AG-WaMED | Advancing non conventional water management for innovative climate-resilient water governance in the Mediterranean Area

Watershed management plan - Spanish LL

Partnership for Research and Innovation in the Mediterranean Area Programme (PRIMA)
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1.1 Description of river basin characteristics

• *Location and boundaries of the basin*

The Campo de Cartagena irrigation district is in the southern Murcia region in southeastern Spain. It is part of Hydrographic District XI, covering 1,602 km², which belongs to the Segura River basin (20,000 km²). The Comunidad de Regantes del Campo de Cartagena encompasses an irrigable area of 42,435 ha with 9,699 members, extending across the municipalities of Cartagena, Fuente Álamo, Los Alcázares, Murcia, San Javier, San Pedro del Pinatar, and Torre Pacheco in the province of Murcia, and El Pilar de la Horadada in the province of Alicante.

It is upstream of Mar Menor, an environmental protection area that contains several wetlands and a salt lagoon of international importance catalogued and protected under different figures (RAMSAR, Special Protection Area for birds). In addition to its environmental importance, it supports numerous socio-economic activities. The Campo de Cartagena area has a population of 363,000, representing 24% of the Murcia region to which it belongs. The study area has a semi-arid Mediterranean climate with an average annual rainfall of 300 mm and an average annual temperature of 18 ºC. Additionally, its geographical location provides ample sunlight, which benefits agricultural development.

• *Status of Surface Water Bodies and Aquifers*

The Segura Basin covers most of the area encompassed by the Segura River Basin District. However, the Campo de Cartagena irrigation district lies outside the Segura River basin, encompassing several watercourses draining to the Mar Menor, of which the main one is the Albujón “Rambla”. All are dry most of the time, except for the Albujón, which in its final stretch drains the shallow Quaternary aquifer and discharges a permanent flow into the lagoon.

The status of surface water bodies in the 2015–2021 River Basin Management Plan (RBMP) was deemed moderate. The objective of achieving good status by 2021 was deemed unachievable. Specifically, the Albujón “Rambla” is classified as a highly mineralised Mediterranean river. Additionally, water from irrigation drainage ditches has a high salinity and cannot be used for irrigation. Deeper water from wells, which generally has less salinity, is rather used, mixed with higher-quality water. The situation has not improved. According to the most recent 2022–2027 Plan, a good ecological status hasn’t been achieved (RBMP, Environmental Status). An extension until 2027 has been granted by the European Union owing to technical limitations and natural conditions that prevent good ecological and chemical status.

• *Status and Quality of Groundwater*

The Campo de Cartagena aquifer is multilayered, with a complex structure, and the upper level – Quaternary – is the one that drains into the lagoon. Groundwater resources associated

with the Campo de Cartagena aquifer are estimated to be overexploited. However, overexploitation varies according to aquifer levels and years, with a close relationship with the availability of the Tagus-Segura transfer. Figures from Segura Basin Authority and IGME-CSIC, suggest that around 25 hm^3/yr have been pumped in recent years, of which about 5 hm^3/year are from the shallow Quaternary layer. This figure may reach values as high as 50 hm^3/yr in some years. The quality of these aquifers, already deemed poor in the 2009 River Basin Management Plan (RBMP), remains like the current situation (2022/27 RBMP). Significant concentrations of nitrates, chlorides, and sulfates were observed, indicating lack of control of fertilizer use in the past. The origin of salinity can be linked to several reasons: persistent effect of past marine intrusion, evapoconcentration process, impact of the rejection of desalination plants, among other. Saltwarer intrusion was produced before the water transfer, during the decades of 1960s and 70s, but now is believed to be controlled. There are no current processes of marine intrusion in the Quaternary aquifer. Given that achieving good chemical status by 2039 is unlikely without disproportionate costs (such as a complete halt to agricultural activities), 2027 has been set as an interim target for reducing nitrate concentrations in groundwater.

• The *Presence of Conventional and Unconventional Waters*

The Campo de Cartagena irrigation district uses more water than is locally available from conventional surface and groundwater sources. Consequently, the supply of non-conventional water is crucial. The allocated water from surface sources in the Segura basin is 4 hm^3, but the real contribution varies according to the situation. This is a negligible figure compared to the needs of the area, which is supplied by non-conventional water sources, such as desalinated water, regenerated water, and water from the Tajo-Segura transfer in varying magnitudes from year to year. Thus, the water resources for the Campo de Cartagena irrigation district come from the Tajo-Segura transfer (31 hm^3 on average) and wastewater treatment plants (6 hm^3). Additionally, water is sourced from the Torrevieja desalination plant (33 hm^3) (CRCC Memoria 2019/20).

