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SUSTAINABILITY OF HISTORIC IRRIGATION SYSTEMS IN THE RICOTE VALLEY. THE MENJÚ HYDRAULIC SYSTEM (MURCIA-SPAIN)

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ABSTRACT

In the Vega Alta del Segura (Murcia Region, Spain), a series of hydraulic systems of weirs and irrigation ditches have made it possible to divert the waters of the Segura River to create traditional and historic irrigated landscapes. Water-lifting wheels and electric motors have extended irrigation throughout the slopes of the valley and even beyond. These are cultural landscapes, built over the centuries, as the result of the relationship between man and environment, forming a rich hydraulic heritage [norias (water wheels) and motors], which is now threatened by the low economic profitability of the farms and by the high prices of energy. This represents a challenge to the sustainability of the orchard production system, to the value attributed to the tangible and intangible heritage and to the perception of the irrigated landscapes in this section of the Segura Valley. The Menjú System extends throughout the municipalities of Cieza, Abarán and Blanca and here we carry out a regional study of irrigation; both diachronic (evolutionary) and comparative (with other places), with reference to quantitative and qualitative research. Fieldwork included interviews with irrigators, to assess the situation of the various hydraulic systems and associated cultural landscapes. The diagnosis reflects strengths, such as the availability and quality of irrigation water and also weaknesses, such as the cost of energy for irrigation by elevation and the reduced size of most farms attempting to offer a commercial volume of product. We describe an agrosystem that is a candidate for Globally Important Agricultural Heritage Systems (GIAHS) that derives value from the hydraulic and cultural heritage manifested by the Menjú system, which will facilitate the local development of these municipalities.

Keywords: cultural landscapes, irrigation weir-ditch, orchards, traditional irrigation, Vega Alta del Segura.

INTRODUCTION

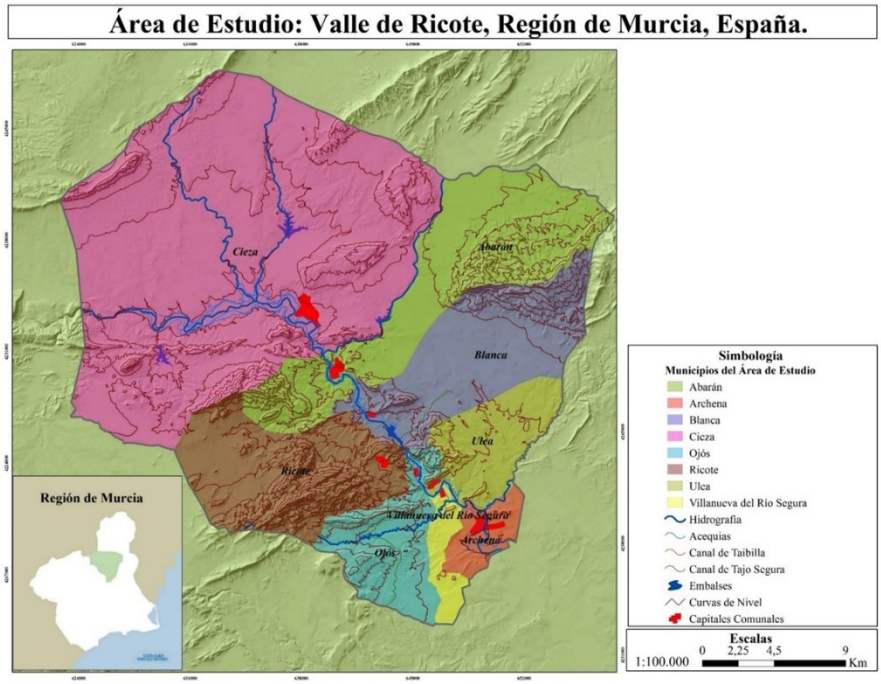
In the Segura Basin (Southeast of Spain), a series of hydraulic complexes of weirs and ditches that descend in steps following the slope of the river course, allow the waters to be diverted; thus creating the cultural landscapes of the orchards (Gil and Gómez, 2018).

The Segura River, in the Vega Alta section known as the "Ricote Valley", has taken advantage of a series of faults to cut through the Betic relief, which stretches from NE to SW in the central Murcia Region. Successive narrow

channels cut through the mountain ranges (Menjú, Canales, Piedra Negra, Solvente, etc.), with other wider stretches passing through the intramontane depressions (Hoya de D. García, Abarán basin, Huerta de Arriba de Blanca, Huerta de Abajo de Blanca, etc.). The orchard is not continuous throughout the river valley; it is interrupted by rocky outcrops, so that the cultural landscape of the irrigation system forms a rosary of orchards, linked by the Segura River course (Gómez, 2015; Gil, 2015) (Figure 1).

