39th IAHR WORLD CONGRESS GRANADA, SPAIN 2022 From Snow to Sea 19-24 June 2022

Proceedings of the 39th IAHR World Congress
19–24 June 2022, Granada, Spain
doi://10.3850/IAHR-39WC2521716X20222029

The Irrigation Systems of Jérez del Marquesado (Granada, Spain)

José Abellán Santisteban[1], Blas Ramos Rodríguez[2], José María Martín Civantos[3]

[1,] Laboratorio de Arqueología Biocultural MEMOLab, Granada, Spain,abellansan@go.ugr.es
[2] Laboratorio de Arqueología Biocultural MEMOLab, Granada, Spain, blasramos@ugr.es
[3] Laboratorio de Arqueología Biocultural MEMOLab, Granada, Spain, civantos@go.ugr.es

Abstract

Sierra Nevada is one of the most important mountain ranges on the Iberian Peninsula. It has an important native flora and fauna. It also has one of the most important water management systems. Jérez del Marquesado is a municipality located in the northern part of the Sierra Nevada, which maintains irrigation systems that date back to the medieval period. These systems are fed by meltwater and have ensured the cultivation and irrigation of crops for at least 700 years. These systems have proved to be efficient, ensuring a constant flow of water for agriculture in the summer periods.

Keywords: Water Management, Sierra Nevada, Archaeology, Islamic irrigation, Medieval Ages

1. INTRODUCTION

The study of historical irrigation systems has been a subject of special interest for the discipline of Archaeology for some decades now. These systems, which are resilient to agricultural changes and modernisations, are often preserved as fossilised elements that show the past of communities. Knowing these systems from a historical point of view, we can make interpretations of production and settlement in medieval times. In recent times, disciplines such as hydrogeology have become increasingly interested in the study of these systems, their techniques and their management (Martos et al, 2020). The irrigation channels are responsible for taking the water coming from the high peaks and redirecting it through the ravines and hills to the fertile plains where the fields are cultivated.

2. METHODOLOGY

The volume and complexity of the irrigation systems of Jérez del Marquesado mean that their study must be approached from a multidisciplinary perspective. The characteristics of the municipality allow its waters to flow from the high peaks in the south to the river junctions on the plain in the north. The result is a complete hydraulic network that develops from the highest part of the slopes of the Sierra Nevada to the fertile lowlands of the municipality, where it reaches its greatest density. This density responds to the logic of the evolution of the settlement and the territorial organisation of the municipality throughout history.

Thus, the landscape of the slopes and plains of the northern part of the Sierra Nevada is the scene of a constant struggle for the survival of ancestral water management systems in the face of the hydraulic modernisation of irrigation areas, which are supposed to be more profitable. The relationship between human beings and the natural environment has marked the rhythms and conditioning factors of the settlement of human populations, giving rise to a stratified and complex landscape (Martín 2008, p. 34) in which the natural and social reality of human groups intermingle. Its historical characterisation is given, in part, by the different documents from the Andalusian period which tell us of the existence of numerous irrigation systems throughout the Marquisate of Zenete (González, 1940). It is a complex landscape, which requires a study that highlights the dynamism and flexibility of the historical agricultural and livestock systems, and which must be approached with a multidirectional, open and integrating focus (Orejas, 1991, p. 192, using a transdisciplinary approach. If all the factors of the environment have been anthropised at one time or another, it is necessary to evaluate them from a historical, archaeological, hydraulic, hydrogeological, agrological and environmental point of view, as it is this complexity that shapes the different historical realities. These factors show that ancestral water management systems are fundamental in the rural world, due to the enormous transformation of the human livelihood they generate. The irrigation systems of the Sierra Nevada are an example of the adaptation and resilience of peasant communities since the Middle Ages (Martos et al 2020, p.367) and Jérez del Marquesado is shown as a place where these agricultural systems survive, represented by cultivation areas irrigated by numerous irrigation ditches (Martín, 2007) whose origin dates back to the Andalusian period.