• The *Complexity of Water Management*

The CRCC carries out a joint and coordinated exploitation of all available resources, including reclaimed and desalinated water, by mixing it in the Main Canal of the Campo de Cartagena. This management approach allows the use of groundwater from the Campo de Cartagena and from the wastewater treatment plants of Los Alcázares, San Javier and San Pedro del Pinatar, which have electrical conductivities that are not suitable for irrigation. This approach encourages the improvement of agricultural production and the reduction of the contribution of salts to the soil. If low salinity flows (Tagus-Segura Transfer and desalinated water) were not available, groundwater and reclaimed water could not be applied to irrigation, and would reach the Mar Menor in many cases, with the environmental damage and social alarm that this would generate. Figure 1 shows the evolution, from the hydrological year 2005/06 to 2022/23, of the different water sources jointly distributed by the CRCC.

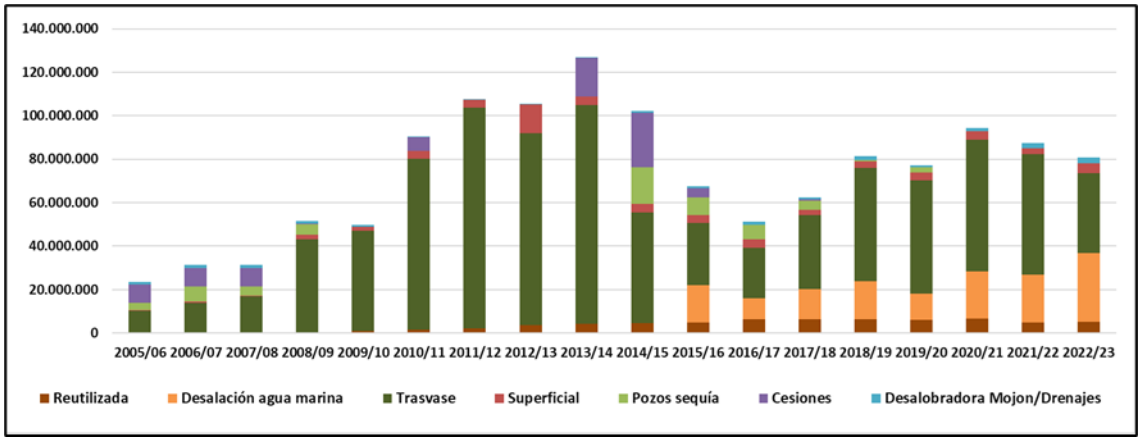

Figure 1: Evolution of the water sources distributed by the CRCC

The water from the Tagus-Segura Transfer, with high Ca and Mg contents, zero or minimum levels of B, Na and Cl, affordable price and moderate associated greenhouse gas emissions, represents a basic pillar to effectively mitigate the problems associated with non-conventional resources (high cost, high concentration of phytotoxic ions, high associated emissions in desalinated water or high salinity in regenerated water). In this sense, the joint exploitation of desalinated water with all available resources, and especially its mixture with the waters of the Tagus-Segura Transfer, solves the main agronomic problems related to the physicochemical uniqueness of desalinated seawater (Martínez Álvarez and Martín Górriz, 2014).

1.2 Summary of human impacts and pressure

• *Main water uses by sector*

The primary use of water in Campo de Cartagena is agriculture, which is related to food production. The average water allocation for irrigation was 4,692 m³/ha/year, which equated to a total gross demand for 259 hm³/year. This amount is much larger that availability in some years in which water has barely been made available from the Tagus-Segura water transfer. Groundwater has been used in those years to supply irrigation. The predominant crops in the irrigated area, in order of importance, are vegetables (lettuce, melon, artichoke, and broccoli), citrus fruits (lemon, orange, and tangerine), and greenhouse crops (peppers). Nearly all crops used drip irrigation techniques (98%). This region has one of the most profitable irrigated agricultural operations nationally and across Europe, and is one of the largest and most developed irrigation districts in Europe.

The Comunidad de Regantes del Campo de Cartagena covers an irrigable area of 42,435 ha with 9,699 members. The distribution infrastructure includes the main Campo de Cartagena Canal, which is 64 km long, and transports and distributes resources stored in the La Pedrera Reservoir to the main pipelines of each irrigation sector. The irrigated area comprises 33 irrigation sectors with 1,033 km of pipelines and 25 small reservoirs, with a total capacity of 2.5 hm³. It is one of the largest and most technologically advanced organisations in Europe. Modernisation has enabled precise control of the water used by each member, allowing irrigators to manage their irrigation via the internet or mobile phones.

The agricultural structure has many small- and medium-sized farms, and large enterprises and cooperatives dedicated to exporting to Central and Northern European countries (Germany, the United Kingdom, France, and the Netherlands). Land consolidation by the state and private sector has led to a reduced number of large farms (over 50 hectares), but these occupy a larger territorial area.

