Sassanian Mesopotamia [51].

However, the use of these techniques in Roman agriculture is known in a very fragmentary way. What is relevant is not the mere fact of knowing a technique existed, but rather how it was used and its relation to the hydraulic system in which it is included. From what little we know about Roman hydraulics applied to agriculture, the selection of techniques and spaces and the organization of the hydraulic complexes are governed by very different criteria. Roman hydraulic structures and their remains were rarely reused in the construction of Andalusi irrigated spaces [52]. An example of reuse is the Roman dam of Almonacid de la Cuba (Zaragoza). However, it was used as a means of water derivation and no longer as a reservoir because it was filled with sediment [53]. Thus, the discovery of the *Lex Rivi Hiberiensis* is indicative of an irrigated fluvial space near the Ebro River and an organization of the distribution of water [50–54], but it does not provide information about the continuity of either the space or its management, nor does it justify the inability

to build new hydraulic systems in the Middle Ages. Nevertheless, the spatial association between irrigated areas and the archaeological sites near the Martín River (from the 6th and 7th centuries) and in the area of La Redehuerta, in the valley of the Guadalupe River (Alcañiz), (from the 4th and 5th centuries) made it possible to suggest that the irrigation in the bottom of these valleys predates the Islamic conquest [55,56].

Research on peasant settlements in Al-Andalus has made it possible to establish a typology of hydraulic systems based on whether they were built on a terraced slope or the bottom of a valley. The location of the water catchment on the valley floor or the slope also determines different morphological solutions [33]. In general, the irrigated space is near the water catchment. The choice of where to build the fields is determined by the location of the water catchment. For this reason, there are usually no long canals in peasant-irrigated areas, and the residence areas usually are not coincident with Roman or late antique ones. These technological choices show that even though some hydraulic techniques may have been known before the Islamic conquest, the creation of irrigated areas is indeed the result of new selections.

The criteria for the construction of these spaces are not only technical. The preference for small sizes is likely in response to risk minimisation strategies, population growth, and segmentation processes [57,58]. The average size of the rural irrigated areas is 1.2 ha, and a scale of sizes of irrigated areas associated with rural settlements has been set: small areas are those with a maximum size of 1 ha (56.6%), medium-sized areas measure between 1.1 and 2 ha (18%), and large areas are those between 2 and 15 ha (21%) [31]. These sizes leave little room for individual forms of ownership and require cooperative mechanisms for their construction and management. Areas larger than 2 ha were often shared by several settlements while conversely, those less than 2 ha rarely allowed for shared management and seem to be associated with a single peasant group [58]. It is also possible to describe peasant strategies for the organization of grinding through hydraulic mills inserted in the water circuit, which aim to ensure compatibility with irrigation operations while diversifying grinding occasions [59]. Regional studies in the Balearic Islands have shown that these cultivation areas and the associated residential areas form settlement networks with collective or negotiated management of hunting and gathering territories [26–29,32,60].

3. Urban *huertas*

In the bibliography on medieval irrigation in the Iberian Peninsula, the term *huerta* refers to a large irrigated area of at least one hundred hectares. These areas were usually irrigated by canals derived from a river, although there are also huertas irrigated by wells equipped with water-lifting wheels. Some authors have suggested that their formation was linked to urban growth and state-related initiatives. Mentions in the 11th century of the urban *huertas* or the cultivars from certain cities are taken as proof of the chronology of the construction of these irrigated areas while, in fact, they only allow us to ascertain that they existed at this time [20,21].

Attributing the construction of urban *huertas* to the state is generally the result of an assumption, linked to the current extension of these spaces, which is that they would have been unattainable for modest peasant groups [61]. Researchers who have defended this Wittfogelian view also consider that only urban expansion from the 10th century onwards (or not even before the 11th century) can justify the creation of these *huertas* [20,21] (see the review made by Fèlix Retamero [62]). At the same time, they attribute a certain level of appropriation and control of these irrigated spaces to a social sector known as the "oligarchy", "landowners", or "aristocracy"—one that is not based on any kind of identification of the contours and surfaces of these properties. The so-called *almunias*, farms often linked to people holding positions close to the state, are considered irrefutable proof of the state and urban origins of *huertas* (Some examples of *almunias* can be seen in [63]). Since the consolidation of the Islamic state is linked to the Caliphate of Córdoba and the so-called process of "Islamisation" of the society—which did not culminate before the 10th century—no earlier dating of the urban *huertas* is conceivable.

There are few clear references to hydraulic works undertaken by governors or members of the state, and the construction projects that can reliably be attributed to the state representatives prioritize the supply of domestic water to citadels, baths, mosques, and dwellings, and secondarily aim (but not always) to irrigate an urban area of gardens. In other cases, the purpose of the hydraulic system built is to irrigate vegetable gardens linked to a residential area related to the state (citadel, palace, or *almunia*) [25].