3. GEOGRAPHICAL CONTEXT

The Sierra Nevada is the southernmost mountain range in Europe, as well as the largest after the Alps (Titos, 1997, p. 13). It has more than twenty peaks exceeding three thousand metres in altitude. It is

considered the most important biodiversity hotspot in the western Mediterranean (Anderson et al 2011, p. 1615-1616), hosting endemic species of flora and fauna (Lorite, 2006; Ruano et al 2013; Blanca and López 2002). On its northern side is the municipality of Jérez del Marquesado, one of the ten villages of the Marquesado del Zenete, which extends from its peaks in the south to where the plains end and the boxed-in torrents of the rivers Jérez and Lanteira join to open up the Hoya de Guadix (Martín 2007, p.215). The Marquisate of Zenete is bounded to the south by the peaks of the Sierra Nevada, and the north by the Sierra de Baza, ensuring a natural passage from the Hoya de Guadix to Almería through the Fiñana corridor.

Hydrographically, the fluvial network unfolds in an east-west direction following the relief of the Sierra Nevada, creating numerous valleys through which streams and small rivers flow in a south-north direction towards the Hoya de Guadix. This water flows towards the river Guadix, continuing towards the river Fardes and then towards the Guadiana Menor, ending in the Guadalquivir. In its northwestern part, the water flows towards the Gobernador River and then towards the Nacimiento and the Andarax, finally flowing into the Mediterranean Sea (Martín 2007, p.224). Below the plains of the Marquesado del Zenete and towards the Hoya de Guadix in the northeast, there is a large aquifer that collects the infiltrated water. This groundwater body is identified as 051.012. It is in turn closely related to the adjoining body of the Sierra de Baza 051.011, located to the east. This groundwater body has a maximum elevation of 1,825 m a.s.l. and a minimum elevation of 766 m a.s.l. It is located in an area whose lithology (Plio-Quaternary gravels and sands and Quaternary alluvium) allows for high permeability (IGME 2010). As for the municipality of Jérez, three watercourses end up flowing into the River Guadix: the Arroyo Bernal, the River Alhorí and the Alcázar. The rivers are fed by meltwater from the snowmelt on the peaks of the Sierra Nevada and end up joining in the north of the municipality in the same way as explained above towards the River Guadix.

3.1. HISTORICAL CONTEXT

Archaeological evidence indicates that the earliest human settlement in this area dates back to the Argaric period. This is attested to by the numerous archaeological sites which, although they have not been the subject of archaeological stratigraphic interventions, yield a considerable amount of data regarding the characterisation of the settlement. This first occupation is manifested in different archaeological sites, in which we can find a marked mining and metallurgical character, giving rise to the exploitation of different natural resources. Some archaeological sites, such as Alcázar 01/Los Caserones, the mining settlement of Fuente del Castaño (Lanteira) or the Peñón de Alrután are good examples of this. The remains found in surface surveys suggest settlements from at least prehistoric times, which continued into the Iberian and Classical periods. However, the best-characterised period in Jérez del Marquesado in the Middle Ages. There are numerous remains from this period, often clearly evident in the monumentality of some buildings, such as the Alcázar Tower or the castle itself. The presence of these structures reflects a medieval settlement characterised by a dispersed habitat, made up of small farmsteads that would gradually disappear, with the population concentrating around more secure population centres (Martín 2004, 2007). The greatest trace of this medieval past can be read in the landscape through the irrigation systems and their landscape implications.

4. SYSTEM DESCRIPTIONS

The systems described below are supplied with water from the rivers and springs that appear in the lower areas of the Sierra. However, all the irrigation systems that exist in the vega are dependent on the irrigation ditches that are present at higher altitudes, as they fulfil a basic function for the maintenance of the irrigation network described above. These water collection systems have been and are the subject of archaeological and hydrogeological research by public research bodies such as the University of Granada and the Spanish Geological and Mining Institute (IGME).

4.1. Careos

The irrigation ditches are unlined water channels, made through a ditch dug in the ground. Their function is to extract water from the riverbed and transport it to other points in the mountains, fulfilling various functions in this process. Historically, they are presented as ditches of different sizes, depending on the type of ditch, its characteristics and its use. The ditch is normally made by excavating it in the ground, which means that sometimes they are not dug in the ground but in the rock itself. Recently there have been important transformations that have affected the structure of this type of ditch, mainly due to the introduction of modern construction materials, which often lead to a substantial loss of efficiency in the ditches.