The other two uses of water are domestic and industrial. Urban water is mostly supplied by the “Mancomunidad de Canales del Taibilla”. The city of Cartagena alone has a gross urban water supply of 304 L/eq-person/day, which translates to a total annual demand of 27.67 hm³. Meeting the urban water demand in Campo de Cartagena, particularly in the city of Cartagena, presents a unique challenge. The region relies on a combination of desalinated water and water transferred from the Tajo-Segura Aqueduct. Regarding the industrial sector, the municipality uses 1.92 hm³ of water annually for industrial purposes.

• *Flood Risks*

In the study area, four zones with a significant risk of flooding were identified, primarily around Mar Menor. These floods can be either fluvial or pluvial. The region experienced numerous flood-related incidents between 2005 and 2019. The episode of December 2019 was particularly acute, with over 100 mm falling on Campo de Cartagena in a very short time. The risk is particularly concentrated around municipalities and urban areas near Mar Menor, notably in the municipality of Los Alcazares, which is the one that has suffered the most important floods, repeatedly, during the last two decades.

• *Sources of Pollution*

Despite its economic prosperity, intensive agriculture in the Campo de Cartagena, particularly near the Mar Menor Lagoon, poses a major environmental threat. The excessive use of fertilisers in agriculture has led to contamination of groundwater resources by nitrates, resulting in diffuse pollution. This contamination poses a serious risk to the ecological balance of Mar Menor, a fragile ecosystem of great ecological and economic value.

Furthermore, other sources of point-source pollution come from urban and industrial discharges, which exert significant pressure. Pollution is very intense in flash floods, since torrential rain causes the washing of all the pollutants that have been accumulating on the pavements in dry periods and drags them along the channels to the Mar Menor, producing a very pronounced peak of pollution.

Regarding diffuse pressures, nearly 90% of the surface water bodies of the region are subject to pressures related to agricultural use, with a particularly high percentage of irrigated land. Additionally, more than half of the surface water bodies (58.8%) face pressure owing to the presence of abandoned industrial areas. Another widely reported diffuse pressure source is associated with mining areas (50% of water bodies) and urban runoff (40.4% of water bodies), owing to the widespread distribution of population areas in the middle and upper parts of the basin (scattered rural areas).

However, protective measures are not properly implemented (for example, Sites of Community Importance, ecosystems included in the Natura 2000 Network, and Special

Protection Areas for Birds), and environmental degradation persists. As a result, Spain was sanctioned by the European Union for noncompliance with the Nitrates Directive on 2 July 2020. The anti-nitrate pollution plan implemented by the Regional Government has proven insufficient. The lack of coordination among different administrations is a barrier to finding and implementing sustainable solutions.

• *Drought Risks*

The Segura Basin has experienced four significant drought episodes: 1980–1983, 1993–1995, 2005–2008, 2015-2018 and the current episode. On 26 December 2018 Order TEC/1399/2018, published in the BOE, approved a revision of the Special Drought Plans for the Segura River Basin. This plan establishes the criteria for identifying drought conditions and measures to be taken. The measures implemented from 2015 to the present primarily focus on the use of new wells and the increase and granting of subsidies for the use of desalinated water, as outlined in the Segura RBMP Annex IV. In March 2024, the Segura River Basin District declared an exceptional situation of extreme drought in parts of the basin, including Campo de Cartagena. This declaration allowed, among other things, the opening of wells to obtain additional water.

1.3 Projected Water Scenarios

The available data produced by AG WAMED apply to the average annual flow of the Segura Basin, from which data for the Campo de Cartagena area can be derived. The results are summarised in the following table (units in km³/year). According to the SIMPA data, the average annual flow (AAF) for the Segura River Basin was 0.840 km³/year.

All models (H08 and CWatM) and scenarios (ssp126, ssp370, and ssp585) predicted that the average annual flow will decrease in the Segura basin over the years. The average annual flow, which was 0.920 km³/year from 1980–2019, is projected to range between 0.83 and 0.96 km³/year for 2020–2059 and between 0.59 and 0.83 km³/year for 2060–2099. This represents a reduction of between 16% and 40%.

Table 1. Scenarios in Segura Basin

Scenario	obsclim 80-19	historical 75-14	ssp126 20-59	ssp370 20-59	ssp585 20-59	ssp126 60-99	ssp370 60-99	ssp585 60-99
gswp3	0.92							
gfdl		0.96	0.85	0.92	0.70	0.71	0.66	0.60
mri		1.00	1.32	0.88	1.00	1.19	0.93	0.74
ipsl		0.98	0.78	0.79	0.67	0.69	0.53	0.41
mpi		0.95	0.79	0.85	0.81	0.76	0.71	0.63
ukesm1		1.04	1.07	0.87	0.97	0.80	0.58	0.60
mean	**0.92**	**0.99**	**0.96**	**0.86**	**0.83**	**0.83**	**0.68**	**0.59**

Sources: AG WaMED project, 2024.