Research consists of a regional geographical analysis of the hydraulic system (dam, intakes and pipelines), organized in the Menjú (Cieza area) and the authority in charge of water heritage and irrigation societies in the municipalities of Abarán and Blanca. We undertake a rural geographical study of irrigated areas that contrast markedly to the rest of the territory, which has a semi-arid environment like the Iberian Southeast (Gil, 2006). It is diachronic, because the analysis covers from 1613, the year when the Moors[3] were expelled from the Ricote Valley, up to the current situation in 2023, assessing how the model for the diversion of perennial waters has evolved, focussed on a river course; nowadays regulated by a system of reservoirs, as occurs in the case of the Segura.

The study of this irrigation method divides into two types; the first uses water below the irrigation ditch and the other water that is elevated. On-foot



Source: self-elaborated, by José Marcelo Bravo Sánchez, 2016.
Figure 1. Location of the Ricote Valley (Murcia region, Spain).

.irrigation, using gates or below the ditch, is organized below the levels of the ditches, which adjust to the topography, in order to irrigate corners and groves along the river bank. The method that raises water from the river or from the ditches requires terracing the slopes of the river valley (with dry stone walls)[4] and raising the water by means of traditional devices (water elevating hydraulic wheels of varying sizes), and by motors (steam engines, simple gas engines, diesel-oil engines and electric motors). These would spread throughout the valley, once hydroelectric plants, commonly known as light factories became established, supplying areas with electricity (the Menjú hydroelectric plant in Cieza, the Sagrados Corazones hydroelectric plant in Abarán, the Nicolás Gómez Tornero plant in Soto Damián, and the San Rafael hydroelectric plant in Blanca) (Gómez and Gil, 2014).

The aim of this research was to undertake a regional geographic analysis of the Menjú agrosystem, hydraulic heritage, as well as native ethnobotany and biodiversity, and the associated cultural landscape[5]. Among the objectives of the research, was to indicate the difficulties-risks and the resources-potentialities, in order to propose sustainable strategies for the traditional and historical agrosocial irrigation model in the Vega Alta Segura.

Among relevant antecedents, we should mention publications by Glick on the Valencia orchard (Glick, 1988) and those by Herin on the Murcia orchards (Herin, 2012). Among the most recent works, those by Gómez and Gil on these irrigated areas and their governance stand out (Gómez, 2012; Gómez *et al*., 2022) and also those by Sanchis on adaption to climate change (Sanchis and Boelens, 2018; Sanchis *et al*., 2020, Sanchis *et al*., 2021).

THEORETICAL FRAMEWORK

The conceptual framework comprises cultural landscapes with traditional and historical irrigation (Hermosilla, 2010; Piqueras, 2013); concerning the link between irrigated agriculture and civilization (Palerm, 2002; Palerm and Martínez, 2009) write about the development of a culture of irrigation ditches (Rivera, 2009; Ponte, 2005); about water authorities (Palerm, 2015; Gimenez and Palerm, 2007; Gómez *et al*, 2022); on the heritage aspect (Hermosilla, 2011; Molinero and Tort, 2018); and likewise concerning the increase in cultural practices involving water management and procedures for the development of orchards in regions of North Africa, such as Testour in Tunisia (Hamrita and Rejeb, 2023).

Two doctoral theses have recently been written on these historic irrigation systems. Bravo (2018) "Rural landscape and hydraulic heritage, outstanding examples from the rural culture of the Ricote Valley (Spain) and the Central zone of Chile" deals with the line of inheritance and seals of identity, as perceived by those who live in or visit the Ricote Valley. A seal of identity required by

the water-elevating hydraulic wheels (the azudas) and the lesser hydraulic applications related to the milling industry stand out. These hydraulic devices are similar to those that exist in the central part of Chile (O'Higgins Region). Pastor's (2018) "The historical and traditional irrigation systems of the Ricote Valley" focuses on irrigation culture and associated landscapes, with the history of irrigation by elevation in the section of the river valley between the Menjú and the Baños de Archena. It describes the construction of the Ricote raised garden, using water from a point of emission (the Fuente Grande) and water elevated from the Segura; focusing on the modernization process of the Huerta de Ricote, which conserves the inheritance of Water Heritage and the functionality of the Irrigation Community.

METHODOLOGY

We initiate this study with an analysis of the bibliography and documentation from the Archive of the Hydrographic Confederation of Segura (AHCS), the General Archive of the Region of Murcia and the municipal archives of Abarán and Blanca. The bibliography included in the "cited literature" section was revised and consulted; this was complemented by field work in the section known as the Ricote Valley, in order to photograph the irrigation infrastructures and orchard landscapes that comprise the Menjú System. Several interviews were also undertaken with water managers (presidents of estates, societies and communities of irrigators) and also other irrigators, in order to perceive their opinion on the future of these historical irrigation systems. With this information, we undertook a diagnosis of strengths-weaknesses-opportunities-threats (SWOT), regarding irrigators and orchards. We had the opportunity to be in contact with experts in hydraulic and agronomic heritage, who seek to construct agricultural practice models, such as those of the Menjú System, recognized as a Globally Important Agricultural Heritage System (GIAHS)[6].