This type of canal required constant maintenance, which was supervised by the figure of the "acequiero", who was in charge of complying with the established water rights and carrying out specific actions. The annual

maintenance, aimed at keeping the irrigation channel in working order (repairing damage, cleaning the canal, etc.), was paid for by the entire community, which was also involved in the process itself. Some of the most important functions of the irrigation ditches are the following:

Transfer of water

Some irrigation ditches have the function of transferring water from one watercourse to another. This ensures the supply of water to the driest watercourses. The transfer of water is a constant feature of the irrigation channels of the Sierra Nevada, and takes place at different points of the massif, involving entire communities. The organisation, distribution and management of water between various communities are subject to a series of rules previously established by mutual agreement between the two parties. This ensures that water flows to one point for several days, while it flows to another, or continues in its natural direction, for another time.

In Jérez del Marquesado this function is represented by the Acequia del Jaral, a 2.5 km long canal whose function is to collect the water subsequently provided by another irrigation channel (the Acequia del Corazón, which draws water from the Alhorí river basin). Once the water has been loaded, it is transported to the Bernal basin, where it is released at an altitude of 1720 m above sea level. The water would have been previously collected by the Acequia del Corazón at an altitude of 2405 m above sea level, so there is both a longitudinal and altitudinal route. Figure 1.

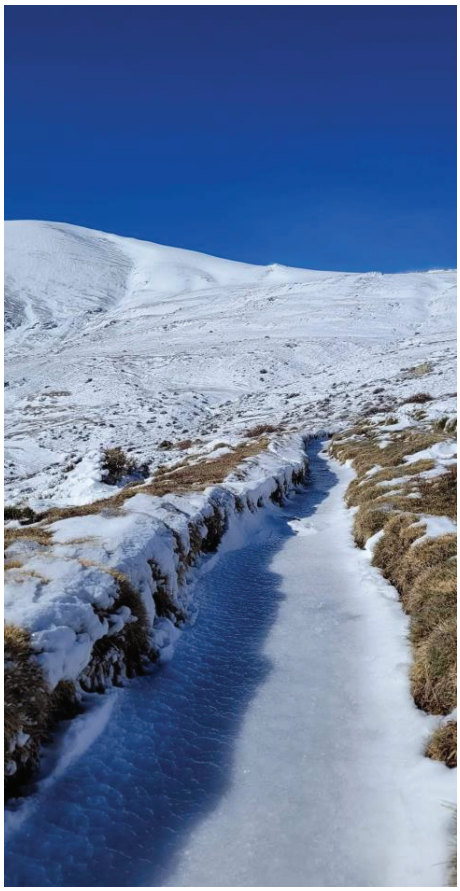

Figure 1. Detail of Acequia del Corazón in winter. The irrigation ditches begin to function from spring onwards, when the thaw begins.

This water transfer mainly affects the irrigation systems of the Alrután/Bartillana community, with the communities that take water from the Alhorí providing the water.

Another irrigation channel used to transfer water to the Bernal basin is the Acequia de la Cañada del Mirador. In this case, it is a shorter canal (788 m), whose function is to collect the water from the springs of the Cañada del Mirador, which originate at an altitude of 2,380 m above sea level in the Alhorí basin, and then transfer it, like its counterpart at Jaral. The springs of the Cañada del Mirador are related to the cycle of

thawing and infiltration of the water, and their flow, although it varies throughout the year, does not usually dry up.

This distribution of water, which can occur both in the higher areas of the sierra and at lower altitudes, is a constant in the Sierra Nevada. Some examples of water transfers outside Jérez del Marquesado can be seen between the basins of the Trevélez and Bérchules rivers, or between Bérchules and Mecina Bombarón. In general, those basins with the greatest availability of water are the ones that lend this resource to those where it is not so abundant. In this way, the water from the thawing of the Mulhacén in the Trevélez river is, in part, collected by the Bérchules irrigation channel and, in the same way, part of the water from the Bérchules basin is ceded to the Mecina river basin.