A good example of this is the *qanāt* built to provide the citadel (*almudaina*) of Madīna Mayūrqa (Palma de Mallorca) with fresh water. The *qanāt* was built at the foot of the Tramuntana mountain range, 15 km away from the city; the canal issued from it crossed the entire city, supplying baths and mosques by means of secondary canals until it reached the citadel, where there was a garden (*almudaina*). Within the enclosure of the city walls, there were vegetable gardens, likely also irrigated by branches of this canal. The *qanāt* was referred to as Emir's Fountain ("Enelemir" in post-conquest documentation as a transcription of *ʿayn al-amīr*) [64,65]. It is possible to think that there was state intervention in the conduction of water to the city given its name, but the design of the hydraulic system is clearly oriented toward the state residence.

The *almunias* located in the vicinity of the cities can indeed be agricultural spaces, often irrigated, linked to representatives of the state or wealthy individuals and sometimes embedded in the canal network of an urban *huerta* [25–63]. However, most of the studies of these *almunias* lack accurate measurements of the cultivated area and their relative proportion to the remaining irrigated surface of the *huerta* where they are located.

Instead, when detailed field and plot morphological studies are conducted, it appears that the initial formation of *huertas* is closely linked to networks of peasant settlements. Ferran Esquilache [36] identified a clear spatial relationship between different peasant settlements and discontinuous clusters of plots scattered across the fluvial plain in the Valencian *huerta*. Following this author, in the initial phase, there were large unirrigated spaces distributed throughout which could have been built already in the 9th century. From the 11th century onwards, urban growth led to the expansion of irrigated areas in the interstices between these groups of plots. *Almunias* and other types of private properties often held by prominent city personages are mainly located in these zones of enlargement. Hence, the creation of new irrigated areas did not erase or invade the previous ones. Furthermore, those interstices were still quite large and unoccupied at the time of the Catalan conquest in the 13th century.

Following Rafael Azuar and Sonia Gutiérrez [66], the initial settlement in the lower Segura River between the 8th and 9th century was based on small rural sites that exploited the richness of a large marshland at the mouth of the Segura. The finding of waterwheel pots led the authors to suppose some form of irrigation on the borders of this marshland. A second phase of development of the *huerta* was due to the growth of the city of Orihuela, from the 10th century on. The canals originated in dams would substitute for the initial phase of wells with waterwheels. The chronology is based on a reference from a-Udhrî (11th century), who attributes the opening of the Callosa canal to the inhabitants of Orihuela. Recently, research done by Miriam Parra [37] suggests that the main canals of Callosa and Alquibla issued from the Segura River were built during the initial phase of the *huerta* of Orihuela. There were water-lifting wheels to extract water from the canals, which explains the finding of waterwheel pots in several sites dated in the 8th and 9th centuries. Both canals are spatially related to a network of rural settlements, so it is difficult not to consider that the inhabitants of these settlements were involved in the organization of the hydraulic system. If the waterwheel pots found in the earlier settlements were used in waterwheels connected to the canal, as suggested by Miriam Parra, the initial phase of development of the *huerta* de Orihuela must be dated as early as the 9th century. In Murcia, a city founded in 825 CE upstream of the Segura River, some structures related to waterwheels have been excavated [67]. The waterwheels were equipped with pots, which can be dated to the 9th century and were installed in wells that received water from a canal via a pottery tube, the same procedure that Miriam Parra believes to be used in Orihuela. Furthermore, Miriam

Parra has identified the same type of parcel clusters associated with peasant settlements as has been identified in Valencia [38].

The irrigation of the *huerta* of Madīna Ṭurṭūša (Tortosa), located on the left bank of the Ebro near its delta, is not based on dams and canal diversions, but on water-lifting devices (*sāniya*) and drainage, following the same guidelines as the cultivation areas associated with rural settlements in the same area. To the south of the city, an extensive area of marshland surrounded by a meander of the Ebro River was gradually drained by canals and devoted mainly to the cultivation of cereals [30]. The first phase of this drainage operation has been dated to between the 8th and 9th centuries [42]. Joan Negre [68], who has not completed a detailed field and plot morphological study and who misreads the Latin documents dated after the Catalan conquest of the 12th century, proposes the state as responsible for building large canals derived from the Ebro River. Not a trace of these canals is recognisable before the end of the 19th century [30].

In short, several cases indicate that, at least in the 9th century, there were already attempts at the organisation of irrigated spaces in relation to some cities. Undoubtedly, later urban development, which does not seem to have been significant before the 10th century, as Sonia Gutiérrez [69] has described, must have contributed to the consolidation and expansion of the *huertas*.