The initial hypothesis is evidently correct; a crisis exists concerning the historical irrigation system, which even involves farms being abandoned, even though the water resources and heritage to sustain it still exist. Among the paramount objectives of the research are to present a model of perennial water diversion in a river such as the Segura River, to highlight the management of water for irrigation carried out by Heredamientos (estates with inherited rights), Water Societies and Irrigation Communities, to make a prognosis of the sustainability of these irrigation systems, with proposals for improvement to adapt and facilitate their continuity and future in climate change scenarios.

RESULTS

The Menjú hydraulic system is organized with reference to a dam on the Segura, which retains and raises the water to a sufficient height so that it can

enter through the open intake to the extreme left end of the dam. Here the Abarán Canal initiated, which since 1805 has been the section that joins with the Blanca Canal, but which after the Molino Papel Division, divides once again to form the Principal Abarán and Principal or Mayor Blanca canals. The height of water created by the dam also made it possible to open the Charrara Canal intake on the right bank in 1727 (Figure 2).

The Report for the 1933 Hydrological Plan, describes the Menjú dam: "The Menjú Dam is located 215.65 kilometers from the source of the Segura River, in the Cieza area, but very close to the Abarán area. It is made of planks and dry stone, and stands at a height of one meter above the river bed. Two irrigation ditches emerge from this dam, one on each bank; these irrigate the Abarán and Blanca areas and some of the Cieza area, where it is located" (Arévalo, 1933). The water course on the left bank was thus described in 1933: "From the dam and on the left bank, the Abarán and Blanca irrigation ditch emerges, which runs first through the Cieza area for about 100 meters, crossing the Rambla del Moro by means of an aqueduct and then enters the Abarán area, where it irrigates directly and also by means of lifting devices. On reaching the paper mill, the irrigation ditch forks into two channels, known as the Principal de Abarán and Principal de Blanca, respectively. The Blanca irrigation ditch takes two thirds of the flow and the Abarán irrigation ditch the remaining third. The Abarán irrigation ditch tails off in the Barranco de La Carraila, where the Resurrección's propulsion engines are located. The Blanca irrigation ditch ends in the river, near the Solvente dam" (Arévalo, 1933) (Figure 3).

Source: authors (15-03-2023).
Figure 2. Azud del Menjú dam on la Vega Alta of the River Segura (Cieza).

Source: authors (30/11/2017).
Figure 3. Paper Mill diversion on the left bank of the Segura, Las Canales neighborhood.

From these channels (ditches) using a system of gates, opened and closed with planks, the land situated below the level of the ditch is irrigated; these constitute on-foot irrigation systems, using a gate or below a "ditch". Land above the level of the ditch is irrigated with water raised by traditional devices such as hydraulic wheels (Banegas and Gómez, 1992) and also by propulsion motors, consisting of irrigation by elevation. In the water wheel census for agricultural use in 1929, 62 devices were included in the Azud del Menjú to the Azud del Solvente. Of these, 38 were water powered irrigation wheels, with some hand pumps; these raised water from the Abarán and Blanca ditches, on the left bank of the Segura (Figure 4); on the right bank, 21 devices were connected to the Charrara irrigation channel and 3 to the turbine of the Noria and Campillo heritage (Gómez, 2012). Some of these are still in operation (such as those of D. García, la Grande, Candelón and Ñorica; all in Abarán), declared a site of cultural interest, in the category of place of ethnographic interest (Official Bulletin of the Region of Murcia-BORM, 163, 2016).

Procedures undertaken by "entrepreneurs" interested in irrigation and the availability of technological improvements such as electric motors, resulted in a large part of the traditional devices being replaced by motors by the end of the 19th century and during the first decades of the 20th century (Gómez, 1983; Gómez, 1983a). Having greater propulsion power, these motor pump conglomerations permitted more water to be pumped to a greater height. Irrigation societies were created with initiatives such as the Motor Resurrección. In 1912, the Estate of the Main Ditch of Abarán, yielded a flow of 200 liters/

Source: authors (15/03/2023).
Figure 4. Diversion towards the joint section of the Abarán and Blanca irrigation ditches, on the left bank of the Segura (Menjú-Cieza).

second, to be propelled to a geometric height of 134.10 meters by this motor, so as to irrigate more than 600 hectares of dry land of Casa Alcántara, Casa Matías, Barranco Molax, Casa Pelona, Hoya del Campo, Casa Marín, Cañaicas; places in the northeast of the Abarán municipality and far from the narrow reach of the river valley (Gómez, 2012).