Artificial recharge of aquifers

The artificial recharge of aquifers is the main characteristic of the irrigation ditches, and the one that has the greatest impact, both in the modification of the hydraulic network and on the landscape itself. This system works according to a logical and pragmatic use of resources: when there is more water, during the thaw, water is collected in the ravines. The water is transported to mid-slope or, in some cases, to specific points, causing water to be released on them. Figure 2.

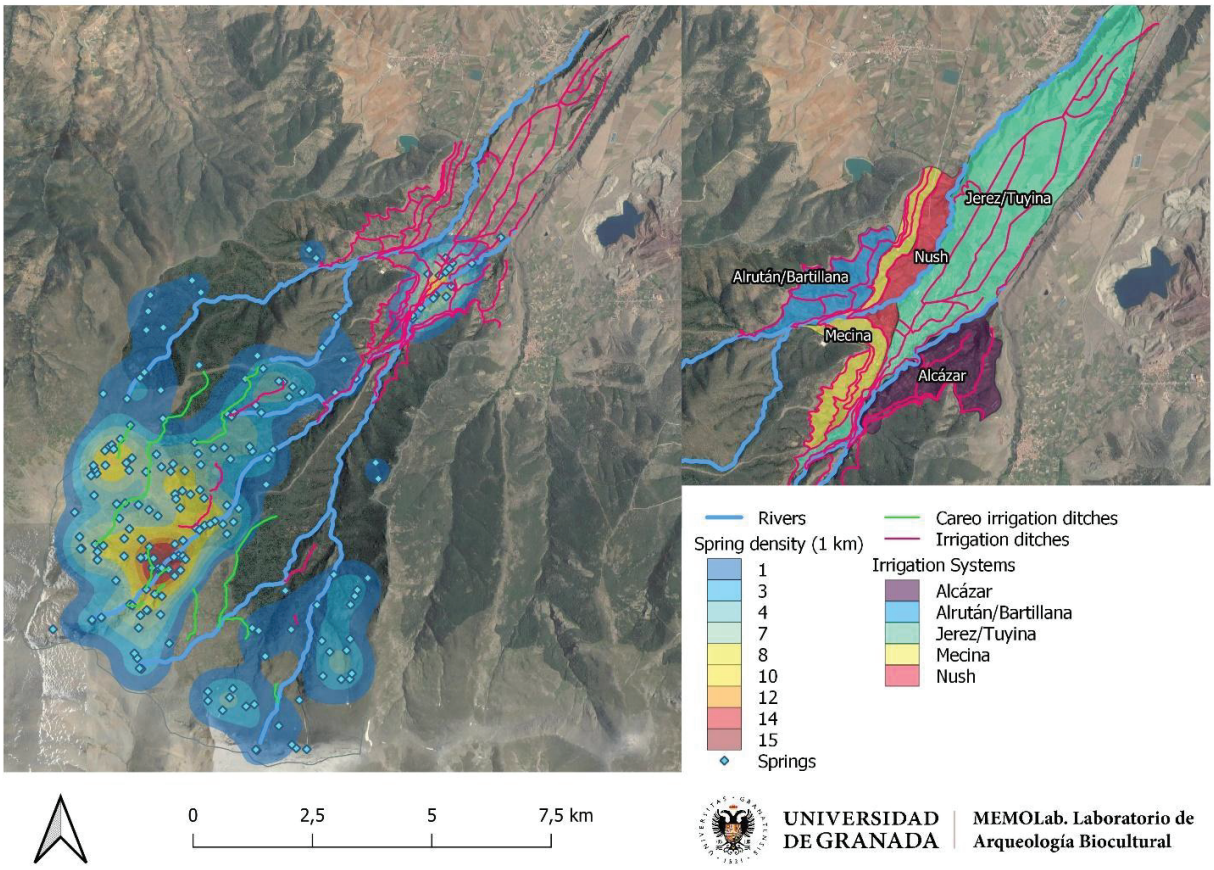

Figure 2. Map showing the location of the irrigation and careo ditches with the density of springs per square metre. Top right: Location of the medieval irrigation systems.