For all the models and scenarios, the absolute values and rates of change were similar up to 2040. From 2040 to 2080, availability depends on the scenario. For the least conservative

scenario (ssp126), both models show that water availability remains stable from 2040 onwards. For the other scenarios, availability shows a more significant reduction, being higher for the most conservative scenario (ssp585). The H08 model shows a greater reduction for the same scenarios (ssp370 or ssp585) than the CWatM model.

For the Campo de Cartagena area, the reduction in contribution (in terms of AAF) was approximately 55% for the long-term scenario ssp585 compared to the historical scenario. The potential water availability for the historical scenario and for the long-term scenario ssp585 were approximately 15% and <10% of the AAF in the same scenario, respectively. However, Campo de Cartagena is not fully exposed to these changes in average annual flow because the water used for irrigation is not sourced from local flow, but from numerous non-conventional sources. Nevertheless, water from the Tajo-Segura transfer has likely been reduced to zero in the past few decades. Thus, Campo de Cartagena needs to adapt by irrigating with the non-conventional resources it can generate, along with their cost and quality.

Recent modeling conducted using the SIMGES module of the Aquatool system—based on hydrological data from the SIMPA model—provides further evidence of the declining reliability of water transfers from the Upper Tagus Basin to the Segura (AG-WaMED, 2025). Results show that an increase in ecological flow requirements by 82 hm^3/year results in a corresponding reduction of 73 hm^3/year in transferable water. This discrepancy of 9 hm^3/year is attributed to increased evaporation losses, which stem from operating the reservoirs at lower levels due to higher releases within the Tagus basin. These operational constraints not only reduce water availability for the Segura Basin but also affect reservoir storage dynamics, further limiting system flexibility. For the Campo de Cartagena, these findings reinforce the structural shift away from reliance on the Tajo–Segura transfer, highlighting the urgent need to consolidate a long-term irrigation strategy based on non-conventional water sources.

1.4 Economic analysis

The Segura Basin contributes more than 3% of Spain's GDP. The Murcia region is one of the most productively irrigated areas in the country. In Campo de Cartagena, farmers employ business strategies aimed at international markets. According to the Segura Basin Authority, the total economic value of agricultural production in Campo de Cartagena was nearly €550 million in 2015. The most profitable crops include vegetables (lettuce, peppers, and melons), citrus fruits, and artichokes. The research work entitled "Economic valuation of agricultural activities in the Campo de Cartagena" (Del Villar, 2020) analyzes the economic importance of irrigation in the Campo de Cartagena. Its results reflect that irrigation-related activities in Campo de Cartagena are of utmost importance, since they generate a gross value added of almost €2.8 billion per year, employing some 47,400 full-time workers. This economic value represents 37% of the gross domestic product of the region. Other economic activities have developed around agricultural activities that have driven a process of growth and unique economic dynamism. This growth has been achieved through a constant search for efficiency and productivity, integrating suppliers and customers in various forms of collaboration. Thus, the value chain of the products has extended beyond production, encompassing distribution, marketing and agri-food industry activities in the area. The Campo de Cartagena also stands out for its significant investment in Research, Development and Innovation (R+D+i) processes, exceeding the national average in dedicated resources. This dynamism is unparalleled in other

parts of the Spanish territory, placing the agriculture of Campo de Cartagena and its associated industries among the most competitive in the world, and attracting investment in all related sectors.

Water is a crucial input to sustain the economy. However, determining the price is challenging because it varies with consumption levels, seasons, sources used, and production and transportation costs. Cost allocation is a highly complex issue, particularly in agriculture. In the Segura basin, there are nine different sources of water supply, both conventional and non-conventional. Farmers are required to pay not only for the water itself but also for the energy costs associated with pumping and for the amortization of internal infrastructure within irrigation communities, such as regulation reservoirs and distribution pipelines. Furthermore, explicit or hidden subsidies alter the overall cost structure. The variability in water supply from year to year further complicates the calculation of the amortization's impact on total costs. Additionally, there is flexibility for negotiation and trading of water usage rights among farmers, leading to significant disparities in the price of water across different areas within the basin. Within individual irrigation communities, costs can also vary widely.