In the Water Registry of the Segura Basin, in February 2008, the Acequia Charrara diversion was recorded as having existed since 1727, directly from the right bank of the Segura River, flowing as a result of gravity and taking advantage of the elevation of the water that occurred at that point thanks to the Menjú Dam (Figure 5). This would reach a flow of 3.7 cubic hectometers per year to irrigate a crop surface of more than 500 hectares (that is, a maximum flow of 600 liters per second, approximately 7,525 cubic meters per hectare, per year). Along its route of approximately 9.5 kilometers, it had two historic low-flow water wheels that are still operating; the Candelón and Ñorica wheels.

In order to avoid replacing the weir used by the Blanca irrigation canal in Las Canales, which was destroyed in 1805 by a catastrophic flood that eliinated several weirs, in 1807 an agreement was reached between the estates of the Abarán and Blanca irrigation canals, to share the Menjú weir. Francisco Lician (a hydraulic works expert) was hired to expand the Peñasco mines and facilitate the passage of a greater volume of water through the section of irrigation canal connecting the Menjú and Las Canales. A water division was established between the two irrigation canals at the exit of the mines. He also designed a low-flow water-

Source: authors (11/03/2023).
Figure 5. Diversion of the Charrara Canal, on the right bank of the Segura (Menjú-Cieza).

elevating wheel, La Noria Grande, which began to operate in 1807 (Figure 6). In the Las Canales area, the Molino de Papel industrial complex (paper mill, fulling mill and industrial sawmill) would also be developed, using water to create the energy (Gómez, 1991).

Source: authors (20/10/2017).
Figure 6. Low-flow waterwheel in Abarán, the Great Waterwheel or the Paper Mill.

In 1850, irrigated land in the Segura river valley, in Abarán and Blanca consisted of 123 hectares; 44.77 and 78.26 hectares, respectively (Madoz, 1850). Most of this area was located on the left bank, and more than two thirds was irrigated by irrigation ditches.

One hundred and thirty years later, in 1980, 1,050 hectares were irrigated in Abarán with water from the Segura River and 375 in Blanca. Most of the land was irrigated by elevation; in the first area production predominantly consists of stone fruit trees with citrus trees in the second (Gil and Gómez, 1985; Avellaneda *et al*, 1983).

Today, in 2023, 1,190 hectares are irrigated on the left bank of the Segura, managed by 1,320 irrigators (Table 1). However, most of this corresponds to irrigation on the part of the Resurrección Motor and to Group 1,485, located outside the valley, in backcountry areas such as Hoya del Campo, Venta de la Aurora, Vergeles, Rellano, etc.

An analysis of traditionally irrigated areas, on the right bank of the Segura in 2023, estimated to be an irrigated area of 490 hectares, managed by 1,192 irrigators (Table 2).

The structure of the agricultural holdings irrigated by the Menjú System shows the predominance of small farms of less than 1 hectare. On the right bank of the river, using irrigation by elevation, more than half of the irrigable area (55.33%) and five sixths of the irrigators (92.06%) correspond to farms of less than 1 hectare. Only the Triunfo Motor community and the Noria and Campillo communities have farms and irrigators within the irrigable area that combine farms of more than 5 hectares (Table 3).

On the left bank of the Segura, in the municipality of Abarán, the two irrigation communities with the largest farms are Motor Resurrección and Group 1,485, both with most of their irrigable surface outside the narrow limitations of the

Table 1. Irrigated land on the left bank of the Segura (section between the Menjú dam and the Ojós dam), in the Abarán and Blanca areas.

Community	Areas (ha)	%	Irrigators (number)	%
Noria de la Hoya de D. García	41.40	3.48	54	4.09
Motor San Pablo	14.00	1.18	42	3.18
Noria Grande or the Paper Mill	1.10	0.09	6	0.45
Motor Resurrección	640.50	53.82	663	50.23
Motor Group 1485	220.00	18.49	260	19.70
Motors of the Blanca Acequia (El Progreso, Saque and Navela, etc.)	212.90	17.89	190	14.39
On foot irrigation, using gates below a ditch	60.10	5.05	105	7.96
Total	1,190.00	100.00	1,320	100.00

Source: self-elaborated (01-03-2023).

Table 2. Irrigation on the right bank of the Segura (Abarán and Blanca terminals).