By infiltrating the water into the slope, or into the corresponding water-carrying chasms, it is possible to achieve what is known in the popular tradition as "water stalling", i.e. to delay the time during which the water continues its course towards the gully, which allows the use of this resource for a prolonged period. Once the water has infiltrated, it will travel through a specific space for a certain period and then rise again. This is the reason why many of the springs in the Sierra Nevada, in general, and in Jérez del Marquesado in particular, have a genesis related to the practice of water-carrying. Consequently, if the process of water sniffing ceases, many of these springs disappear, leading to an increase in the aridity of the environment in which the water previously arose.

In Jérez del Marquesado there are several irrigation channels for water infiltration. The most important, and the one on which most of the weight of the infiltration system falls, is the Acequia del Corazón. This is a canal almost 5 km long that runs south-north along the entire slope, from its intake at the El Corazón snowfield, at an altitude of 2,405 m above sea level, to the vicinity of the Bernal basin, where it ends at an altitude of approximately 1,949 m above sea level. Throughout its route, water is systematically released in small ravines and in the middle of the slope itself. In this way, the entire slope is "soaked", which will later result in different fountains and springs.

The generation of these springs through the artificial recharge of the aquifer allows for the supply of water in summer periods, which implies the maintenance of the network of irrigation ditches in the village's fertile plain. At the same time, it also entails the modification of both the settlement and the management of the irrigated land, as the water can be used at new points, generating irrigated areas in higher areas.

The aquifer recharge system has many parallels in the Sierra Nevada. The irrigation channels are, to a large extent, the articulating axis of the water supply in the whole massif and, therefore, they are the backbone of how human habitat is produced in this mountain range. This makes them one of the greatest assets of the area. Examples can be found in most of the municipalities of the Sierra Nevada, and with all kinds of nuances, particularities and varieties. For example, while in Jérez del Marquesado the water is released along the entire course of the irrigation channel, in other places such as Cáñar or Mecina Bombarón, the water is directed towards specific points known as "chasms", usually formed by fractures in the rock or areas of alluvial accumulation on the tops of hills[1].

Pasture Generation

Although there has traditionally been a dichotomy between livestock farming and historical irrigation systems in the debate on the management of irrigation versus livestock farming in studies on al-Andalus, the fact is that the network of irrigation ditches plays a fundamental role in livestock farming. In the case in question, the role of the irrigation ditches in generating pastures, especially between the Oromediterranean and Cryo-Mediterranean levels, should be highlighted. The areas of high mountain pastureland, or "*borreguiles*", which in many cases have a natural origin (through the infiltration of meltwater and its subsequent appearance in streams, where pastures are generated naturally), have been consciously extended using the irrigation ditches, so that, to a large extent, the borreguiles constitute an anthropised pasture system, with an obvious livestock function, as their name suggests.

These plant communities are of great ecological value. They are made up of grasses and fawns of *Nardus stricta* and *Festuca Iberica*. Depending on the capacity and amount of waterlogging of the soil, a whole series of species appear among the sheepfolds, such as the hornbeams (*Carex nigra subsp. intricata, Carex nevadensis and Carex echinata*) or the communities of *Vaccinium uliginosum subsp. nanum*, which represents the climactic stage of the Nevadan grassland on hydromorphic soils of the oromediterranean floor.

Thanks to the system of “careos”, and often as a consequence of the interest in recharging the aquifers, pastures are generated locally. In Jérez del Marquesado there are two ways of generating artificial pastures: on the one hand, through the Acequia del Corazón, where, with its abundant water releases for infiltration, pastures are generated along the entire area immediately behind the irrigation channel itself. On the other hand, there are small ditches, smaller in size, but also intended for water infiltration, which fulfil this function.

[1] This is the case of the water from the Barjas irrigation channel (Cáñar) in the "Cerromán" sinkhole, and the "Arroyadas" sinkhole of the Bérchules irrigation channel (Mecina Bombarón), in the latter case, infiltrating water that has been transferred.

Figure 3. Acequia de careo (irrigation channel) releasing water to generate pasture for cattle in Jérez del Marquesado.

4.2. Islamic irrigation systems in the fertile plain of Jérez del Marquesado.

The water from the melted snow and those springs linked to snow infiltration are collected through the irrigation ditches (Martín, 2007 p. 350). These are the backbone of the hydraulic irrigation network and the social organisation around water. Figure 3.