In response to these complexities, the management plan developed under the AGWAMED project has opted to use the average water cost values outlined in the cost recovery annex of the Segura River Basin Management Plan. Table 2 provides the average water costs from various sources. The average unit cost in the basin is €0.47/m³, but it ranges from €0.70/m³ for desalinated water to €0.09/m³ for gravity-fed irrigation water. However, farmers do not bear the full cost, as some supplies are subsidized. The "real cost" column presents an estimate of the actual water cost for the agricultural sector. It is important to highlight the high cost of desalination, especially considering that it is one of the key solutions for improving water availability in the future. Despite its potential, the elevated cost of producing desalinated water, which can reach up to €0.56/m³, presents a significant challenge. This underscores the need for careful consideration of economic sustainability when integrating desalination into long-term water management strategies.

Table 2. Average water costs in Segura Basin Hydrological Plan

Proveniencia del agua	Tipo de uso	Utilización del agua		Costes de los servicios de agua							Ingresos			
		Agua servida	Agua consumida	Operación y mantenimiento	Inversión (coste anual equivalente)	Total	Ambiental	Total 2019	Coste 15/21	Coste unitario	Coste recuperado sobre 2019	% Recuperación		Coste unitario real
		hm3/a	hm3/a	M€/a				2019	2015	€/m3		2019	2015	€/m3
Servicios de agua superficial en alta	Agricultura/Ganadería	589,2	86,3	42,96	16,84	59,81	6,13	65,94	53,32	0,11	41,65	63%	53%	0,07
Servicios de agua subterránea en alta	Agricultura/Ganadería	8,2		1,74	1,21	2,95	0	2,95	0	0,36	2,95	100%	sd	0,36
Distribución de agua para riego en baja	Agricultura	788,2	645,1	33,17	16,72	49,89	19,72	69,61	72,63	0,09	34,48	50%	41%	0,04
Abastecimiento urbano en baja	Agricultura/Ganadería	0	0	0	0	0	0	0	0	0,00	0	sd	sd	0,00
Autoservicios	Agricultura/Ganadería	477,1	390,5	101,34	70,42	171,76	177,4	349,15	190	0,73	171,76	49%	41%	0,36
Reutilización	Agricultura/Ganadería	83,8	0	5,7	0,33	6,03	9,32	15,36	9,56	0,18	0,23	2%	3%	0,00
Desalinización	Agricultura/Ganadería	185	0	85,27	45,02	130,29	0	130,29	36,38	0,70	103,64	80%	77%	0,56
Recogida y depuración fuera de redes públicas	Agricultura/Ganadería/Acuicultura	0		0	1	1	0	0	0	0,00	0	sd	sd	0,00
Recogida y depuración en redes públicas	Agricultura/Ganadería/Acuicultura													
Totales	Abastecimiento urbano	200,5	52,1	231,82	102,8	334,62	53,4	388,02	328,49	1,94	308,53	80%	71%	1,55
	Regadío/Ganadería/Acuicultura	1343,3	1121,8	270,18	150,54	420,72	212,58	633,3	361,9	0,47	354,7	56%	45%	0,26
	Industria	20,2	10,9	36,01	14,45	50,46	13	63,45	63,83	3,14	36,8	58%	58%	1,82
	Generación hidroeléctrica	s.d.	s.d.	0	0	0	0	0	0	0,00	0	s.d.	58%	0,00
	Total	1564	1184,8	538,01	267,69	805,8	278,97	1084,77	754,22	0,69	700,02	65%	57%	0,45

Sources: Hydrological Plan 2022-2027 – Annex 09. Cost Recovery. Table 9 (pp. 28-29), Table 34 (p. 55), and Table 74 (p. 82).

Party II Medium and long-term strategy

2.1 Analysis of priority problems

• *Main Issues*

The main issues faced by the Campo de Cartagena irrigation district are as follows.

1. The sustainable and affordable water supply for irrigation in an equitable manner is currently compromised.

2. The current infrastructure does not adequately connect various non-conventional water resources of varying quality to irrigation networks.

3. Land use and productive activities, such as agriculture, tourism, and industry, lead to the pollution of soils, watercourses, and groundwater, and contribute to the environmental degradation of Mar Menor.

4. Fluctuations in water prices and changes in legislation complicate the organisation of agricultural activities.

• *Analysis of Priority Issues*

1. Securing water supply: Owing to the impacts of climate change, it is anticipated that this basin will experience a reduction in natural resources, which could compromise the reliability of the water supply. To ensure the sustainability of agriculture dedicated to food production, it is essential to provide sufficient water for irrigation. This water must be available in an affordable and equitable manner, considering the priorities and appropriateness of its intended use. The water-pricing structure must enable farmers to adapt while maintaining the profitability of agricultural production. In addition, the origin and management of water resources must ensure their sustainability.

2. Insufficient Infrastructure: It is crucial to have adequate infrastructure to connect resources, particularly unconventional resources, to irrigation water distribution networks. Despite the considerable efforts of farmers, supported by various public administrations, to modernise irrigation systems and optimise water use, there remains a lack of infrastructure to link resources from wastewater treatment plants or desalination plants to irrigation networks.