Community	Areas (ha)	%	Irrigators (number)	%
Noria de Candelón	1.68	0.34	15	1.26
Virgen del Oro Motor	108.22	22.09	263	22.06
Calvo Sotelo Motor	28.00	5.72	125	10.49
Ñorica	0.80	0.16	1	0.008
Santa Cecilia Motor	24.00	4.90	139	11.66
Asunción Motor	47.00	9.59	162	13.59
El Llano Motor	1.50	0.31	10	0.84
Triunfo Motor	138.00	28.17	195	16.36
Corona Motor	36.00	7.35	104	8.72
Barranco or the Conde Motor	20.01	4.08	17	1.43
Noria and Campillo Estate	68.50	13.98	82	6.88
On foot irrigation, using gates below a ditch	16.20	3.331	79	6.63
Total	490.00	100.00	1,192	100.00

Source: self-elaborated (01-03-2023).

river valley. They have two large elevated water areas, fed from the tail of the Abarán Main Ditch, at a height of more than 140 meters, to Cabezo del Piricú or La Mina; from that summit, the water of the Segura reaches the land of places including Casa Alcántara, Barranco Molax, Hoya del Campo, Vergeles, Venta de La Aurora, Balsa Redonda, Casa Marín by gravity, etc. (Figure 7).

On the left bank, but in the Blanca area, the use of water for irrigation, for farms exceeding 5 hectares, by the I.C. (irrigation canal) of the Acequia de Blanca Estate (including those irrigated by the Motor Progreso) and above all, by the I.C. of Zone II (Blanca) of Vegas Alta and Media, (Table 4), also mainly outside the Segura valley.

Table 3. Structure of farms in the Menjú elevated irrigation system on the right bank of the Segura River.

Community	<1ha		From 1 to 3 ha		From 3.01 to 5 ha		From 5.01 to 20 ha		Total	
	Irrig	Area	Irrig	Area	Irrig	Area	Irrig	Area	Irrig	Area
Motor Calvo Sotelo	122	21.00	3	7.00	-	-	-	-	125	28.00
Virgen del Oro	249	72.82	12	26.30	2	9.10	-	-	263	108.22
Motor Santa Cecilia	136	20.55	3	4.45	-	-	-	-	139	25.00
Motor Asunción	155	35.30	7	11.70	-	-	-	-	162	47.00
Motor El Triunfo	159	51.79	29	44.65	3	10.74	4	31.72	195	139.90
Motor Corona	94	20.50	10	16.30	-	-	-	-	104	36.80
Noria y Campillo	70	28.40	6	10.19	1	4.00	5	26.00	82	68.59
Total	985	250.36	74	120.59	6	23.84	9	57.72	1,070	452.51
%	92.06	55.33	6.54	26.65	0.56	5.27	0.84	12.75	100	100.00

Source: self-elaborated using surveys from 31-12-2022.

Source: authors (29/10/2016).
Figure 7. Electric motors of Group 1,485.

The I.C. of Zone II has among its water resources, a supply of water from the Segura (in the form of traditional irrigation), to which groundwater is added (especially from the Ascoy-Sopalmo aquifer, which was initially used for new irrigation projects). Since 1980, this has also been supplied by water from the Tajo-Segura Transfer, to which is added recycled water from the Blanca Wastewater Treatment Plant (WWTP). Given the decrease in water transfers from the Tajo Basin in recent years, the water mix has had to be topped up with desalinated water (Table 5).

Rich biodiversity is characteristic of crops grown in the Ricote valley. Along with aerial crops, soil crops are also grown (vegetables and tubers, aromatic and medicinal plants, etc.), all adapted to the eco-topological conditions of the

Table 4. Layout of farms in the Acequia de Blanca Estate irrigated by the I.C. of Zone II (Blanca) Vegas Alta and Media (high and low).

Area	Ac. Blanca Estate				Zona II (Blanca)			
	Irrig	%	ha	%	Irrig	%	ha	%
Less than 1 ha	6	31.58	3.54	1.46	225	46.78	107.34	3.63
From 1 to 3 ha	2	10.53	4.11	1.69	121	25.16	215.88	7.27
From 3.01 to 5 ha	2	10.53	8.57	3.53	36	7.48	145.03	4.90
From 5.01 to 20 ha	6	31.58	46.01	19.94	69	14.34	658.90	22.26
20.01 or more	3	15.79	180.70	74.39	30	6.24	1,832.76	61.92
Total	19	100.00	242.92	100.00	481	100.00	2,951.91	100.00

Source: self-elaborated from interviews undertaken 31/12/2022.

Table 5. Origin of water used in the I.C. of Zone II (Blanca) Vegas Alta and Media.