In the fertile plain of the municipality, which develops from the foothills of the hillside until well into the plain, the irrigation systems of Jérez del Marquesado are delimited based on various elements, such as the organisation of the settlement itself or the origin of the water. Five major historical irrigation systems have been identified and characterised in the fertile plain of Jérez del Marquesado, with water rights determined according to the distribution of water.

These systems exist thanks to the function of the aforementioned meltwater flows. The traditional irrigation system is recorded in various historical sources, such as 16th-century Castilian documentation, where the land registers show the functioning of the irrigation systems in the village's fertile plain. Concerning the identification of the system of careo in the high peaks, we find more interesting a lawsuit from the 12th century, edited by González Palencia (1940) between the farmsteads of Bartillana and Lubros. The dispute, brought before the qadí of Guadix in 583/third decade of May 1187, was about the water of the springs of a place called Murūŷ al-Sawdān (Meadows of the Blacks) near the place called Qabr al-'lly (burial place of the donkey), south of the road to Granada (González, 1940 p. 308). The inhabitants of Bartillana claimed that the water from these springs belonged to them because part of the water flowed down the irrigation channel that went to their farmstead. However, the inhabitants of Lubros replied by saying that they had built the western part of the irrigation channel. The dispute was brought before experts, who decided that the springs and fountains in the eastern part belonged to Bartillana, while those in the western part belonged to Lubros. It is also explained how this agreement would be subject to the condition that the people of Bartillana could not build an al-Barraŷūl (wall) in the aforementioned springs to cut off the water to the people of Lubros (González, 1940 pp. 323-328).

The importance of this lawsuit lies in the fact that the inhabitants of Bartillana had already extended the irrigation channel at some point, leaving the people of Lubros without water. On the other hand, it shows that the water rights in these mountains were already in use, with water legislation that was manifested by the existence of illegal or prohibited actions. Moreover, it is noteworthy that this lawsuit is the only mention of the use of what we identify as "careos". The rest of the documents with similarities to this practice deal with the generation of mountain pastures for livestock, which are also related to water fetching. The oldest document in this regard is contained in the biography of the Sufi master Abu Marwan

al-Yuhanisi, a native of Ohanes, who travelled the peaks of the Sierra Nevada on the occasion of his constant spiritual retreats (Boloix, 2010). This mention is made a century later, in the 13th century, and praises the blessings of the pastures of the neighbouring municipality of Lanteira, based on maintenance work related to the cleaning and maintenance of the irrigation channels (Al-Qashtal, 1974). Of the other documents that deal with the creation of high mountain pastures, the oldest concerning the Zenete belongs to the 15th century. It recounts the disagreements between the inhabitants of Alcázar and Jérez and the neighbouring farmstead of Lanteyra over the ownership of land and pastures. The right of ownership of the land seemed to be linked, from time immemorial to the mountains of the castles (González 1940, 311). For this reason, and fearing bloodshed, the qadí of Guadix had to visit the mountains between the two towns and issue a judgement about the ownership of the places and the roads, but also about the meadows. The judgement (855/November 1451), which would be resolved with the cession of the use of the meadows to Lanteyra, would be extended in time. Finally, Lanteyra will lose all rights to pastures, wells, crops, forests and utilities, being relegated only to the right of way (González 1940, p.313).

Similar rights still apply today, based on the tradition that originated in the Middle Ages. Thanks to the lawsuits collected in the documentation, it is possible to establish chronologies about the irrigation systems, which are presumed to be older than those established in the lawsuits of the 12th century, taking into account that the water rights were already well consolidated, and must have been established in the first irrigation systems of the five parts of the vega. In this way, the five towns that depended on these waters would have established the rights that would govern their management (Martín 2007).

The five irrigation systems to which we refer are organised according to the five farmhouses that populated the present-day municipal district, and run parallel from west to east. These farmhouses have been identified both archaeologically and through toponymy (Martín 2006, 2007). The systems described below correspond to the different farmsteads, and these were responsible for managing the different irrigated areas within their boundaries.