3. Pollution and Environmental Degradation: The delicate environmental situation of the Mar Menor requires measures with proven and quantifiable effectiveness to avoid arbitrary and/or subjective decisions that could compromise the economic viability of other activities. Improving the management of irrigation systems is crucial to reduce pollution, particularly diffuse pollution related to the use of phytosanitary products. Additionally, overexploitation of

groundwater can exacerbate the problems of marine intrusion. Many projects have been designed and commitments made by the State; however, they have not been implemented. Campo de Cartagena has significantly contributed to nutrient flow into the Mar Menor in the past, representing the most notable environmental impact in terms of agriculture and hydrology. However, the agricultural sector is not the only cause of the deterioration of Mar Menor. The latter has also been affected by pressures and impacts resulting from the growing urban and tourist development around the lagoon over recent decades. The expansion of urbanised areas has led to the loss of many natural habitats and unique ecosystems that are essential for the biological balance of the Mar Menor. Measures recently implemented in Campo de Cartagena have reduced substantially the amount of pollutants discharged into the environment by agricultural activity, but the problem will persist for many years due to the long residency time of pollutants in groundwater bodies. The CRCC has taken the following direct and indirect measures to reduce the level of pollution in the Mar Menor: using treated water from the wastewater treatment plants in the Campo de Cartagena to prevent it from reaching the Mar Menor; utilizing water collected by the capture infrastructures of the El Mojón Brackish Water Desalination Plant, which prevents large amounts of water from the water table or the Quaternary aquifer from reaching the Mar Menor; developing a plan for environmental monitoring and surveillance of groundwater extraction in the irrigated area of the Campo de Cartagena; and aiming to improve on-farm agricultural practices. These are just a few examples, as they are also committed to projects with various stakeholders to seek and implement solutions (such as the Polytechnic University of Cartagena and the European project AQUIFER). This effort should also be politically and financially supported by public administrations at different levels.

4. Price and Legislative Instability: Farmers have highlighted the serious problem posed by the uncertainty related to irrigation water management, both in terms of the sustained availability of resources over the long term and price formation. This uncertainty is exacerbated by frequent legislative changes that further complicate farmers' adaptation to these new conditions.

2.2 Goals of Basin Action Plan

The Water Action Plan for the Campo de Cartagena Irrigation District sets out key objectives focused on sustainable water management practices by the Water Framework Directive and the Floods Directive. The plan aims to address the various challenges facing the region, particularly to reconcile the good ecological status of water bodies with the use of productive resources in Campo de Cartagena, seeking to balance these two objectives. The significant socioeconomic value of tourism in the Mar Menor region and irrigated agriculture in Campo de Cartagena justifies the search for solutions that preserve these activities as much as possible.

To achieve this, four strategies must be developed in tandem.

1. Improve the availability of sustainable water resources by promoting accessible and equitable unconventional water production solutions to reduce dependence on traditional water sources.

2. Consolidate the currently allocated water resources such as those from the Tagus-Segura Water Transfer, whose availability is being reduced by the new Tagus River Basin Management Plan
3. Develop infrastructure to enhance water distribution and supply, particularly improving connectivity between non-conventional water production points and irrigation areas.
4. Implement measures to mitigate the environmental impact of diffuse contamination from irrigation leachage and runoff and from abstraction of water resources.
5. Establish mechanisms to secure farmers in terms of agricultural product pricing and water management standards to minimise uncertainties and contradictions between legislation and short- and long-term policies.

These objectives and strategies align with the Water Framework Directive and the Floods Directive, ensuring that they do not contravene the establishment of ecological flow requirements for watercourses and exacerbate flood risks.

2.3 Main measures

Legal measures:

1. Defining normative frameworks for water management in which the various plans developed by all involved administrations integrate non-contradictorily, with a common long-term vision that extends beyond the typical time frame of the plans (usually between three and five years).

2. Consolidate the legal framework that regulares the Tagus-Segura Water Transfer, providing stability for the operation of the infrastructure.

3. Regulate the pricing of agricultural products through the application of appropriate legislation and establishment of negotiation committees.

Political measures:

1. Promote the financial accessibility of unconventional water resources and ensure fairness in their distribution.

2. Improve the production and use of desalinated water through better maintenance and operation of desalination plants, develop additional desalination capacity, and introduce renewable energy sources to minimise operational costs.

3. Develop a realistic plan to achieve full cost recovery for the provision of water services, avoiding indefinite subsidies

4. Invest infrastructure to connect non-conventional water production facilities with transport and distribution infrastructure for irrigation systems.