Origin	Volume (m^3)	% in terms of origin	Media (m^3/ year)
Water from Segura rivers	21,319,077	50.94	4,263,815.4
Trasvase Tajo-Segura	10,066,799	24.05	2,013,355.8
Aquifer wells	4,625,001	11.05	925,000.2
Recycled water (EDAR)	1,955,000	4.67	391,000.0
Assignment of rights and drought wells	2,224,833	5.32	444,966.6
Desalinated water	1,662,983	3.97	332,596.6
Total	41,853,693	100.00	8,370,738.6

Source: self-elaborated, with data from the I.C. of Zone II (Blanca) of the Vegas Alta and Media, during the 2016-2020 period.

river valley and surrounding area and to historical cultural practices, which constitute the typical identity of the Moorish orchards. In terms of landscape, in the irrigated oases that dot the Betic relief, the date palm (*Phoenix dactylifera* L.) stands out as a predominant image along with the low-flow water wheels (azudas and norias).

In the geographical area of the Menjú System, among the range of uses, evidently soil crops predominate in the case of on-foot irrigation, whereas in the groves, corners and terraces close to the river's course and dispersed throughout the area, there are date palms, orange, lemon, pear and medlar trees, etc. (Figure 8).

Source: authors (29/03/2023).
Figure 8. Soil crops with some aerial species in Cañada de Hidalgo, on the right bank of the Segura (municipal district of Abarán).

In the elevated irrigation system that has dominated the valley slopes (high river terraces and slopes), crops such as citrus and fruit trees predominate. In terms of their distribution, orientation is very important. If altitude reduces the risk of inversion frosts, orientation towards the sun favors ripening. Thus, in the sun of Sierra del Oro, early varieties of stone fruit are grown, which are put on the market a few days or weeks earlier. In Abarán, at a higher altitude and further north, where there are more hours of cold, stone fruit trees such as apricot and peach trees predominate (Figure 9). In Blanca, citrus trees are most common, especially lemon trees of the "Berna" and "Fino" varieties.

Varieties of citrus fruits, which must be Valricotes are still found here, as currently these are not found outside this area. These are citrus varieties that stand out for their aromatic properties, such as the bergamot (*Citrus bergamis L.*) and the citrus lemon (*Citrus médica L.*). The former is very aromatic, with a flattened lemon shape and very smooth skin. These are traditionally used in confectionery and even perfumery, as is the lemon, which is highly sought after by confectioners (Rivera and Obón, 1998) (Figure 10).

DISCUSSION

Concerning the social organization of water distribution for irrigation, usage has been established in Water Estates, in Civil Property Societies and in Irrigation Communities. Distribution includes all those estates that receive water from the same intake, thus, in the Menjú System, on the right bank of

Source: authors (15/03/2023).
Figure 9. Stone fruit trees in bloom, in the San Pablo Motor irrigation system in the Hoya de D. García, on the left bank of the Segura (in the municipality of Abarán).

Source: authors (29/03/2023).
Figure 10. Date palm and citrus lemon tree, irrigated by flooding with water from the Segura, by means of the Charrara Canal.

the Segura River, one Estate consists of Users of the Charrara Ditch. In this case, the Civil Property Societies consist of groups of irrigators interested in elevating water for irrigation; an example is the Asunción Society. As regards the Irrigation Community, Water Law 29/1985 designates this as an organization that directs the collective uses of public waters that they share –both surface and underground –; for example the I.C. of Virgen del Oro.

Article 81 in the Revised Text of the Water Law (RTWL) specifies that "irrigation communities consist of organizations that have the autonomy to draft and approve their Statutes and Ordinances and to exploit public benefits inherent to their use". Researchers Giménez and Palerm, 2007, affirm that these are autonomous and represent an example of functional decentralization; the State does not appoint their representatives, nor does it finance them (Giménez and Palerm, 2007). In a recent work by Gómez *et al*., 2022., they indicate that if the State protects them, "The Hydrographic Confederations will ensure they comply with statutes and ordinances" (Gómez *et al*., 2022).

This diagnosis manifests itself in the SWOT matrix (Table 6). In summary, weaknesses consist of: W1. Limited arable land; W2. Difficulties presented by the terrain; W3. Small farm size; Threats: T1. Low farming profitability; T. Fluctuations and increases in energy prices; T3. Expansion of urban land, at the expense of orchards. Strengths: S1. Availability of ample, good quality water; S2 Rich natural and cultural heritage; S3. Landscape variety and biodiversity. Opportunities: O1. Existence of funds for re-evaluating heritage; O2. Technology and energy efficiency; O3. Political and social support for the GIAHS proposal.