- Alrután/Bartillana: This system appears in the medieval documents of Jérez del Marquesado, in the context of lawsuits to settle the distribution of water for irrigation. It is known as Alrután or Bartillana. The toponym probably corresponds to the Vulgar Latin anthroponym Vertilius, which would mark the ownership of land: Vertiliana. The main irrigation channel of this system is the one that gives its name to it: the Acequia del Caz de Alrutan. It takes its water from the river Bernal, and, together with its secondary canals, has a total length of 7 km of irrigation ditches. Our estimate of the irrigated area of this system is about 13 km2.
- Mecina: This irrigation system carries water through the so-called Acequia Alta de Cogollos or Acequia de Mecina. The water is taken from the basin of the river Alhorí. This irrigation channel irrigates the area up to the channel immediately below, the Nush system (Acequia de Guadix), and then enters the municipality of Cogollos de Guadix, entering the mill of this locality. It has a surface area of 14.4 km2 and 11 km of irrigation channels.
- Nush: This system is located between the irrigation system of Tuyina and that of Mecina, described above. It is the system with the smallest surface area and is irrigated by the Acequia de Guadix, which is just over 6 km long. The intake of this irrigation channel is located on the western side of the Alcázar river, at the point where it joins the Alhorí river. It has an irrigated area of 10.8 km2, which is irrigated by a total of 11 km of irrigation ditches and their branches.
- Tuyina: The Acequia de Jérez is the one that supplies this system, located in the centre of the municipality. The irrigated area is 71 km2, and it has a total of 27 km of irrigation ditches and branches. The main irrigation channel has its catchment in the south of the municipality, much higher than the rest of the irrigation channels, in the basin of the river Alhorí, and at a much higher altitude than the rest of the channels that make up these systems (1450 metres above sea level). This irrigation channel supplies water to numerous mills along its entire length.
- Alcázar: This system is the most easterly of all those described above. This irrigation channel takes water from the Alcázar river, which joins the Alhorí river and forms the Jérez stream. The intake is located at 1370 m above sea level on the right bank of the river and is known as the Acequia de Alcázar, which is just over 3 km long. The Acequia de Alcázar is in charge of supplying water to the area of the same name. These lands are located in the area between the River Jérez and the River Pueblo de Lanteira to the east. This system has a total length of 8.7 km of ditches and irrigation channels, spread over 19.7 km2.

5. CONCLUSIONS

Jérez del Marquesado is an excellent place to study and model historical irrigation systems. The systems were already established and consolidated during the early Islamic period, between the 8th and 10th

centuries, by local peasant communities. Water rights between different villages and land owners were also established as part of the governance systems. In Jérez del Marquesado we can clearly distinguish two different areas: the careos in the upper part of the mountain as an artificial aquifer recharge system and the vega in the lower flat area where intensive irrigation takes place. The careos are demonstrating their efficiency infiltrating water at higher altitudes and creating meadows and old cultivated lands currently abandoned. They increase water availability during summer feeding springs and streams and allowing irrigation in an extensive cultivated area for centuries. Traditional water management has demonstrated its efficiency, resilience and sustainability at least for one thousand years, producing an important amount of ecosystem services including not only water regulation, but also biodiversity, soil fertility or avoiding erosion (https://regadiohistorico.es/argumentario). Despite these values and services, the system has been threatened by abandonment since the 70's, when agrarian modernization meant migration and the marginalization of these traditional agrarian socio-ecological systems. Currently the main threat is "modernization", meaning the destruction and transformation into a technified pressurized irrigation system and an industrialized agriculture. This kind of agriculture is expanding in the Southeast of Spain, increasing negative impacts on soils and water resources, but also on bio and agrodiversity. Ecosystems services produced by traditional irrigation systems are completely lost arguing highest efficiency and water saving. But water management should always be seen from an integrated approach and efficiency from multifunctionality. From this perspective, historical and traditional water management become an important tool for facing current environmental and social challenges, including the adaptation and mitigation of climate change effects.