In the Balearic Islands, conquered in 902 CE, the chronology of the creation of *huertas* must begin in the 10th century. The *huerta* of Madīna Yābisa (Ibiza) was formed because of the partial drainage of a coastal marsh and the introduction of wells with water-lifting wheels. Several settlements surrounded the irrigated area, so it is plausible to attribute the organisation of this cultivated area to the farmers who inhabited it, together with the inhabitants of the city [34]. Madīna Manūrqa had more than one cultivated area, also irrigated with wells with water-lifting wheels [35].

Almunias are present in those *huertas*, and when they are clearly identified, as in Valencia or Tortosa, they represent small spots in the field system of the *huerta*, with discrete surfaces and often in marginal areas [36–70].

4. Expansion of Irrigated Areas

It is difficult to identify any expansion of irrigated land before the Christian conquest. In the Balearic Islands, rural irrigated areas typically did not change their original design until well after the Christian conquest in the 13th century. However, the reduplication of tribal names that can be traced in place names, the transformation of originally complementary areas (*rahal*) into rural settlements (*alqueria*), and possibly the creation of new settlements with non-tribal place names, are evidence of the expansion of the cultivated areas. It was not a question of extending existing field systems, but of establishing new ones. The selection criteria, the techniques mobilised, and the resulting morphology of the new spaces remain the same; therefore, the morphology of these new field systems does not differ from that of the original ones [58].

In the urban *huertas*, the process was similar. Certainly, the expansion of urban *huertas* was facilitated by the growth of cities. Ferran Esquilache [36] has shown how the process of enlargement was carried out in the *huerta* of Valencia. The enlargements follow the same criteria of organization of the original clusters of plots while occupying the interstices between them. Newer groups of plots can be identified by a different toponymy. They are often called *rahales* or *almunias*, which were farms associated with individuals and even town or state officials. Modifications of this type have also been identified in the Lower Ebro and the *huerta* of Madīna Yābisa (Ibiza) [70]. These examples demonstrate that there was an expansion of cultivated space that can be linked to the growth of the cities from the 10th century onwards. However, it is extremely important to carry out a detailed study of the morphology of the plots. The lack of surface measurements and fieldwork leads to the assumption of large-scale transformations and urban and state interventionism. When these interventions are spatially identified and measured, we see that they reproduce

the pre-existing technical criteria and that the new cultivated areas do not substitute the previous ones.

Urban development in Al-Andalus began to become significant in the 10th century and particularly further developed in the 11th century [69–71]. The consolidation of peasantry with local forms of craft production and rural and informal exchange procedures precede urban development. The emergence of specialists in construction and craftsmanship and the concentration of trade in urban markets coincide with this urban development. At this time, the state also had sufficient revenue capacity to pay for the construction of the city, its main seat. The city could not grow without the rural areas that were to provide for it [72,73]. The late urban consolidation of Al-Andalus has no other explanation than the need for a previous process of peasant agrarian colonization.

Therefore, this urban development must have led to an expansion of the cultivated area. But this development does not imply the replacement of the original layout of the *huertas* nor the appropriation of most of the agricultural space by a class of rich landowners linked to the cities. When *almunias* are properly measured, they constitute a minor surface of the *huerta*. Networks of rural settlements around the *huertas* lasted well after the growth of the city and are thus proof that the *huertas* were not managed only by urban dignitaries and were not only dedicated to urban croplands.

5. Dry Farming

Irrigated agriculture was not the only option in Al-Andalus. Rainfed agriculture is supposed to have been the main form of agriculture in large areas of the centre and west of the Iberian Peninsula, although the field systems have not been precisely identified. In regions where irrigation was the preferred option, rainfed crops were complementary [74]. For example, in the Tramuntana mountain range in Majorca, where irrigated areas were built in the flat areas at the bottom of the valleys, dry farming plots occupied the land at the bottom of the valley beyond the reach of the canals. The valley bottoms concentrate the deepest, most fertile soils, which retain more moisture [26].

The research carried out on the Balearic Islands has made it possible to verify that in certain areas, there were settlement networks mainly linked to livestock breeding. The management of herds likely of small size depended mainly on marshland pastures. This is the case of Felanitx [75] and Manacor [32], in the southeast of the island of Mallorca, where irrigated spaces are scarce. In Felanitx, a dry-farmed field system of 32 ha in surface dedicated to cereal has been identified. The written documents produced after the feudal conquest show that this area was distributed among the new settlers and, perhaps, slightly enlarged [75]. In Menorca, this type of space was also identified, located in valley bottoms or at the head of the ravines that flow to the south of the island, and where most of the irrigated spaces were built. The surfaces of these dry-farmed lands are around 21 and 24 ha in size [27]. In the northern region of the island of Ibiza, two poljes surely used as grazing areas were surrounded by settlements (Santa Agnès de Corona and Sant Mateu d'Albarca), and at the mouth of the Buscastell torrent (west of the island), in the Salinas area, and the Pla de Vila next to the Madīna Yābisa (south of the island), extensive areas of marshland must also have been used as pastures and, perhaps, on their margins, sown with cereals [34–76].