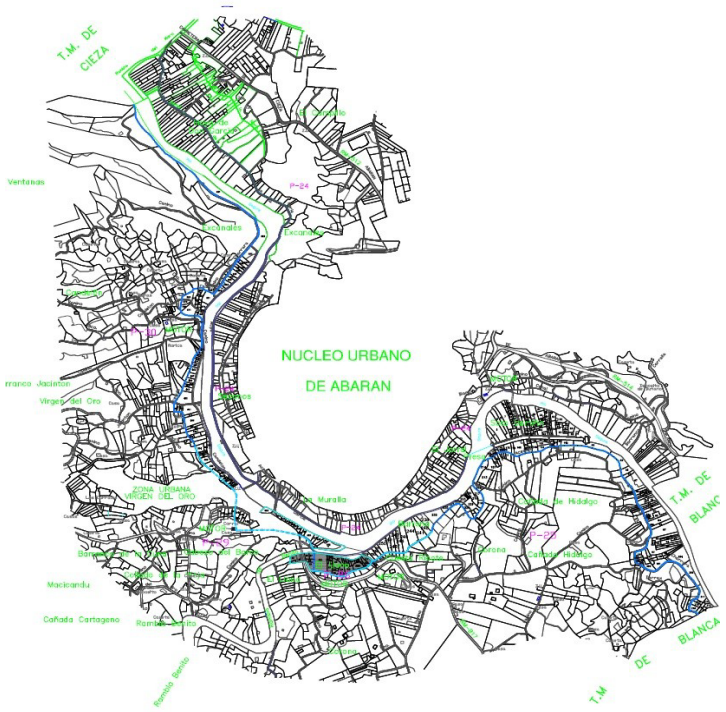
Table 6. SWOT analysis of landscape and heritage in the Ricote Valley.

Weaknesses	Strengths
The layout of the relief and the course of the Segura River create an asymmetrical river valley in the shape of a rosary, where there are narrows and basins or hollows that necessitate compartmentalization into various systems of dams and irrigation ditches.	Availability of ample, good quality water for the rosary of orchards in the river valley and for the Ricote orchard-oasis.
The steep slope of the river valley's hillsides requires terracing (with dry stone walls) and pumping to raise the water with electric motors, requiring energy expenditure.	Rich natural and cultural heritage, with characteristic features such as low-flow wheels (azudas-norias) and dry stone walls (hormas).
The small size of most agricultural holdings results in limited supply of products and does not allow for full-time dedication on the part of the farmer-irrigator.	Traditional Moorish cultural landscape, with aerial crops and soil of ethnobotanical interest that promote biodiversity
Threats	**Opportunities**
Abandonment of agricultural plots due to the low profitability of the crop. Reduced participation, resulting in greater expenses to be shared between heirs and commoners.	Investments to recover the hydraulic and cultural heritage of the Ricote Valley, using funds such as Next Generation EU.
Fluctuations and increases in energy prices, accounting for more than half of the total operating costs of irrigation by elevation	Development of energy efficient projects for the Rural Development Programs in the Murcia Region (as contemplated in the 2014-2020 RDP)
Expansion of urban centers at the expense of orchards, with the consequent loss of fertile areas and hydraulic heritage.	Initiative which proposes the Ricote Valley as a Globally Important Agricultural Heritage System (GIAHS).

Source: self-elaborated.

In recent years, the agro-social systems created by the Menjú hydraulic complex (dam-ditches) for irrigation on both banks of the river have presented weaknesses and threats that have led to a significant reduction in irrigated area. This has happened with the Noria Grande or Molino Papel Estate, which irrigated more than 18 hectares in the mid-twentieth century due to the urban expansion of the Abarán nucleus, extended at the expense of the orchard, leaving scarcely more than 1 hectare under cultivation, causing the agricultural holdings in places such as Cañada de Morzaletes and Bajo Solana to disappear (Figure 11).

Likewise, urban expansion in the Blanca core and the Azud de Ojós reservoir basin have eliminated a large part of the irrigated area under the Huerta Baja de Blanca irrigation ditch. This is the case in the irrigated area of the Ciecón or the Molino and that of the Rival irrigation ditch and even part of the Bayna orchard has experienced the disappearance of the old agricultural holdings, as they have been converted into service areas, such as the Municipal Sports Centre and the Parque de las Cuevas (Molina and Gómez, 2016) (Figure 12).



Source: authors (April, 2023).
Figure 11. Plan showing plots of irrigable land in the Segura river valley in the municipality of Abarán.

An increase in energy prices makes many traditional irrigation projects with electric motors economically unsustainable. In 2022, some of these irrigation companies paid 0.40 euros per cubic meter of water, more than half of which corresponded to the cost of electricity.

Modernize of irrigation is crucial (more than 1.5 million hectares have been modernized in Spain in the last fifty years); however preserving the heritage of traditional irrigation infrastructures and their functionality has occurred as part of the modernization carried out by the Ricote Irrigation Community (Baraja *et al*., 2006; Gómez, 2019).