6. ACKNOWLEDGEMENTS

We would like to thank especially the Instituto Geológico y Minero de España for its contribution to this paper that is the direct result of the projects "Inspiring rural heritage: sustainable practices to protect and conserve upland landscapes and memories (IRIS)", funded by the JPICH programme – PCI2020, European Union and "Análisis de sistemas históricos de manejo del agua como herramienta de adaptación al cambio climático", funded by Proyectos de I+D+i en el marco del Programa Operativo FEDER de Andalucía 2014-2020. We also thank the Comunidad de regantes de Jérez del Marquesado for its collaboration and the farmers' effort and dedication.

7. REFERENCES

Al-Qashtal (1974) *Kitāb tuhfat al-mugtarib bi-bilād al-Magrib fī kamārāt al-šayj Abī Marwān*, Ed. GRANJA.

Anderson, R. S., Jiménez-Moreno, G., Carrión, J. S., & Pérez-Martínez, C. (2011). Postglacial history of alpine vegetation, fire, and climate from Laguna de Río Seco, Sierra Nevada, Southern Spain. *Quaternary Science Reviews*, 30(13-14), 1615-1629.

Boloix, B. (2010). Prodigios del maestro sufí Abu Marwan al-Yuhanisi de Almería. Estudio crítico de la Tuhfat al-Mugtarib de Ahmad al-Qashtali. Tarragona: Mandala Ediciones.

Martín, J. M. (2004). El Marquesado del Zenete, un modelo de implantación castellana en el Reino de Granada. Chronica Nova. *Revista de Historia Moderna de la Universidad de Granada*, (30), 371-400.

Gómez Cruz, M. (2010) Condicionantes naturales del término de Jérez. Editorial C.S.V. Granada.

Gómez Palencia, A. (1940). Documentos árabes del Cenete*. Al-Andalus: revista de las Escuelas de Estudios Árabes de Madrid y Granada*, 5(2), 301-382.

Instituto Geológico y Minero de España (2010). Encomienda de gestión para la realización de trabajos científico-técnicos de apoyo a la sostenibilidad y protección de las aguas subterráneas. Identificación y caracterización de la interrelación que se presenta entre aguas subterráneas, cursos fluviales, descargas por manantiales, zonas húmedas y otros ecosistemas naturales de especial interés hídrico. Masa de agua subterránea 051.012 Guadix-marquesado. Ministerio de Ciencia e Innovación. Ministerio de Medio Ambiente y medio rural y marino.

Lorite, J. (2002). La vegetación de Sierra Nevada, in Blanca López, G., & López Onieva, M. R. (2002). Flora amenazada y endémica de Sierra Nevada. Junta de Andalucía, Consejería de Medio Ambiente.

Lorite, J. (2016). An updated checklist of the vascular flora of Sierra Nevada (SE Spain). Phytotaxa, 261(1), 1-57.

Martín Civantos, J. M. (2007). Poblamiento y territorio medieval en el Zenete (Granada). Universidad de Granada.

Martín Civantos, J. M. (2008). Arqueología y recursos naturales: notas para la arqueología del paisaje. In *Medio ambiente y arqueología medieval* (pp. 17-40). Alhulia.

Martos, S., Martín, J., Ramos, B., Abellán, J., González, A., Jódar, J., J, D. (2020). Recuperación de sistemas ancestrales de manejo del agua que utilizan soluciones basadas en la naturaleza. Las acequias de careo

de Jérez del Marquesado. XI Congreso Ibérico de Gestión y Planificación del Agua. September 2020, (September), 358-369.
Navarro, J. A., Ruiz, J. M., Perez, R. R., & Moreno, M. E. (1986). El Marquesado del Cenete: historia, toponimia y onomástica, según documentos árabes inéditos. Universidad de Granada.
Orejas Saco del Valle, A. (1991). Arqueología del paisaje: historia, problemas y perspectivas. *Archivo Español de Arqueología*, 64(163), 191–230.
Ruano, F., de Figueroa, J. T., & Tinaut, A. (2013). Los insectos de Sierra Nevada: 2000 años de historia. Asociación Española de Entomología.
Titos, M. (1997) Sierra Nevada: Una gran historia. Editorial Universidad de Granada.
Vera, J. A. (2002). Bibliografía geológica de la cordillera bética y baleares (1978-2002)