Recently, some researchers have begun to study areas on the peninsula where most settlements are not linked to irrigated areas. The livestock dedication of these settlements, usually of small size, seems quite clear. They are located near traditional droveways and marshlands where rich natural pastures could be maintained, often mentioned in documents after the feudal conquests. This is the case of the faḥs Maškīğan, in Lleida [77], the Gúdar and Javalambre ranges (Teruel) [78], and the district of Chinchilla (Albacete) [79]. In some excavated settlements such as El Quemao (Teruel) or La Graja (Higueruela, Albacete), silos have also been found that indicate the existence of cereal agriculture [78,79]. However, the cultivation areas, their limits, and their extension have not yet been adequately identified.

Josep Torró [80] described the dry land system linked to a *qarya* in a mountainous valley of the *šarq* al-Andalus in detail. Aialt is in the valley of Castell de Castells, in the heart of the massif situated on the easternmost flank of the Baetic System (Alacant). Irrigation played a central role in neighbouring valleys and was a major asset for nearly every settlement. To understand the Aialt choice for dry farming, both the special characteristics of the soils sown with cereals and the livestock dedication must be considered. Two of these arable "islands" or *plans* (plains), currently known as Pla d'Aialt and El Xorquet, have been identified in this sector of the valley. The depression of Pla d'Aialt is at the foot of the old residential area; it was the initial field system and is between 54 and 57 ha in size, whereas the arable land in El Xorquet covers approximately 47 ha. The construction of the agricultural terraces in El Xorquet likely took place later than those in Pla d'Aialt, which show different phases of construction. Both spaces were connected by a droveway. Along with droveways and the use of sinkholes as grazing areas, the importance of stockbreeding in Aialt is also demonstrated by the presence of several water catchment points that have been adapted to use as troughs. Furthermore, Torró assumes that the combination of both activities could guarantee the fertilisation of the lands.

6. Conclusions

During the 8th and 9th centuries, as M. Barceló pointed out, the agrarian transformations that took place due to the Arab and Berber migrations were not a simple reproduction of the previous agrarian developments in the places of origin. The selection and adaptation by the new settlers of new technologies, local techniques, and different climatic and geographical conditions produced a technological synthesis in the Iberian Peninsula [60–81].

This newly cultivated landscape was not homogeneous, and research in different regions has shown that these groups made technological choices depending on the conditions of the specific areas in which they settled, drawing upon a larger breadth of knowledge. But they couldn't reproduce the original conditions of their homeland from the Near East to the Maghreb, so the new agricultural areas in the Iberian Peninsula were not replicas of those that the immigrants knew in their homelands [81]. However, the criteria mobilized to build the new cultivated areas are recognisable because they were technological and linked to specific social conditions. The result was a transformation of the previous agricultural landscape while likely adopting local solutions.

The Balearic Islands, conquered in 902 C.E., are the final stage of this migratory process. The migrants brought this consolidated knowledge with them, and all of them drew on the same technological package that had been formed during the migration process that began in the Middle East in the 7th century; this explains the variety of technological solutions and combinations. We can find *qanāt*(s) in the north of Mallorca and some in Ibiza, built in a very similar way with dry stone, but they are not found in Menorca, nor have they been identified in very many areas of the Iberian Peninsula. Water-lifting wheels can only be found in river plains, near the outlet of torrents, or around marshlands. Each technique is used only when local conditions make it useful; for example, water mills are only found in canals where the water flow is strong enough to successfully foster milling.

The ecological impact of this transformation was so severe that the previous agricultural landscape of late antiquity is barely recognisable, preserved only as fossilised structures. Moreover, the subsequent Christian conquest from the 12th to the 15th centuries based the new migration and colonisation on the agrarian landscape that the conquerors found. Of course, the new Christian settlers and landowners introduced new ways of managing water, mills, irrigation canals, and dry-farming fields. They extended vineyards within irrigated areas and began to expand the surfaces or create new cultivated areas; however, they had to rely on the previous agricultural layout. In fact, until at least the middle of the 20th century, the original selections made by the Berber and Arab farmers still determined the shape and structure of most of the irrigated areas, which is why they can still be recognized despite the expansion that has mainly taken place in modern times. However, the more recent and destructive capitalist agriculture is erasing the last vestiges

of the Andalusi agricultural landscape. Plot concentration, new irrigation canals for the cultivation of former rainfed areas, and massive greenhouse agriculture are proving to be even more destructive of the historical landscape than abandonment.

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