Among the strengths and opportunities, it is worth highlighting the availability of quantity and quality water (from surface resources of the Segura Basin) with allocations in terms of irrigation concessions, ranging from 4,500 m3/ha/year, up to 7,500 m3/ha/year. The regulatory fee for the Segura Basin is affordable, with a cost of 14.44 euros/ha/year, for traditional irrigation ,prior to 1933 and 15.49 euros/ha/year, for those joining after 1933 (BORM, 2022). It is also worth highlighting the value attributed to hydraulic infrastructures and irrigated cultural landscapes, which form an attraction in terms of water

Source: authors (20/10/2017).
Figure 12. Blanca's low-lying orchard threatened by urban expansion and the Azud de Ojós reservoir.

routes, itineraries and hikes that attract visitors, such as the norias route or the route of flowers (Gil *et al*., 2020).

From the Azud del Menjú to the Azud de Ojós, there is a network of hydraulic infrastructures (ditches, irrigation equipment, waterwheels, water pumping motors, aqueducts, siphons, etc.), which have been used to distribute the waters of the Segura River and create cultural landscapes of discontinuous and terraced irrigation, such as the Valricotie orchards (of Moorish origin). There is rich material heritage declared as a Site of Cultural Interest (BIC) that includes the water wheels, which combines with intangible knowledge of agricultural practices and about the biodiversity of crops, pertinent for aspiring to the System of Global Importance of Agricultural Heritage (GIAHS). These are aspects that the Food and Agriculture Organization of the United Nations (FAO) have already recognized in more than 60 places around the world.

CONCLUSIONS

Maintaining these applications and the landscapes generated requires seeking to make them sustainable for their users, posing challenges. One of these is the need to improve water storage, at the level of societies and communities of irrigators. On the right bank, only the Virgen del Oro Irrigation Community has two large-capacity reservoirs (70,000 m^3 between them) and some irrigators of the Triunfo and Asunción Motors have their own reservoir. On the left bank, Motor Resurrección and Group 1,485 have large reservoirs (Moaire, Asomada and Casa Alcántara), but these are insufficient to fulfill the

pressure requirements for local irrigation. There is a need to limit pumping and boost electricity during the hours of lowest cost (in 2022, this accounted for more than half the hourly cost of water and caused an increase in non-payments for irrigation distribution). In addition to reservoirs that dictate the irrigable perimeters, energy saving measures are necessary, in the form of power inverters, installations that avoid losses throughout the networks, while moving towards self-consumption, by using small photovoltaic energy parks, for example.

The size of the farms (small ones predominate) reduces the volume to be marketed after the harvest, meaning that production must be directed to nearby markets. Bureaucracy that has been imposed because of the need to assess product traceability; however long distances prohibit many traditional farmers from being able to market, as well as leaving them defenseless against marketing agents. Cooperative methods related to the creation of brands to identify these products can serve to increase their value (origin, quality, etc.) and make them more profitable. Production from most farms does not allow full-time dedication on the part of the farmer-irrigator and current production scarcely enters into foreign marketing circuits (exports). To encourage the preservation of these cultural landscapes and agro-social systems, the proposal for Globally Important Agricultural Heritage Systems (GIAHS) should contribute to the validity of local products and the tangible and intangible heritage of the cultural landscapes of the orchards of the Ricote Valley in the Vega Alta del Segura.

These constitute proposals for procedures that will benefit the environmental, social and economic sustainability of the weir-ditch model, with the aim of maintaining the orchards, while complying with the model for rural landscapes of heritage and cultural interest.

NOTES

[3]More than 300,000 Moors moved to Tunisia, of these more than 50,000 left after the expulsions of 1609, 1610 and 1613. Moorish character is evident in the management and handling of the orchards of Testour (Tunisia) (Vilar, 2011-2013).

[4]These are masonry works consisting of regularised vertical walls. Their stability is guaranteed through an adequate choice and installation of stones, which is why it is important that the stone mason makes an in-depth study when matching and and assessing the balance of each stone, combining them in copliance with their different sizes. In this way, greater stability, functionality and aesthetics are achieved (Gómez, 2023). This ancestral craft of dry stone wall construction (stone masonry) was declared Intangible Cultural Heritage of Humanity. On December 22, 2022, this was declared an Asset of Cultural

Interest (BIC) of intangible nature in the Murcia Region (BORM, 204, 2022, 46065).

[5]The cultural landscape is the result of the interaction between people and the natural environment over time; its expression is perceived and valued in this territory for cultural qualities, as the product of a process, which fortifies the identity of a community (Cruz, 2017).

[6]GIAHS, are agrosystems inhabited by communities living in an intrinsic relationship with their territory. These constantly evolving sites are resilient systems characterized by remarkable agricultural biodiversity, traditional knowledge, cultures and invaluable landscapes, managed sustainably in such a way that they contribute to livelihoods and food security

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