5. Encourage public and private sector investment in R&D&I to solve the problemas associated to rainwater harvesting and field drainage systems for reuse, improve soil quality to support water availability improvements, and reduce the negative impact of fertiliser and pesticide use on ecosystems.

6. Prevent nutrient entry from agriculture into the Mar Menor by making it hydrologically independent, controlling underground flows from the Quaternary aquifer and occasional surface runoff in the watershed during heavy rainfall events, and increasing control over pollutant discharge.

7. Evaluate the implementation of precision irrigation and controlled deficit irrigation techniques and improve water loss control and management, particularly in ponds, reservoirs, and canals, through actions such as lining and covering.

Institutional measures:

1. Improve communication and coordination between the various public institutions responsible for water management, their action plans, and policies being implemented.

2. Create organisations comprising all stakeholders involved in water management to coordinate decision-making and implementation of actions. These organisations would provide coordinated oversight of administrative processes related to the construction of infrastructure.

Practical measures:

1. The combination of uses and water mixes should be optimised to promote crop growth while minimising the pollutant load infiltrating the soil by using groundwater from wells with acceptable salinity or mixing it with higher quality surface water, such as that from the Tajo-Segura transfer or desalination, using intermittent pumping of groundwater to smooth out the irregularity of supplies from the Tajo-Segura transfer. The final mix should be economically sustainable in the long term.

2. Adapt crop types in terms of water needs to the potential availability of water, considering crop rotation and the combination of crops with different growth cycles.

3. Upscale the already existing computerized platform for the sustainable management of crop fertilization and irrigation. The platmorm should monitor information from relevant indicators of the water status of the soil-plant-atmosphere at most plots. Improve the predictive model to propose an environmentally sensible irrigation schedule that can be followed by all farmers.

These actions align with the European Green Deal, Water Framework Directive, and Segura River Basin Management Plan. At the regional level, the two main strategies or plans providing context to this Action Plan are territorial guidelines and urban planning within the functional area of “Campo de Cartagena - Mar Menor”, and the Integrated Coastal Zone Management Strategy for the Mar Menor socio-ecological system and its surroundings.

2.4 Financing strategy

To finance the necessary measures, it is essential to involve all relevant administrations: the General State Administration, the Regional Government, the Provincial Councils, and Local Corporations and Municipalities. The current hydrological plan for the Segura River Basin stipulates that the General State Administration should finance 69% of the investment in the program of measures. The Autonomous Communities of Murcia, Valencia, and Andalusia fund

24%, and local entities cover the remainder. For the development and execution of the connection infrastructure, funding will also come from the EU.

Cost recovery through water pricing is a principle of the water sector. In cost recovery analyses conducted as part of the Segura River Basin Management Plan, a cost recovery rate of 86.9% was achieved for the 2022–2027 planning cycle compared to an index of 82% in the previous 2015–2021 planning cycle. This represented a significant improvement in the cost recovery of the basin. However, the total cost recovery has not yet been achieved. However, the increase in desalination that will be necessary to replace the reduction in Tagus-Segura Water Transfer as a result of the new Tagus River Basin Management Plan has not been taken into account. In areas highly dependent on the water transfer, such as the Campo de Cartagena, the impact can be very significant.

The financing of water services in the Segura Basin is highly controversial. The distribution of costs among different water users is uneven and influenced by different factors. For urban use, nearly 100% cost recovery is achieved, whereas in agriculture and other sectors, cost recovery is much more variable. Some users, such as those using water from the Tagus-Segura transfer, are subject to very strict cost recovery rates, whereas others, such as users of desalinated water, receive indirect subsidies, as costs are not fully recovered.

It is also important to note that the same cost cannot be applied to urban and agricultural water, as urban water takes precedence over agricultural water, and in times of shortage, the urban water supply will be prioritised. As a result, the agricultural sector should, in principle, pay a lower rate.

2.5 Integration into current legislation

1. Amend Royal Legislative Decree 1/2001 to Improve Coordination Between Institutions and Coherence of Measures

Coordination between various government administrations is crucial to ensure the effectiveness of any action plan for sustainable management of water resources. The revised Water Law, approved by Royal Legislative Decree 1/2001 of 20 July 2001 transposes the European Union Water Framework Directive. In Spain, water resource management responsibilities are divided between central and regional authorities. Generally, the General State Administration (AGE) manages integrated water and resource management for intercommunity basins, while Autonomous Communities (CCAA) are responsible for intra-community districts. Agricultural, rural development, and environmental policies are primarily managed by regional governments (CCAA), but the State Administration (AGE) sets a framework for these policies to harmonise them across Spain. Urban water management mainly falls under the jurisdiction of municipalities and the CCAA. Effective coordination between administrative authorities on water and agricultural issues is the key to achieving sustainable water use.

2. Define and Implement Measures to Protect Rural Environment

Agricultural development in Spain has had various environmental impacts. In this context, Royal Decree 47/2022 of 18 January (BOE 2022) addressing the protection of waters against diffuse pollution from agricultural nitrates, offers tools to tackle this issue. Despite the complexity of the subject, inadequate regulation could be a significant cause. It would be pertinent to revise Law No. 45/2007 (BOE 2007a), which pertains to the sustainable development of rural areas, by incorporating new measures to promote a holistic approach to rural development and improve the quality of life in these regions.

3. Promote the Production of Non-Conventional Water by Amending Royal Decree 1620/2007 and Law 11/2005

Regulatory changes are necessary to enhance the use of recycled water and adapt desalinated water production to meet environmental standards while minimising the environmental impact. To encourage the use of recycled water, it would be beneficial to amend Royal Decree 1620/2007 (BOE 2007b), which establishes the legal regime for the reuse of treated water to ensure adequate protection of health and the environment. The law specifies permissible limits and quality standards for different uses and classifies them into five categories: urban, industrial, agricultural, recreational, and environmental. Although domestic use of recycled water has not yet been implemented in Spain, legislation provides for this possibility in cases of emergencies. Additionally, it is necessary to promote sustainable desalination practices. This involves amending the Law 11/2005 (BOE 2005), which approves urgent measures for water resource management, and encourages desalination as an alternative to address water scarcity. The 2005 AGUA program (Actions for the Management and Use of Water) includes desalination projects aimed at reducing dependence on inter-regional water transfers. However, it is important to recognise that these investments will lead to higher tariffs for urban water, in line with the principle of full cost recovery and the polluter pays principle, also derived from the Water Framework Directive (WFD). While studies indicate that urban users are willing to pay higher tariffs for recycled water owing to its environmental benefits, it is essential to assess whether this tariff increase is socially sustainable to avoid water poverty. Accessibility and equity of water resources must be considered, particularly for groups that may be disproportionately affected by these tariff increases.

4. Comply with decisions to protect the Mar Menor.

Authorities have made several commitments to improve the environmental quality of the Mar Menor. However, some of these commitments have not been fully implemented and enforced. It is recommended to move forward in this direction, doing everything possible to implement the decisions made to protect the Mar Menor. For example, progress on the Resolution of May 8, 2006, issued by the General Secretariat for the Prevention of Pollution and Climate Change, which includes the environmental impact statement on the evaluation of the project for the Expansion of the El Mojón Brackish Water Desalination Plant and its pipelines. Another example is ensuring compliance with Law 26/2009 of December 23 regarding the General

State Budgets for 2010, which declares the Collection and Disposal of Brines from the network of brackish water desalination plants in the Campo de Cartagena and their discharge into the Mediterranean Sea to be of general interest. Finally, the Program of Measures (Annex 10) of the Segura Basin Hydrological Plan for 2009/15 and 2015/21 included several pending actions, such as the construction of brine pipelines to collect discharges from private desalination plants in the Campo de Cartagena; the installation of a battery of wells to prevent the Mar Menor from receiving groundwater from the Campo de Cartagena with high nitrate concentrations; the expansion of the Mojón desalination plant and its network of collectors for desalinating irrigation return flows collected in the Campo de Cartagena drainage system; or the denitrification of groundwater resources captured by the perimeter well battery in the Campo de Cartagena and subsequent discharge into the Mediterranean Sea.

2.6 Socialization and implementation of Basin Action Plan

The Action Plan could be socialized through a workshop involving all identified stakeholders concerned with the issue. The goal is to share the main recommendations and conclusions from scientific research conducted under the Ag-Wamed project.

The development of the proposed actions requires the participation and coordination of three administrative levels: General State Administration (AGE), Autonomous Communities, and municipalities. Specifically, the regulatory changes needed for the implementation of the plan primarily falls under the responsibility of the National Government (Ministry of Ecological Transition and the Demographic Challenge; Ministry of Agriculture, Fisheries, and Food) and the Autonomous Communities (Government of the Region of Murcia). Funding and management of the infrastructure necessary to connect various resources will involve both national and regional government resources, including EU funds, and will require the participation of Irrigation Communities. Efforts to enhance irrigation efficiency and manage losses, such as reservoir lining and covering, will require the involvement of these communities, municipalities, and regional governments. Effective coordination between all three administrative levels, along with water user representation, is crucial for the negotiation and decision-making committee. Additionally, involving other stakeholders, such as water users and representatives of the food supply chain, may be advantageous for discussions on price formation.

Debate forums and workshops, such as those developed in this project, are effective measures for sharing issues and outlining possible solutions. In the long term, the forum provided by the negotiation and decision-making committee itself would serve as an appropriate means for continuing the process of socialization.

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